User’s Manual for the BMPTRAINS Model

Prepared By:
Marty Wanielista, Mike Hardin,
Przemyslaw Kuzlo, and Ikiensinma Gogo-Abite

September 1, 2014

FDOT Project number: BDK78 #960-03

The author’s appreciate the input from the many users of the Model and Manual. Updates to the Model are frequent and thus the Manual may not always be in agreement with the Model output for the example problems. The Manual however reflects the basic development and navigation of the BMPTRAINS program to help understand BMP applications.
# Table of Contents

List of Tables .................................................................................................................. iv  
List of Figures ................................................................................................................... v  
Introduction .................................................................................................................... 1  
Literature Review ........................................................................................................... 2  
  Jordan/Falls Lake Stormwater Nutrient Load Accounting Model ....................................... 2  
  BMP SELECT Model ......................................................................................................... 3  
  Clinton River Site Evaluation Tool (SET) ............................................................................ 5  
  Virginia Runoff Reduction Method Worksheet ................................................................. 7  
  Department of Environmental Services (DES) Pollutant Loading Spreadsheet Model .......... 9  
  Stormwater Best Management Practice Design Workbook .............................................. 11  
  Stormwater Management and Design Aid (SMADA) .......................................................... 12  
  Best Management Practices Treatment Aid (BMPTRAINS) ............................................. 14  
Introduction .................................................................................................................... 14  
Watershed Characteristics ............................................................................................... 16  
Stormwater Treatment Analysis ....................................................................................... 18  
Retention Basin ............................................................................................................... 19  
Exfiltration Trench .......................................................................................................... 21  
Pervious Pavement .......................................................................................................... 24  
Wet Detention .................................................................................................................. 25  
Stormwater and Rainwater Harvesting ............................................................................ 27  
Floating Islands (wetlands) .............................................................................................. 29  
Filtration Including Biofiltration ...................................................................................... 29  
Greenroof .......................................................................................................................... 31  
Vegetated Natural Buffer and Vegetated Filter Strip ......................................................... 33  
Swale .................................................................................................................................. 35  
Rain (Bio) Garden ............................................................................................................ 37  
Tree Well .......................................................................................................................... 38  
Lined Reuse Pond with Underdrain Input ........................................................................ 40
List of Tables

Table 1 - Comparison table of BMP options available within different models ................................ 13
Table 2 – Examples of Pollution Control Media Mixes ........................................................................ 22
List of Figures

Figure 1 - Watershed Characteristics input tab for the Jordan/Falls Lake Stormwater Nutrient Load Accounting Model ................................................................. 2
Figure 2 - Structure of the Jordan/Falls Lake Stormwater Nutrient Load Accounting Model ................................................................. 3
Figure 3 - Starting page of the BMP SELECT Model ................................................................. 4
Figure 4 - Structure of the BMP SELECT Model ................................................................. 5
Figure 5 - Site Data input worksheet for the Clinton River Site Evaluation Tool ................ 6
Figure 6 - Schematic of the Clinton River Site Evaluation Tool ........................................ 7
Figure 7 - Site Data input worksheet for the Virginia Runoff Reduction Method Worksheet ................................................................. 8
Figure 8 - Schematic of the Virginia Runoff Reduction Method Worksheet ....................... 8
Figure 9 - Input worksheet for the DES Simple Method Pollutant Loading Spreadsheet Model ................................................................. 9
Figure 10 - Schematic of the DES Simple Method Pollutant Loading Spreadsheet Model .... 10
Figure 11 - Starting page of the Stormwater Best Management Practice Design Workbook .... 12
Figure 12 - Introduction Page worksheet ........................................................................ 14
Figure 13 - General Site Information worksheet ................................................................ 15
Figure 14 - Watershed Characteristics worksheet .......................................................... 17
Figure 15 - Stormwater Treatment Analysis worksheet .................................................. 18
Figure 16 - Retention Basin worksheet ............................................................................ 20
Figure 17 - Exfiltration Trench worksheet ........................................................................ 23
Figure 18 - Pervious Pavement worksheet ...................................................................... 25
Figure 19 - Wet Detention worksheet ............................................................................. 26
Figure 20 - Stormwater Harvesting worksheet ................................................................ 28
Figure 21 - Filtration including Biofiltration worksheet .................................................. 30
Figure 22 - Greenroof worksheet ...................................................................................... 32
Figure 23 - Vegetated Natural Buffer worksheet ............................................................ 34
Figure 24 - Swale worksheet .............................................................................................. 36
Figure 25 - Rain (Bio) Garden worksheet ......................................................................... 38
Figure 26 - Tree Well worksheet ..................................................................................... 40
Figure 27 - Lined Reuse Pond with Underdrain Input worksheet ...................................... 41
Figure 28 - User Defined BMP worksheet for Street Sweeping ........................................ 42
Figure 29 - User Defined BMP for Misc. Retention ........................................................... 43
Figure 30 - User Defined BMP for Misc. Detention ............................................................ 43
Figure 31 - Multiple Catchments and Treatment Systems Analysis worksheet ................ 44
Figure 32 - Introduction Page worksheet ......................................................................... 45
Figure 33 - Introduction Page worksheet ......................................................................... 46
Figure 34 - Introduction Page worksheet ......................................................................... 47
Figure 35 - General Site Information worksheet ............................................................. 47
Figure 36 - Name of Project Input ................................................................................... 48
Figure 37 - General Site Information worksheet ............................................................. 48
Figure 38 - Meteorological Zone Map Description .......................................................... 49
Figure 81 - Retention Basin worksheet................................................................. 93
Figure 82 – Catchment and Treatment Summary Results worksheet......................... 94
Figure 83 - General Site Information worksheet...................................................... 96
Figure 84 - Watershed Characteristics worksheet ..................................................... 97
Figure 85 - Wet Detention worksheet.................................................................. 98
Figure 86 - Vegetated Natural Buffer worksheet. .................................................. 99
Figure 87 – Catchment and Treatment Summary Results worksheet....................... 100
Figure 88 - General Site Information worksheet .................................................... 102
Figure 89 - Watershed Characteristics worksheet ................................................... 103
Figure 90 – Rain (Bio) Garden worksheet .............................................................. 104
Figure 91 - Catchment and Treatment Summary Results ........................................ 105
Figure 92 – Rain (Bio) Garden.............................................................................. 106
Figure 93 – Rain (Bio) Garden Selecting a Media Mix............................................... 107
Figure 94 - Catchment and Treatment Summary Results ........................................ 108
Figure 95 - General Site Information worksheet .................................................... 111
Figure 96 - Catchment Configuration Options worksheet ....................................... 112
Figure 97 - Watershed Characteristics worksheet .................................................. 113
Figure 98 – Swale worksheet .............................................................................. 114
Figure 99 - Retention Basin worksheet ................................................................ 115
Figure 100 - Wet Detention worksheet ................................................................. 115
Figure 101 - Catchment and Treatment Summary Results. ..................................... 116
Figure 102 - Catchment Configuration Options worksheet ..................................... 117
Figure 103 - Watershed Characteristics worksheet ............................................... 118
Figure 104 - Catchment and Treatment Summary Results. .................................... 119
Figure 105 - General Site Information worksheet .................................................. 122
Figure 106 - Catchment Configuration for part 1 of this problem. ........................... 122
Figure 107 - Watershed Characteristics worksheet ............................................... 125
Figure 108 – Swale worksheet ............................................................................ 126
Figure 109 - Retention Basin worksheet.................................................................. 127
Figure 110 - Wet Detention worksheet .................................................................. 128
Figure 111 - Catchment and Treatment Summary Results. ..................................... 129
Figure 112 - Catchment Configuration K ............................................................... 130
Figure 113 - Watershed Characteristics worksheet ............................................... 132
Figure 114 - Catchment and Treatment Summary Results. ..................................... 132
Figure 115 - General Site Information worksheet .................................................. 134
Figure 116 - Catchment Configuration for this problem. ........................................ 134
Figure 117 - Watershed Characteristics worksheet ............................................... 135
Figure 118 - Retention Basin worksheet .................................................................. 135
Figure 119 - Catchment and Treatment Summary Results. ..................................... 136
Figure 120 - General Site Information worksheet .................................................. 138
Figure 121 - Catchment Configuration for part 1 of this problem. ........................... 139
Figure 122 - Watershed Characteristics worksheet ............................................... 140
Figure 123 - Retention Basin worksheet......................................................................................... 141
Figure 124 - Catchment and Treatment Summary Results............................................................... 142
Figure 125 - Catchment Configuration C. ......................................................................................... 143
Figure 126 - Watershed Characteristics worksheet ........................................................................ 144
Figure 127 - Catchment and Treatment Summary Results............................................................... 145
Figure 128 - General Site Information worksheet ......................................................................... 147
Figure 129 - Catchment Configuration for this problem................................................................. 147
Figure 130 - Watershed Characteristics worksheet ........................................................................ 148
Figure 131 - Wet Detention worksheet ......................................................................................... 148
Figure 132 - Catchment and Treatment Summary Results............................................................... 149
Introduction

Pollution in stormwater runoff, also known as nonpoint source pollution, contains an array of contaminants which contribute to the degradation of water quality (both surface and ground water). According to the Environmental Protection Agency (EPA), stormwater runoff pollution is the leading remaining cause of water quality problems reported by the states (EPA, 2010). Stormwater runoff can be high in pollutant mass derived from both natural and manmade sources. Stormwater can be polluted with nutrients, sediments, oils, greases, toxic chemicals, wastes, and bacteria. An increase in stormwater runoff pollution can be caused by many factors, but is most often associated with land use activities. The magnitude of the mass load of pollution transported by urban runoff to receiving water bodies is in most cases greater than that of treated sewage in many cases (Viessman and Hammer, 2005).

The control of stormwater pollution at its source can be achieved through the implementation of best management practices (BMPs). A best management practice is a stormwater control system that is economically and technically feasible as a means of reducing the quantity of pollutants to meet water quality goals (Wanielista et al., 1997). There are many types of structural and nonstructural stormwater BMPs which are currently used to minimize pollution. There are also many BMPs, which because of limited operational results have not been as popular in application. However, there has been research conducted in recent years in an effort to assess and predict the effectiveness of stormwater BMPs (Denver Urban Drainage and Flood Control District, 2010; Chopra et al., 2011; FDEP, 2010; Hardin, 2006; Harper and Baker, 2007; Low Impact Development Center, 2011; North Carolina Division of Water Quality, 2012; Ryan et al., 2010; USEPA, 2007; USEPA, 2005; Urban Drainage and Flood Control District, 2011; Wanielista et al., 2011; Wanielista et al., 1991; Wanielista et al., 2011).

The main objective of this manual is to report on the use of an EXCEL spreadsheet model to evaluate stormwater runoff nutrient loads as well as treatment efficiencies of BMPs based on the findings of studies conducted in recent years within the State of Florida. The model is to serve as a comprehensive assessment and evaluation tool which can be used by private entities and governmental agencies to aid in the choice of stormwater BMPs. Another benefit of this model is to educate individuals about the availability and benefits of different BMP options.
Literature Review

Jordan/Falls Lake Stormwater Nutrient Load Accounting Model

The Jordan/Falls Lake Stormwater Nutrient Load Accounting Model is an Excel spreadsheet model developed by North Carolina State University in coordination with the North Carolina Department of Environment and Natural Resources. While the original application of this tool is the Jordan Lake Nutrient Strategy, it may also be applied to any location within the State of North Carolina (Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (Version 1.0) User’s Manual, 2011). Input data for the model is shown in Figure 1.

Figure 1 - Watershed Characteristics input tab for the Jordan/Falls Lake Stormwater Nutrient Load Accounting Model.

The Jordan Lake model is used to calculate the annual Total Phosphorus and Total Nitrogen mass loading produced by runoff from the existing condition and new, developed condition. Additionally, it is used to calculate nutrient removal by the stormwater BMPs chosen for a watershed. Calculations performed within the model are governed by two basic principles: Simple Method (for runoff volume and pollutant loading calculations) and the median effluent concentration BMP efficiency metric (for BMP reduction calculations) (Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (Version 1.0) User’s Manual, 2011).
The structure and set up of the Jordan Lake loading tool is relatively simple and easy to follow. The first tab, entitled “Instructions,” contains a description and user information for the users of the spreadsheet tool. It also contains physiographic region and annual precipitation location maps for the State of North Carolina to aid with appropriate input selection in the model. The next two worksheets are “Watershed Characteristics” and “BMP Characteristics” input tabs (Figure 2). On the Watershed Characteristics worksheet, users enter all information pertaining to the site of interest, including both pre- and post-development conditions (Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (Version 1.0) User’s Manual, 2011). The information relevant to the type and properties of the BMPs is specified in the BMP Characteristics tab.

![Figure 2 - Structure of the Jordan/Falls Lake Stormwater Nutrient Load Accounting Model.](image)

The setup of the model allows the user to divide the developed watershed into as many as six catchments. Each catchment can be treated by up to three BMPs. The available BMP choices comprise of Bioretention with IWS (Internal Water Storage Zone), Bioretention without IWS, Dry Detention Pond, Grassed Swale, Green Roof, Level Spreader/Filter Strip, Permeable Pavement, Sand Filter, Water Harvesting, Wet Detention Pond, and Wetland (Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (Version 1.0) User’s Manual, 2011). The summary of the analysis output is displayed in the final worksheet entitled “Development Summary” (Figure 2).

**BMP SELECT Model**

The BMP SELECT Model (Figure 3) is a Microsoft Excel based model developed on behalf of Water Environment Research Foundation (WERF) by a work group consisting of ACR, LLC, Colorado State University and the University of Utah. This software was developed by WERF in response to WERF Subscribers who desired a simple tool that could be readily applied
to evaluate the relative performance and cost implications of various BMP control options (Pomeroy and Rowney, 2009).

The BMP SELECT Model is a tool that has the capability of evaluating water quality parameters such as Total Suspended Solids, Total Nitrogen, Total Phosphorus and Total Zinc. It also evaluates the effectiveness of stormwater BMPs and the cost implications associated with the application of these systems. The stormwater BMPs that can be analyzed with this software include extended detention, bioretention, wetlands, swales, permeable pavement and filters.

Figure 3 - Starting page of the BMP SELECT Model.

The BMP SELECT Model is a “planning-level” tool with a focus on limiting the extent and/or complexity of input data necessary to generate results (Pomeroy and Rowney, 2009). The design of the model allows the user to run the calculations with limited information about the watershed characteristics, BMP types, and BMP sizes. The calculations performed by the model are focused in four major areas: watershed runoff calculations, BMP quantity calculations, pollutant load calculations, and cost calculations.
The BMP SELECT Model is relatively easy to use. The calculation workflow is shown in Figure 4. Prior to beginning to work with the model, the user may change default Watershed Parameters, BMP Parameters and Meteorological Data in the “Set Default Values” window. The model has the capability of adding, saving, and retrieving multiple scenario data in the “Save or Retrieve Scenario” tab. All the information pertaining to the watershed and the BMPs is indicated in the “Edit Catchments and BMPs” tab. Once all the required input is indicated, the water quantity and quality calculations are performed in the “Do QQ Calculations” (quantity and quality) tab. The cost calculations are performed in the “Do Cost Calculations” section.

![Figure 4 - Structure of the BMP SELECT Model.](image)

**Clinton River Site Evaluation Tool (SET)**

The Clinton River Site Evaluation Tool (SET) is a Microsoft Excel spreadsheet which is designed to aid in the assessment of development plans and available Best Management Practices (BMPs) to achieve water quality objectives (Tetra Tech, 2008). Another model was developed by the U.S. EPA (2007) and Tetra Tech that is a Geographic based model called SUSTAIN for cost analysis and BMP efficiencies. The SET model is presented here.

The SET model evaluates the annual pollutant loads for the Total Suspended Solids, Total Nitrogen, Total Phosphorus, E. Coli Bacteria and Copper based on the pre- and post-development watershed characteristics. The BMP selection in the model is based on achieving the annual sediment load reduction percentage or a specified runoff volume reduction target. The
BMP selection in the model is not determined however by matching the pre- and post-development annual nutrient loads.

The SET spreadsheet model is very easy to use, even for first time users. The model opens with only one visible worksheet entitled “Site Data” (Figure 5). Here, the user indicates the general site information and the type of analysis that they want to perform. The next input tab, entitled “Land Use,” has input fields for the overall site land uses for both proposed and existing conditions (Tetra Tech, 2008). In Figure 6, input data for all drainage areas (DAs) are assigned to include proposed pervious, impervious, and stormwater management areas to their appropriate DA. Each of the respective drainage areas are then assigned to the BMPs which serve these areas in the “BMPs” worksheet. In Figure 6 is also shown the BMP analysis workflow.

Figure 5 - Site Data input worksheet for the Clinton River Site Evaluation Tool.

The BMPs available for analysis include extended wet detention, extended dry detention, infiltration basin, bioretention, sand filter, infiltration trench, vegetated swale, vegetated filter strip, dry well, rain barrel, cistern, green roof, porous pavement, hydrodynamic device, catch
basin with sump, street sweeping and user-defined BMP. If the user cannot find an appropriate BMP from a wide selection built into the model, a custom treatment system can be specified in the “User BMP” sheet. However, the pollutant removal efficiencies and other properties of the user specified BMP must be included with this selection.

![Figure 6 - Schematic of the Clinton River Site Evaluation Tool](image)

**Virginia Runoff Reduction Method Worksheet**

The Virginia Runoff Reduction Method Worksheet is a model developed on behalf of the Virginia Department of Conservation and Recreation by the Center for Watershed Protection, Inc. and the Chesapeake Stormwater Network. The spreadsheet is designed to help users plan combinations of stormwater BMPs for a particular site in order to meet the standards in the proposed regulations within the State of Virginia (Virginia Department of Conservation and Recreation, 2011). There are two versions of the model, one for new development and one for redevelopment.

The Virginia Runoff Reduction Method Worksheet calculates the annual post-development Total Phosphorus and Total Nitrogen loadings and the required post-development treatment volume. The methodology used in this model is based on the calculation of the post-development pollutant loads associated with the site specific conditions and selection of BMPs to meet the pre-determined target pollutant loads. The input data worksheet for post-development conditions is shown in Figure 7. The target pollutant load, which is only established for Total Phosphorus, is achieved by the appropriate combination of the Environmental Site Design, Runoff Reduction, and Pollutant Removal Practices.
The Virginia Runoff Reduction Method Worksheet is a very straightforward modeling tool. In the first worksheet entitled “Site Data,” the user indicates the site information such as annual rainfall and post-development land cover. The following five worksheets (Figure 8) allow the user to split the project area into five separate drainage areas. In each of the worksheets, the user may choose from a large menu of Runoff Reduction and Pollution Reduction practices and apply them to the respective drainage basins. The Runoff Reduction practices include bioretention, infiltration, green roofs, dry swales, wet swales, grass channels, extended detention ponds, permeable pavement and impervious surface disconnection. Finally, the results of the analysis are displayed in the “Water Quality Compliance” worksheet.
Department of Environmental Services (DES) Pollutant Loading Spreadsheet Model

The Simple Method Pollutant Loading Model (Figure 9) has been developed by the New Hampshire Department of Environmental Services (NHDES) Watershed Management Bureau. This Microsoft Excel spreadsheet is based on the Simple Method which estimates pollutant loading of stormwater runoff for urban and developing areas (New Hampshire Department of Environmental Services, 2011).

![Figure 9 - Input worksheet for the DES Simple Method Pollutant Loading Spreadsheet Model]

The methodology used in this model estimates the annual pre- and post-development Total Suspended Solids, Total Phosphorus, and Total Nitrogen loads. This technique is recommended by NHDES because of the modest amount of information it requires, which includes subwatershed drainage area and impervious cover, annual precipitation, and stormwater runoff pollutant concentrations (New Hampshire Department of Environmental Services, 2011).
The Simple Method Pollutant Loading Spreadsheet Model requires the user to input the BMP removal efficiencies for all pollutants included in the analysis. This information can be obtained from the NHDES Stormwater Manual which contains BMP removal effectiveness values of different stormwater systems.

The NHDES Simple Method Pollutant Loading Spreadsheet Model is simple in operation. The sequence of the analysis is shown in Figure 10. The first tab contains general information about the model and instructions for the user. In the following two worksheets, the user indicates the pre- and post-development watershed information. These input worksheets require information about land use, types of pervious areas, and types of impervious areas. The next sheet requires input information about the average annual precipitation. In the last input sheet, analyzed BMPs are specified along with their pollutant removal efficiencies. It also allows the user to provide pollutant load reductions associated with the use of low nutrient fertilizers under post-development conditions (Comstock, 2010). The model does not contain any specific BMPs or the data on their associated effectiveness. Therefore, the user is required to provide this information. All results of the analysis are provided in the last four worksheets.

Figure 10 - Schematic of the DES Simple Method Pollutant Loading Spreadsheet Model.
Stormwater Best Management Practice Design Workbook

The Stormwater Best Management Practice Design Workbook is an Excel spreadsheet model published by the Urban Drainage and Flood Control District (UDFCD) in Denver, Colorado. This tool has been developed by the UDFCD in an effort to help users of their stormwater management manual to select BMPs which are best suited for their project. This tool helps to screen BMPs at the planning stages of development (Urban Storm Drainage Criteria Manual Volume 2).

The UD-BMP tool provides a list of BMPs for consideration based on site-specific conditions (Urban Storm Drainage Criteria Manual Volume 2). The BMP evaluation in the Stormwater Best Management Practice Design Workbook is based on a few steps. First, the model factors in Excess Urban Runoff Volume (EURV) reduction. Quantification of runoff volume reduction takes into account such practices as Minimizing Directly Connected Impervious Area (MDCIA), implementation of Low Impact Development (LID) practices, and other BMPs. Factoring these runoff reduction practices into the model yield total imperviousness and effective imperviousness values. These values can then be used in the assessment and sizing of the BMPs. The functions provided by BMPs may include volume reduction, treatment and slow release of the water quality capture volume (WQCV), and combined water quality/flood detention (Urban Storm Drainage Criteria Manual Volume 3, 2010). The BMP selection in the model is based on achieving the annual runoff volume reduction target. The BMP selection in the model is not dictated by matching the pre- and post-development annual nutrient loads.

The UDFCD Stormwater Best Management Practice Design Workbook is user friendly and simple in operation. The introduction page (Figure 11) contains general information about the function and content of the model. The model contains a helpful tab entitled “BMP Selection”. In this tab, the model identifies potential volume reduction and WQCV BMPs for the user based on general site information such as development characteristics and existing soil conditions. Volume reduction practices, such as MDCIA, can be evaluated in the following Impervious Reduction Factor (IRF) worksheet which will allow the user to obtain the effective imperviousness value. This value can be used in calculating the required WQCV for the individual BMP options. Individual BMP selections in the model include grass buffer, grass swale, rain garden, extended detention basin, sand filter, retention pond, constructed wetland pond, constructed wetland channel, and permeable pavement system.
Stormwater Management and Design Aid (SMADA)

Stormwater Management and Design Aid (SMADA) is a set of separate computer models which provide a complete hydrology package. SMADA is one of the very first models which were able to estimate pollution removal as well as hydrograph shapes. These programs work together to allow hydrograph generation, pond routing, storm sewer design, statistical distribution and regression analysis, pollutant loading modeling, and other functions.

One of the calculation routines in SMADA’s provides pollution loading calculation capabilities and is called PLOAD. It is a program which estimates pollutant loading on a time basis using typical watershed land uses and total rainfall (Wanielista et al., 1991). The PLOAD model can calculate pollutant loadings for a watershed from built in or user specified land use information. The user has to specify this information upon the initiation of the program. In
addition to the land use information, the user must indicate analysis time frame, a rainfall amount for analysis time frame, watershed area, and the watersheds runoff coefficient. For a given watershed, calculated results include the load for TSS, BODs, TN and TP, Lead, Copper, and Zinc.

A listing of the BMPs used in each model is shown in Table 1. There are many options available and each with a specific function. Some BMPs have regional names, thus before the use of a BMP, the user should check the physical design before deciding on use of a BMP term.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jordan/Falls Lake Model</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMP SELECT Model</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinton River SET</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia Runoff Reduction Method Worksheet</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DES Simple Method Pollutant Loading Spreadsheet Model¹</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMADA</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMPTRAINS</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Efficiency data need to be provided by user.

Table 1 - Comparison table of BMP options available within different models
**Best Management Practices Treatment Aid (BMPTRAINS)**

**Introduction**

The Best Management Practices Treatment for Removal on an Annual basis Involving Nutrients in Stormwater (BMPTRAINS) is a Microsoft EXCEL based model for specified BMPs. The model is based on the findings from studies conducted in recent years primarily within the State of Florida. It is in response to a need to address concerns for the over-enrichment of Florida’s surface waters, ground waters, and springs by nutrients (FDEP, 2010). The Introduction Page of the model is shown in Figure 12.

![Figure 12 - Introduction Page worksheet.](image)

The calculations in the BMPTRAINS model consist of three major parts. The first part includes the estimation of the required annual removal efficiency of BMPs for nitrogen and phosphorus. Some of the methodologies for calculation of the nitrogen and phosphorus removal efficiency used in this model comes from the “Evaluation of Current Stormwater Design Criteria within the State of Florida” report published by Harvey Harper, Ph.D., P.E. in June, 2007.
The required removal efficiency of the BMP(s) is estimated from the increase or decrease of the annual nutrient loadings due to development. The annual nitrogen and phosphorus loadings are calculated based on the annual runoff volumes and Event Mean Concentrations (EMC) for the pre- and post-development conditions. The annual runoff volumes in the BMPTRANS model are computed based on the project meteorological zone location, watershed area, mean annual rainfall depth, non-DCIA Curve Number, and DCIA percentage input. These parameters are specified in the General Site Information (Figure 13) and Watershed Characteristics worksheets (Figure 14).

Figure 13 - General Site Information worksheet.

The BMPTRANS model also has the capability of analyzing for user specified removal efficiency. This option can be utilized by using the “Specified Removal Efficiency” selection
from the “Type of Analysis” dropdown menu on the General Site Information worksheet. In this case, the BMP is analyzed to see if the specified reduction target is met rather than the removal efficiency found from the difference between the pre-and post-development nutrient loadings. As such, the pre-development condition characteristics do not make any difference in this type of analysis. However, the user still has an option of specifying this information as the pre-development loading values can be useful in certain analysis (i.e. compensatory treatment analysis).

Finally, the BMPTRAINS model is capable of analyzing individual or multiple BMPs to evaluate their effectiveness. For this type of analysis the watershed characteristics are not important and do not need to be entered into the model. This type of analysis is useful for evaluating the efficiency of individual or some combination of BMPs.

**Watershed Characteristics**

The existing and proposed watershed characteristics are indicated in the Watershed Characteristics worksheet (Figure 14). The model provides the capability of subdividing the analyzed watershed into four (4) separate catchment areas. This option can be utilized if the existing or proposed conditions for the project area can be characterized by more than one land use selection. Each catchment area must have a BMP associated with it, otherwise combine areas and use only one catchment. In the Watershed Characteristics worksheet, the user indicates information specific to the watershed area such as non-DCIA Curve Number and DCIA percentage. This is also where the user indicates EMCs by selecting the land use most appropriately representing the existing and proposed conditions. However, if the built-in selection does not contain a representative land use, or if more appropriate site specific information is available, the model has the capability to utilize user specified EMCs as shown in Figure 14.
### Watershed Characteristics V6.0

**Select Catchment Configuration**

- **A - Single Catchment**

**Catchment No. 1 Characteristics:**

- **Pre-development land use:**
  - with default EMCs
  - Post-development land use:
  - with default EMCs

- **Total pre-development catchment area:** 6.00 AC
- **Total post-development catchment or BMP analysis area:** 8.00 AC
- **Pre-development Non DCIA CN:** 85.00
- **Pre-development DCIA percentage:** 0.00%
- **Post-development DCIA percentage:** 40.00%
- **Estimated Area of BMP (used for rainfall excess not loadings):** 0.00 AC

**Catchment No. 2 Characteristics:**

- **Pre-development land use:**
  - with default EMCs
  - Post-development land use:
  - with default EMCs

- **Total pre-development catchment area:** 6.00 AC
- **Total post-development catchment or BMP analysis area:** 8.00 AC
- **Pre-development Non DCIA CN:** 60.00
- **Pre-development DCIA percentage:** 0.00%
- **Post-development DCIA percentage:** 80.00%
- **Estimated Area of BMP (used for rainfall excess not loadings):** 0.00 AC

**Catchment No. 4 Characteristics:**

- **Pre-development land use:**
  - with default EMCs
  - Post-development land use:
  - with default EMCs

- **Total pre-development catchment area:** 6.00 AC
- **Total post-development catchment or BMP analysis area:** 8.00 AC
- **Pre-development Non DCIA CN:** 7.728
- **Pre-development DCIA percentage:** 42.347
- **Post-development DCIA percentage:** 80.00
- **Estimated Area of BMP (used for rainfall excess not loadings):** 0.00 AC

**Overwrite Default Concentrations Using:**

<table>
<thead>
<tr>
<th></th>
<th>Pre:</th>
<th>Post:</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC(N):</td>
<td>mg/L</td>
<td>mg/L</td>
</tr>
<tr>
<td>EMC(P):</td>
<td>mg/L</td>
<td>mg/L</td>
</tr>
</tbody>
</table>

**Overwriting default Event Mean Concentrations associated with pre- and post-development land uses.**

**Selection of catchment configuration is done here.**

---

**Figure 14 - Watershed Characteristics worksheet.**

The model also allows for the specification of a configuration of the catchments within a watershed. For example, if there are three catchments in a watershed and two of the catchments are in series and one is in parallel, the model will allow for this selection. Since this model allows for up to four catchments per watershed each possible combination is presented as a selection. The user is prompted to input the number of catchments at which time all possible configurations will be presented that the user can choose from. It should be noted that if multiple BMPs are used in a watershed they are assumed to be in series, or one after another.

Additionally, if detention and retention BMPs are used within a single catchment, the detention
BMP is assumed to be downstream of the retention BMP. **Multiple BMPs in parallel are to be treated as different catchments.**

**Stormwater Treatment Analysis**

Once the required information is input into the General Site Information and Watershed Characteristics worksheets, the calculated (or user specified) required removal efficiency for both nitrogen and phosphorus can be viewed in the Stormwater Treatment Analysis page (Figure 15). The catchment configuration selected is also displayed on this worksheet.

![Stormwater Treatment Analysis worksheet](image)

**Selection of a single and combination of Best Management Practices available for analysis.**

**Input of pre- and post-development watershed characteristics. This has to be completed prior to proceeding to Best Management Practices.**

**STEP 2: Select one of the systems below to analyze efficiency.**

- **RETENTION BASIN**
- **WET DETENTION**
- **EXFILTRATION TRENCH**
- **RAIN (BIO) GARDEN**
- **SWALE**
- **USER DEFINED BMP**

**CATCHMENT AND TREATMENT SUMMARY RESULTS**

![Diagram of BMP selection](image)

**NOTE !!!:** All individual system must be sized prior to being analyzed in conjunction with other systems. Please read instructions in the MULTIPLE WATERSHEDS AND TREATMENT SYSTEMS ANALYSIS tab for more information.

After viewing the required treatment efficiencies and catchment configuration, the user may proceed to the second part (STEP 2) of the analysis in the Stormwater Treatment Analysis worksheet (Figure 15). The second part of the analysis includes the selection and adequate sizing of the BMP (or combination of BMPs) to meet the required treatment efficiencies. The BMP selections include retention basin, wet detention, exfiltration trench, pervious pavement, stormwater and rainwater harvesting, filtration including biofiltration, greenroof, floating islands with wet detention, vegetated natural buffer, vegetated filter strip, tree well, rain garden, swale,
and a user defined BMP. The third part (STEP 3) of the analysis is to select the Catchment and Treatment Summary Results button and see a summary of the results.

**Retention Basin**

A retention system is one of the more popular BMPs used for stormwater treatment. A retention system is a recessed area within the landscape that is designed to store and retain a defined quantity of runoff, allowing it to percolate through permeable soils into the shallow ground water aquifer.

The BMPTRAINS model has the capability of evaluating the treatment efficiency of retention systems. The effectiveness of the retention system in terms of yearly capture is assessed with the retention efficiency tables published by Harvey Harper in 2007. These tables contain a performance efficiency of dry retention as a function of DCIA and NON-DCIA Curve Number (Harper and Baker, 2007). In the BMPTRAINS model, the retention efficiency tables are also applied to other systems like exfiltration trench, pervious pavement, filtration including biofiltration, swale, vegetated natural buffer, vegetated filter strip, rain garden, and tree well.

In the BMPTRAINS model, any retention system can be analyzed in the Retention Basin worksheet (Figure 16). The user can size the system to provide the entire retention volume required to meet the treatment efficiency goal. Or the user has an option of specifying a fraction of the required retention volume (under sizing treatment) or additional retention volume (over sizing treatment). This option can be utilized in situations where the retention system is a part of a treatment train or if compensatory treatment is required due to site constraints.

As in many of the BMP options found in the BMPTRAINS model and in other models, some calculations are assumed to be done outside of or before a system is evaluated in the model. As an example, the land when the retention system is placed has to be available to meet the area requirements and the invert elevation specifications. Thus, the model provides for partial treatment because of area or other physical constraints.
Another useful feature of the Retention Basin worksheet, or any other retention based BMP worksheet, is the retention efficiency chart. The retention efficiency chart illustrates the treatment efficiency of the retention based system as a function of the retention depth. The properties of the retention efficiency curve are dependent on the post-development watershed characteristics such as non-DCIA Curve Number and DCIA percentage and the rainfall patterns in a rainfall zone. The efficiency of the retention basin sized by the user is shown on the chart as a mark (example would be a red triangle for catchment one). Another purpose of this chart is to illustrate to the user that there is a point of diminishing return as the retention depth is increased. This may enable the user to pursue other treatment options such as treatment trains or compensatory treatment.

The calculation of effluent or groundwater TN and TP concentrations under a retention basin is available in the Retention Basin worksheet. If no pollution control media mixes are used, the groundwater concentration is assumed equal to the basin concentration. If a pollution control...
media mix is used, then the groundwater concentration beneath the mix is calculated. There are at least six pollution control media choices commonly acceptable in Florida. Additional ones will be listed in the future. Their effectiveness is shown in the media mix tab. The fraction of particulate assumed in the model for nitrogen is 60% and phosphorus is 50% (Harper, 1990). Harper showed that the fraction is about the same for residential and highway sites. However, for the commercial sites measured, the particulate concentrations were higher.

**Exfiltration Trench**

Another commonly used form of retention BMP is an exfiltration trench. An exfiltration trench is a subsurface retention system consisting of a conduit such as a perforated pipe surrounded by natural or artificial aggregate which temporarily stores and infiltrates the runoff water (Wanielista and Yousef, 1993). This pipe can also be used with a pollution control media mix (Table 2).
### Table 2 – Examples of Pollution Control Media Mixes

<table>
<thead>
<tr>
<th>SOIL AUGMENTATION</th>
<th>MATERIAL ( % by VOLUME)</th>
<th>ESTIMATED TSS REMOVAL</th>
<th>ESTIMATED TN REMOVAL</th>
<th>ESTIMATED TP REMOVAL</th>
<th>LIMITING INFILTRATION RATE (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPS (ref A) 24&quot; deep below 6 &quot; of top soil</td>
<td>Compost 1 7.5%</td>
<td>40%</td>
<td>20%</td>
<td>30%</td>
<td>10 in/hr</td>
</tr>
<tr>
<td>TPS (ref B) 24&quot; deep no top soil</td>
<td>Shredded Paper 2 7.5%</td>
<td>70%</td>
<td>20%</td>
<td>35%</td>
<td>20 in/hr</td>
</tr>
<tr>
<td>OTE (ref B) 24&quot; deep no top soil</td>
<td>Organics 10 5%</td>
<td>45%</td>
<td>20%</td>
<td>75%</td>
<td>0.80 in/hr</td>
</tr>
<tr>
<td>CSL (ref C, D, *** 24&quot; deep all blended</td>
<td>Compost 1 20%</td>
<td>80%</td>
<td>20%</td>
<td>75%</td>
<td>0.80 in/hr</td>
</tr>
<tr>
<td>COS (ref D, 11) 24&quot; deep under 6 &quot; of top soil</td>
<td>Dade City Clay 6 10%</td>
<td>85%</td>
<td>35%/60%</td>
<td>45%/60%</td>
<td>1.5 in/hr</td>
</tr>
<tr>
<td>SAT (ref E) 12 &quot; deep under 6 &quot; of top soil</td>
<td>sand 100%</td>
<td>85%</td>
<td>30%</td>
<td>60%</td>
<td>2.0 in/hr</td>
</tr>
<tr>
<td>CTS (ref F) 12 &quot; deep under 6 &quot; of top soil</td>
<td>Dade City Clay 6 27%</td>
<td>90%</td>
<td>60%</td>
<td>90%</td>
<td>0.25 in/hr</td>
</tr>
</tbody>
</table>

**NOTES ON TABLE**

- All Effectiveness Estimates to the nearest 5%
- **May export nitrogen**

1. Class 1A STA Compost (approximate dry density = 1000 lbs/CY)
2. 1/4 inch loosely packed shredded paper (approximate dry density = 75 lbs/CY)
3. Sand ASTM C-33 with no more than 3% passing # 200 sieve (approximate dry density = 2200 lbs/CY)
4. Expanded Clay 3/8 in blend (approximate density = 950 lbs/CY)
5. Tire Crumb 1-5 mm (approximate density = 730 lbs/CY)
6. Dade City Blend Clay (approximate density = 2500 lbs/CY)
7. Sand and Compost mix (approximate density = 1200 lbs/CY)
8. Compost, Sand, and Top Soil mix (approximate density = 2000 lbs/CY) top soil can be local scraped
9. Local top soil either scraped from top 6 inches or from local stock pile and free of tree roots and debris
10. Florida Peat (approximate density of 700 lbs/CY) or Class 1A Compost or Mix of both
11. Add 12 inches of internal water storage at the bottom and increase the nutrient removal to 60%

A - Bioretention Urban Storm Drainage, Denver Urban Drainage and Flood Control District, 2010
C - Rain Gardens, Donald Carpenter, Lawrence Tech, Michigan, SOCMME meeting, 2009
E - City of Austin Environmental Criteria Manual, Section 1.6.5, Texas, 2012

Note: There is also a User Defined Media Mix called UDM. The removals and rate are entered by the user.
Just as with the retention basin, the nutrient removal performance of the exfiltration system is estimated from Harper’s retention efficiency charts. The user also has an option of sizing the system to the required removal efficiency, providing additional retention volume or under sizing the system. The Exfiltration Trench worksheet (Figure 17) also contains a retention efficiency chart with the designed system displayed on the curve. An additional feature included with the worksheet is a simple exfiltration trench volume calculator which allows the user to calculate a retention volume provided by the system based on the specified dimensions.

Figure 17 - Exfiltration Trench worksheet.
Pervious Pavement

Pervious pavement is another form of a retention system which is available for analysis in the BMPTRAINS model. Pervious pavement systems include the sub-base and pervious pavement. They can include several types of materials or designed systems such as pervious concrete, pervious aggregate/binder products, pervious paver systems, and modular paver systems (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010).

Similarly to the other retention systems, the nutrient load reduction of the pervious pavement system is calculated based on the retention efficiency tables. However, unlike the retention basin or exfiltration trench, the pervious pavement system retention volume is not automatically sized for the user. Instead, the user must indicate appropriate parameters of the pervious pavement system based on which the treatment efficiency is calculated. The user is alerted by a message whether or not the system is adequate to meet the required treatment efficiency. If the system is not adequate, the pervious pavement system can be used in series with other BMP(s).

The input parameters include the dimension of the individual layers, operational void space of the individual layers and area of the pavement system. The Pervious Pavement worksheet (Figure 18) has a selection of pervious pavement sections and sub-base materials with their appropriate operational void space values built in. These values were obtained from the “Porosity and Curve Numbers for Pervious Pavement Systems” technical memorandum published by the University of Central Florida (UCF) Stormwater Management Academy (SMA). The user may also use other products which are not available in the model’s selection. In order to do so, operational void space information of the products used in the analysis must be provided by the user.
Wet Detention

Wet detention ponds have permanent wet areas. The pond is designed to slowly release a portion of the collected stormwater runoff through an outlet structure (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010). Wet detention ponds are a popular BMP option in areas where groundwater conditions do not allow for percolation based systems.

Wet detention systems are available for analysis in the BMPTRAINS model. The effectiveness assessment of wet detention systems in the model is based on the residence time efficiency equations published by Harvey Harper in 2007. In the study, a linear regression analysis was conducted to evaluate relationships between removal of nitrogen and phosphorus as a function of residence time within wet ponds (Harper and Baker, 2007).

In the BMPTRAINS model the user can analyze wet detention system by indicating the average annual residence time that the system will provide. By indicating the residence time, the model will compute the required minimum permanent pool volume that the wet detention system
will have to provide. The size of the minimum permanent pool volume is dictated by the average annual residence time as well as the amount of annual runoff volume contributing to the pond.

In the BMPTRAINS model, wet detention systems can be analyzed in the Wet Detention (Figure 19), Floating Wetlands with Wet Detention, and User Defined BMP worksheets. In addition to the residence time, the user has an option of specifying an efficiency credit associated with the littoral zone. The littoral zone is that portion of a wet detention pond which is designed to contain rooted aquatic plants (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010). In the Floating Wetlands with Wet Detention worksheet the user may take credit for the use of Managed Aquatic Plant Systems (MAPS) in the design. MAPS are aquatic plant-based BMPs which remove nutrients through a variety of processes related to nutrient uptake, transformation, and microbial activities (Draft Statewide Stormwater Treatment Rule Development, FDEP, 2010).

![Wet Detention worksheet](image)

**Figure 19 - Wet Detention worksheet.**

Just as with the retention BMP worksheets, the Wet Detention and Floating Island with Wet Detention worksheets contain treatment efficiency charts. These charts illustrate the
treatment efficiency of the wet detention systems as a function of the average annual residence time. The efficiency curves for nitrogen and phosphorus removal are adjusted based on the littoral zone and MAPS credit selection. These charts also show the efficiency of the designed wet detention system. It should be noted that the initial treatment efficiency achieved is due to settling of particles and therefore will not be achieved if the wet detention system receives water from another BMP, i.e. is downstream of another BMP. For cases where this is true the achieved treatment efficiency is reduced by 30% for nitrogen and 55% for phosphorus. The purpose of this chart is to illustrate to the user that there is a point of diminishing return as the residence time (and permanent pool volume) is substantially increased. This may enable the user to pursue other treatment options such as treatment trains or compensatory treatment.

**Stormwater and Rainwater Harvesting**

Stormwater harvesting is for a mixed land use, while rainwater harvesting is usually used for roof top collection. They are considered cost-effective methods for nonpoint source pollution control, because the water in many cases, can be sold as a profit to offset the cost of maintenance and operation. Stormwater harvesting uses treated stormwater before it is discharged to surface waters, thus reducing the stormwater volume and mass of pollutants discharged (Wanielista et al., 1991). Stormwater harvesting is an option to improve mass removal from a wet detention pond. Floating islands (wetlands) is another option.

In the BMPTRAINS model, water harvesting can be analyzed in the Stormwater Harvesting and Rainwater Harvesting worksheets. The pollution removal of the water harvesting systems is assessed with the Rate-Efficiency-Volume (REV) curves. The REV curves were developed by long term mass balance simulations of harvesting ponds. Curves reflecting several efficiencies track the appropriate combinations of reuse rates and reuse storage volumes (Wanielista et al., 1991).

The user may use Stormwater (Figure 20) and Rainwater Harvesting worksheets to size the system for the desired harvest efficiency or harvest rate. The Stormwater Harvesting worksheet is more appropriate for watersheds that consist of pervious and impervious areas. As such, the user must indicate the representative Runoff Coefficient of the analyzed watershed. The Rainwater Harvesting worksheet is appropriate for watersheds which consist entirely of
impervious areas (roof, pavement, etc.). This worksheet has built in selections of different types of impervious areas based on which the appropriate Runoff Coefficient is utilized in the calculations. The Runoff Coefficient values for the impervious surface selections were obtained from the study conducted by Wanielista et al. entitled “Evaluating Runoff and Abstraction from Impervious Surfaces as Components Affecting Recharge”, 2011. Additional required inputs include indication of the watershed area contributing to the harvesting system and area available for irrigation.

The user has two calculation options available. In the first option, analysis is performed to solve for the harvest rate. This option involves indication of the available harvest volume and the desired harvest efficiency. The second option allows solving for harvest efficiency. With this selection, the user must indicate the provided harvest volume and harvest rate.

**Error message window for the Stormwater Harvesting worksheet.**

**Input and output for the Stormwater Harvesting worksheet.**

**Rate-Efficiency-Volume Curves for the used for the sizing of the stormwater or rainwater harvesting systems.**

**Figure 20 - Stormwater Harvesting worksheet.**
Stormwater and Rainwater Harvesting display appropriate REV charts based on the meteorological zone selection specified by the user. As with the other BMP options, these charts show the designed system efficiency based on the user specified input. The worksheet also contains an error message window alerting the user of possible errors with their analysis.

**Floating Islands (wetlands)**

Floating islands are a combination of plants floating on platform in a wet detention pond. The wetland is used to reduce nitrogen and phosphorus concentrations (Wanielista, et al., 2012) and thus the mass of nitrogen and phosphorus are reduced in the discharge. The wet detention pond has to be designed according to the specifications listed above. Usually a credit of 10% is given for mass reduction. In rare cases, other higher values are achieved when the wet detention pond is receiving pond bottom material due to internal recycling, or is receiving runoff waters that are much higher is nitrogen and phosphorus concentration, such as from some agricultural operations or in watersheds with excessive drainage from reclaimed water irrigation. The usual design calls for a pond with no more than 10% of the area covered with plants and some of the plants have to be replaced at least once every year (Chang, et al., 2012). There is a separate worksheet for input data related to wet detention pond design and floating island credit, all on the same worksheet.

**Filtration Including Biofiltration**

Filtration including Biofiltration ponds can be another BMP option for areas where soil conditions do not allow for a successful design of percolations systems. Filtration including biofiltration systems are intended to both control the water table elevation over the entire area of the treatment basin, and provide for the drawdown of the treatment volume (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010).

The filtration including biofiltration systems in the BMPTRAINS model are sized with the help of the retention efficiency tables. However, the retention efficiency tables are only utilized to assess the hydraulic annual average capture efficiency of the filtration pond. The hydraulic capture efficiency of the filtration pond is calculated based on the retention depth
stored in the pond below the weir crest. The calculated hydraulic capture efficiency is then adjusted based on the type of pollution control media mix used in the design. This adjustment quantifies the nutrient removal efficiency of the filtration including biofiltration system.

The input parameters for the Filtration including Biofiltration worksheet (Figure 21) include the specification of annual average hydraulic capture efficiency and the selection of the adsorption media used for pollution control. The specification of hydraulic capture efficiency will calculate the required retention depth and the selection of the adsorption media will yield annual phosphorus and nitrogen removal efficiencies of the system.

The input and output for the Filtration including Biofiltration worksheet (Figure 21) is shown below. The chart illustrates the treatment efficiency of the filtration including biofiltration pond as the function of captured runoff depth. Curves are adjusted per media mix type. Chart also shows the sized system efficiency in relation to the curves.
adsorption media selection. The performance efficiency of the sized system is also shown on each curve.

The worksheet also contains a window displaying additional required treatment efficiencies if the system is not adequate. These values can be used as guidance in sizing of the preceding treatment system. The worksheet also contains an error message window alerting the user about issues with the analysis.

**Greenroof**

A Greenroof is a BMP option which can be utilized in areas where there is a lack of space for typical retention/detention ponds. A greenroof/cistern stormwater treatment system is a vegetated roof followed by storage in a cistern for the filtrate which is reused. A greenroof/cistern system is a retention BMP and its effectiveness is directly related to the annual volume of roof runoff that is captured, retained, and reused (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010).

The greenroof/cistern stormwater treatment system is an option available for analysis in the BMPTRAINDS model. Users can analyze the runoff volume and pollution reduction benefits of the greenroof systems in the Greenroof worksheet (Figure 22). The effectiveness of the greenroof/cistern system in the model is assessed with the greenroof harvesting efficiency charts presented by Hardin in 2006. This research showed that a specifically designed greenroof stormwater treatment system with a cistern is an effective way to reduce both the volume of and mass of pollutants in stormwater runoff (Hardin, 2006). The design graphs have been developed for several locations in the State of Florida.
To analyze a greenroof/cistern stormwater treatment system in the BMPTRAINS model, the user must select the closest rainfall station to the project site. In addition, the user must indicate the area of the greenroof and retention depth over the greenroof area provided by the associated cistern. If the design does not include a cistern, the area and retention depth inputs do not need to be specified. The result of the calculations is the runoff volume reduction efficiency of the system and required cistern volume (if retention depth is indicated).

Additional features of the Greenroof worksheet include typical greenroof cross-sections and the greenroof/cistern volume reduction efficiency chart. The analyzed greenroof system efficiency is displayed on the chart. The worksheet also contains a window with remaining treatment efficiency values for undersized greenroof systems.
Vegetated Natural Buffer and Vegetated Filter Strip

Vegetated natural buffers (VNBs) are defined as areas with vegetation suitable for nutrient uptake and soil stabilization that are set aside between developed areas and a receiving water or wetland for stormwater treatment purposes (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010).

VNBs as stormwater BMPs can be valuable in areas where construction of ponds, swales, exfiltration trenches or other systems can be difficult or impossible due to site constraints. VNBs could also be a valuable part of a BMP treatment train for road projects and other development.

In the BMPTRAINS model, VNBs can be analyzed in the Vegetated Natural Buffer (Figure 23) and Vegetated Filter Strips (VFS) worksheets. VNBs and VFSs can be analyzed as retention or detention systems. The difference between VNBs and VFSs is that the VNB design contains natural soil while VFSs contain augmented soil (pollution control media).
VNBs and VFSs are analyzed differently in the BMPTRAINS model for the nutrient load removal efficiency. Therefore, it is important for the user to recognize which option most accurately reflects the designed system. In the retention option, the nutrient load reduction performance is evaluated based on the retention efficiency tables. This is appropriate for a system in which runoff percolates into the groundwater table. In the detention option, the efficiency of the VNB or VFS is analyzed based on the seepage flow removal efficiency. This option is appropriate for VNB or VFS systems where runoff is drained by underdrain collector systems (or other equivalent system). In addition, in all cases efficiency is adjusted for the overland flow effects.

The input parameters for the VNB and VFS BMP worksheets include the buffer (filter strip) width, length, and storage depth, storage capacity of the soil/media within the system and...
width of the area feeding the system. The user must also indicate whether the analyzed BMP is a retention or detention system. In addition, the VFS worksheet requires a type of media mix if the detention system option is selected.

The VNB and VFS worksheets are also equipped with treatment efficiency chart. This chart contains curves which show the treatment efficiency of the VNB (VFS) as the function of system width. In addition, since the width of the contributing area affects the performance of the system, each chart contains five separate curves which are plotted based on the different width ratios of the system to the contributing area. The chart displays system efficiency based on the specified input.

Swale

Swales transport and infiltrate stormwater while encouraging accumulation within an area during storm events. The water is held for a few hours or days with infiltration into the soil. Swales are online retention systems and their treatment effectiveness is directly related to the amount of the annual stormwater volume that is infiltrated (Draft Statewide Stormwater Treatment Rule Development, FDEP 2010).

The BMPTRAINS model contains a worksheet (Figure 24) which can analyze the runoff volume reduction efficiency of swales. The calculation of runoff volume reduction efficiency, and associated nutrient load, is based on the annual runoff volume of stormwater that is retained in the swale and not discharged downstream. Unlike with other retention based worksheets, the annual runoff volume of stormwater that is not discharged downstream includes the runoff volume infiltrated due to flow in the swale and runoff volume retained due to a ditch or swale block. The calculated infiltration in swale is based on the equations presented by Wanielista and Yousef (1993) in the “Stormwater Management” publication. The combined retained and infiltrated runoff depth is used to calculate the efficiency of the swale with the application of Harper’s retention efficiency tables.
The required input information in the Swale worksheet includes the width of the swale, width of the watershed contributing to the swale, length of the swale, length of the watershed contributing to the swale, swale dimensions and soil properties. The combined area of the swale and area contributing to the swale must be equivalent to the post-development watershed area from the Watershed Characteristics tab. The worksheet output includes infiltration depth, retention depth, and associated runoff reduction efficiency.

The additional features of the Swale worksheet include swale diagram and runoff volume reduction efficiency chart. Just like in other BMP worksheets, the efficiency of the sized swale is shown on the chart. In addition, the worksheet contains an error message window communicating possible errors with the analysis to the user. The worksheet also contains a
window with calculated remaining treatment efficiency values for swales which are not sufficient to provide entire required treatment.

Rain (Bio) Garden

Rain gardens provide a combination of landscape esthetics and water quality treatment functionality. A rain garden is a retention or detention area which takes advantage of stormwater runoff in its design and plant selection. Usually, it is a small garden which is designed to withstand the extremes of moisture and concentrations of nutrients, particularly Nitrogen and Phosphorus, which are found in stormwater runoff (Low Impact Development Center, 2007).

In the BMPTRAINS model rain gardens can be analyzed as retention or detention systems. Retention rain gardens are systems where the entire retention depth is infiltrated into the groundwater table. In the model, these types of systems are analyzed just like other types of retention systems. The nutrient reduction efficiency of the system depends on the provided retention depth.

The detention rain garden systems are treated in the model just like the filtration including biofiltration ponds. First, the hydraulic capture efficiency of the rain garden is calculated based on the retention depth stored. The calculated hydraulic capture efficiency is then adjusted based on the type of media mix used in the design. This adjustment quantifies the nutrient removal efficiency of the detention rain garden system.

The input parameters for the Rain Garden worksheet (Figure 25) include the retention depth provided by the system and selection of whether the analyzed garden is a retention or detention system. The indicated retention depth is used to calculate the hydraulic capture efficiency. If the detention option is selected, in addition to the retention depth, the user must select the adsorption media used for a media mix. Based on the media mix selection, the model will calculate the annual phosphorus and nitrogen removal efficiencies of the system.
In addition to the calculated nutrient removal efficiencies, the Rain Garden worksheet includes a treatment efficiency chart with an error message window and calculated remaining treatment efficiencies.

Tree Well

Tree Wells provide a combination of landscape esthetics and water quality treatment functionality. Tree wells are depression areas with media mixes that support vegetation. The typical vegetation used is a tree. During a rain event, runoff water is directed to and across the top of the tree well area and resulting in storage of runoff water in a depth below the tree well area. The soil is a media mix that supports vegetation growth and provides storage of the runoff water (determined based on the media’s porosity). The storage volume is, in general, relatively
small for each tree well, but when many tree wells are used for one catchment, the storage can be significant. In many cases, the addition of trees adds to the beauty of the landscape as well as provide for runoff storage. In dense urban areas, a grate is frequently used to eliminate trip hazards (equal the elevation of the surface pathways) or a "filler" mix of rock/mulch/or rubber chips may be used.

In the BMPTRAINS model tree wells can be analyzed as retention or detention systems. Retention tree wells are systems where the entire retention depth is infiltrated into the groundwater table. In the model, these types of systems are analyzed just like other types of retention systems. The nutrient reduction efficiency of the system depends on the provided retention depth.

The detention tree well systems are treated in the model similar to the filtration including with biofiltration areas, such as a rain garden. First, the hydraulic capture efficiency of the tree well is calculated based on the retention depth stored. The detained water discharge elevation is usually above an elevation where back water will not affect the rate of discharge. If the rate of discharge is affected by the downstream surface water (like flood water in a sewer adjacent to a tree well), then the storage within the tree well will have to be reduced. The calculated hydraulic capture efficiency is then adjusted based on the type of media mix used in the design. This adjustment quantifies the nutrient removal efficiency of the detention tree well system.

The input parameters required to estimate the storage for tree wells is the volume of the media mix, the volume of the "filler" mix with sustainable porosity and the clear volume above the mixes (Figure 26). The porosity of the media mix is usually around 0.16 to 0.25. For most designs, there is a volume of clear storage above the media and "filler" mix and an elevation equal to a paved surface (or other discharge device) elevation when no more water will enter into the tree well. When this clear storage is filled, runoff water will be diverted to a downstream area. That downstream area is frequently referred to as a flood control structure. The indicated retention depth is used to calculate the hydraulic capture efficiency. If the detention option is selected, in addition to the retention depth, the user must select the adsorption media used for a media mix. Based on the media mix selection, the model will calculate the annual phosphorus and nitrogen removal efficiencies of the system.
In addition to the calculated nutrient removal efficiencies, the Tree Well worksheet includes a treatment efficiency chart and calculated remaining treatment efficiencies.

**Lined Reuse Pond with Underdrain Input**

Lined reuse pond with underdrain input is a reuse BMP for the special condition of an irrigated area with an underdrain which drains to a lined pond. The intention is for the grass or other vegetation as well as microbes in the soil matrix to remove pollutants and get rid of water via evapotranspiration. During a rain event, runoff water is directed to the lined pond where it is stored to meet future irrigation needs, excess water is discharged as overflow. The irrigated area can be any number of vegetated areas that have underdrains such as sports fields. This BMP is particularly useful for vegetated areas that are fertilized as nutrient rich runoff waters are
collected are reused for irrigation. This has the additional benefit of potentially reducing fertilization demands which can result in a cost savings.

In the BMPTRAINS model the lined reuse pond with underdrain input BMP is analyzed as a reuse system. Lined reuse ponds with underdrain inputs are systems where runoff water is stored for irrigation with excess water being discharged as overflow. In the model, these types of systems are analyzed just like the green roof BMP. The nutrient reduction efficiency of the system depends on the size of the lined reuse pond and the size of the irrigation area it serves.

The input parameters required to estimate the efficiency for lined reuse ponds with underdrain inputs is the drainage and irrigation area, the retention provided, the irrigation demand, and the rainfall excess (Figure 27).

**Figure 27 – Lined Reuse Pond with Underdrain Input worksheet.**
In addition to the calculated nutrient removal efficiencies, the Lined Reuse Pond with Underdrain Input worksheet includes a treatment efficiency chart and calculated remaining treatment efficiencies.

**User Defined BMPs**

There are additional BMPs that are only partly documented in terms of average yearly effectiveness and/or standards for operation and maintenance are not complete or well defined. At the time of this publication, it is recognized that for application in certain watersheds, such BMPs are not in general permitted for use. Nevertheless the model input allows for inclusion of these. Examples are chemical treatment using polymers, alum or other salts; pre-treatment using baffle box designs, street sweeping, and specialty designs using propriety equipment. It could be possible that some agencies granting permits will encourage the use these nontraditional BMPs and for that reason, this option within the BMPTRAINS model allows for inclusion. Some of the input parameters and the output expected are shown below in Figure 28, Figure 29, and Figure 30.

![Figure 28 - User Defined BMP worksheet for Street Sweeping](image-url)
It should be noted that any BMP used in the User Defined BMP worksheet MUST have an adequate description and all relevant test data to support performance.
Catchment and Treatment Summary Results

Once all the general site conditions, watershed characteristics, and BMP details have been entered, the user can view a summary of the results by selecting the *Catchment and Treatment Summary Results* button on the *Stormwater Treatment Analysis* worksheet (Figure 15). The *Catchment and Treatment Summary Results* worksheet (Figure 31) shows the BMPs used in each catchment, the selected catchment configuration, the N and P mass loadings for the pre and post development conditions, the target N and P efficiencies, the target N and P mass loading, the provided N and P efficiencies, and the achieved N and P mass loads. All of the information presented on this worksheet is carried over from other worksheets within the model. This worksheet is intended to allow the user to see the effect of the overall treatment specified by the user.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment 1:</td>
<td>BMP1</td>
<td>Retention Basin</td>
</tr>
<tr>
<td>Catchment 2:</td>
<td>BMP2</td>
<td></td>
</tr>
<tr>
<td>Catchment 3:</td>
<td>BMP3</td>
<td></td>
</tr>
<tr>
<td>Catchment 4:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary Performance**

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>A - Single Catchment</th>
<th>1/24/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment Nitrogen Pre Load</td>
<td>8.75</td>
<td></td>
</tr>
<tr>
<td>Catchment Phosphorus Pre Load</td>
<td>1.55</td>
<td></td>
</tr>
<tr>
<td>Catchment Nitrogen Post Load</td>
<td>21.43</td>
<td></td>
</tr>
<tr>
<td>Catchment Phosphorus Post Load</td>
<td>2.87</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>4.29</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>4.29 &amp; 9.44</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>0.57 &amp; 1.27</td>
<td></td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>17.14 &amp; 37.75</td>
<td></td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>2.30 &amp; 5.06</td>
<td></td>
</tr>
</tbody>
</table>

Figure 31 - Multiple Catchments and Treatment Systems Analysis worksheet
Example Problems

The example problems are developed to offer the user a step by step entry procedure using actual screen captures.

Introduction

Upon opening the BMPTRAINS model some users may encounter the security warning in the upper left corner of the Microsoft Excel window (Figure 32). This message indicates that some content of the model has been disabled. This is a typical warning message for users whose Excel security settings are disabling all macros within the spreadsheet. In order to navigate through the model, as well as to perform certain calculations, the user must enable all macros upon opening of the document. This process will have to be repeated every time the model is opened until the user’s security settings are changed permanently.

Figure 32 - Introduction Page worksheet.
The model is ready for use when all macro content is enabled. However, prior to the use of the model, the user is strongly encouraged to familiarize themselves with some basic model features, capabilities and limitations.

Key instructions for navigation, viewing and printing the model results are displayed in the Introduction Page worksheet under the help buttons (Figure 33).

![Figure 33 - Introduction Page worksheet.](image)

It should be noted that the navigation between different worksheets is only available via the use of gray macro buttons. The user should become comfortable using these buttons as this is the only way one can navigate through the model since the individual worksheet tabs are not displayed. However, this should not be difficult since the buttons are clearly labeled with the worksheet destinations.

Another important message displayed in the Introduction Page worksheet is related to the printing of the input and output. All worksheets which require an input of information or provide calculated results are formatted to print only the necessary information. However, due to differences in printer resolutions, the user may still need to adjust the print settings for optimum printing results. Another way to get around the printing issue is to use Microsoft Office Image
Writer, Microsoft XPS Office Document Writer, Adobe PDF, or another default software to print the information to document (Figure 34).

Figure 34 - Introduction Page worksheet.

Once the user becomes familiar with all of the important information on the Introduction Page, please proceed to the General Site Information page (Figure 35) by selecting the Click Here to Start button. This is the first worksheet which requires the user to specify information if they desire to begin the BMP nutrient removal efficiency analysis. Therefore, it is important to recognize which cells represent the information input and which cells represent the calculated output. All input cells are characterized by a grey background and blue font. All output cells are characterized by a white background and red font. This arrangement is shown in the upper right corner of each worksheet that requires input (Figure 35).

Figure 35 - General Site Information worksheet.
Another feature permits the user to enter the name of the project on the general site information sheet. This name will carry on to a print out on the multiple watersheds and treatment analysis sheet. There is also an opportunity on the multiple watershed and treatment systems sheet to enter a description for an optional treatment system analyzed. The input area on the general site information sheet to enter the project name is shown in Figure 36.

![Figure 36 - Name of Project Input](image)

The General Site Information worksheet also contains two maps which are provided to aid the user with the appropriate input selection in this worksheet (Figure 37).

![Figure 37 - General Site Information worksheet](image)

The first map is the meteorological zone map (Figure 38). This map can help the user to select the appropriate meteorological zone applicable of the location to the project site. Appropriate selection of the meteorological zone is necessary to ensure that the model is using the correct coefficients in the calculations.
Figure 38 - Meteorological Zone Map Description
The second map is the mean annual rainfall map (Figure 39). This map allows the user to find the annual rainfall amount applicable to the project site location. Appropriate selection of the mean annual rainfall amount is necessary to ensure that calculated annual runoff volumes most accurately represent the existing and proposed conditions.

Figure 39 - Mean Annual Rainfall Map worksheet.
Example problem # 1 - swale - specified removal efficiency of 80%

A 0.1 acre retention swale is serving a 1.1-acre highway project. The site is located in Liberty County, Southwest of Tallahassee, FL area on Hydrologic Soil Group D. The existing land use condition is assumed to be agricultural-pasture with a non-DCIA Curve Number of 80 and 0.0% DCIA. The post-development land use condition is highway with a non-DCIA Curve Number of 85 and 50% DCIA. Does the swale provide treatment sufficient enough to reduce the annual nutrient loading by 80.0%? The swale dimensions are shown in Figure 43. Assume that additional concentration reduction is achieved because of the very low longitudinal slope.

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 40).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Specified Removal Efficiency option from the type of analysis drop down menu in the General Site Information worksheet.
   e. Specify the desired removal efficiency.
2. Select the Go To Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 41).
   
a. Select a catchment configuration from the drop down menu; for diagrams of the different catchment configurations available, click the View Catchment Configuration button to proceed to the Catchment Configuration worksheet. Go back to the Watershed Characteristics worksheet by selecting the Go to Watershed Characteristics button (Figure 41).

3. From the Watershed Characteristics worksheet:
   
a. Select the single catchment option from the drop down menu.
b. Indicate the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.

<table>
<thead>
<tr>
<th>WATERSHED CHARACTERISTICS V6.0</th>
<th>GO TO STORMWATER TREATMENT ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SELECT CATCHMENT CONFIGURATION</strong></td>
<td><strong>CLICK ON CELL BELOW TO SELECT CONFIGURATION</strong></td>
</tr>
<tr>
<td><strong>A - Single Catchment</strong></td>
<td><strong>CLICK ON CELL BELOW TO SELECT CONFIGURATION</strong></td>
</tr>
<tr>
<td><strong>CATCHMENT NO.1 CHARACTERISTICS:</strong></td>
<td><strong>CLICK ON CELL BELOW TO SELECT CONFIGURATION</strong></td>
</tr>
<tr>
<td><strong>Pre-development land use:</strong></td>
<td><strong>CLICK ON CELL BELOW TO SELECT CONFIGURATION</strong></td>
</tr>
<tr>
<td>with default EMCs</td>
<td><strong>Land use</strong></td>
</tr>
<tr>
<td><strong>Post-development land use:</strong></td>
<td><strong>CLICK ON CELL BELOW TO SELECT CONFIGURATION</strong></td>
</tr>
<tr>
<td>with default EMCs</td>
<td><strong>Highway: TN=1.640 TP=0.220</strong></td>
</tr>
<tr>
<td><strong>Total pre-development catchment area:</strong></td>
<td>1.10 AC</td>
</tr>
<tr>
<td><strong>Total post-development catchment or BMP analysis area:</strong></td>
<td>1.10 AC</td>
</tr>
<tr>
<td><strong>Pre-development Non DCIA CN:</strong></td>
<td>80.00</td>
</tr>
<tr>
<td><strong>Pre-development DCIA percentage:</strong></td>
<td>0.00 %</td>
</tr>
<tr>
<td><strong>Post-development Non DCIA CN:</strong></td>
<td>85.00</td>
</tr>
<tr>
<td><strong>Post-development DCIA percentage:</strong></td>
<td>50.00 %</td>
</tr>
<tr>
<td><strong>Estimated Area of BMP (used for rainfall excess not loadings):</strong></td>
<td>0.10 AC</td>
</tr>
</tbody>
</table>

Figure 42 - Watershed Characteristics worksheet.

4. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.
   a. Select the Swale button to proceed to the Swale worksheet (Figure 43).

5. Specify the required input in the Swale worksheet as shown in Figure 43.

6. The example problem specifies additional concentration reduction, so select yes in the cell P6.
**Figure 43 - Swale worksheet.**

### SWALE Worksheet

<table>
<thead>
<tr>
<th>Contributing Catchment Area:</th>
<th>Catchment 1</th>
<th>Catchment 2</th>
<th>Catchment 3</th>
<th>Catchment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required treatment efficiency (Nitrogen):</td>
<td>80.000</td>
<td>80.000</td>
<td>80.000</td>
<td>80.000</td>
</tr>
<tr>
<td>Swale top width calculated for flood conditions (W):</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Swale bottom width (0 for triangular section) (B):</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Swale length (L):</td>
<td>871.00</td>
<td>871.00</td>
<td>871.00</td>
<td>871.00</td>
</tr>
<tr>
<td>Average impervious length:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average impervious width (including shoulder):</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
</tr>
<tr>
<td>Contributing catchment area:</td>
<td>1,000</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### GO TO STORMWATER TREATMENT ANALYSIS

- **Concentration reduction? (If S ≤ 1% or H ≥ 6 in)**
  - Nitrogen efficiency: 73.323%
  - Phosphorus efficiency: 80.000%

- **Provided percent mass reductions in surface discharges are:**
  - Nitrogen efficiency: 73.323%
  - Phosphorus efficiency: 80.000%

### Treatment Efficiency Graph:

The purpose of this graph is to help illustrate the treatment efficiency of the swale as a function of retention depth. The graph illustrates that there is diminishing effectiveness as the retention depth is increased.

### Example Problem 1

- **Input data:**
  - Contributing catchment area: 43550.00 ft²
  - Swale slope (ft drop/ft length) (S): 0.001
  - Manning's N: 0.050
  - Side slope of swale (horizontal ft/vertical ft) (Z): 5.000
  - Infiltrated storage depth: 0.811 in
  - Length of the berm upstream of the crest (LB): 0.000
  - Total volume: 0.811 in

- **Data:**
  - Provided treatment efficiency (Nitrogen): 61.890%
  - Provided treatment efficiency (Phosphorus): 61.890%
7. Select the *Go to Stormwater Treatment Analysis Button* to go to the *Stormwater Treatment Analysis* worksheet and proceed to the *Catchment and Treatment Summary Results* worksheet by clicking the *Catchment and Treatment Summary Results* button (see Figure 44 for details).

8. To increase the removal efficiency, try modifying the swale, for example change the shape from triangular to trapezoidal.
Example problem # 2 - retention basin - pre vs. post-development loading

A 1 acre retention basin is serving an 11.0-acre residential subdivision. The site is located in Tampa, FL on Hydrologic Soil Group A. The existing land use condition is assumed to be agricultural-pasture with a non-DCIA Curve Number (CN) of 50 and 0.0% DCIA. The post-development land use condition is a residential subdivision with a non-DCIA Curve Number of 65 and 25% DCIA. The retention basin is to provide treatment sufficient enough to match the pre-development annual nutrient loads with the existing condition.

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 45).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Net Improvement option from the type of analysis drop down menu in the General Site Information worksheet.
2. Click on the Go To Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 46).

   a. Select single catchment from the drop down menu and indicate the pre- and post-development conditions.

   Select the pre and post development Watershed Characteristics worksheet.

Figure 45 - General Site Information worksheet.

Figure 46 - Watershed Characteristics worksheet.
3. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Retention Basin* button to proceed to the *Retention Basin* worksheet (Figure 47).
   a. The Retention Basin worksheet shows the retention depth required to meet the required efficiency or the user can enter a different depth in the cell “Provided Retention Depth”

5. The user can now view a summary of the treatment achieved for the specified site conditions and BMP used by selecting the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet, and then selecting the *Catchment and*
Treatment Summary Results button to go to the Catchment and Treatment Summary Results worksheet (Figure 48).

**CATCHMENTS AND TREATMENT SUMMARY RESULTS**

CALCULATION METHODS:
1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used,
an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example Problem 2</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP1</td>
<td>Catchment 1:</td>
<td>Retention Basin</td>
</tr>
<tr>
<td></td>
<td>Catchment 2:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catchment 3:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catchment 4:</td>
<td></td>
</tr>
</tbody>
</table>

**Summary Performance**

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>A - Single Catchment</th>
<th>1/24/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment Nitrogen Pre Load</td>
<td>4.32</td>
<td></td>
</tr>
<tr>
<td>Catchment Phosphorus Pre Load</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Catchment Nitrogen Post Load</td>
<td>26.17</td>
<td></td>
</tr>
<tr>
<td>Catchment Phosphorus Post Load</td>
<td>4.13</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>4.32</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>4.32</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>21.85</td>
<td>48.13</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>3.45</td>
<td>7.60</td>
</tr>
</tbody>
</table>

The overall removal efficiency and mass removal is shown.
Example problem # 3 - retention basin - specified removal efficiency of 75%

A 1 acre retention basin is serving an 11.0-acre residential subdivision. The site is located in Tampa, FL on Hydrologic Group Soil A. The existing land use condition is assumed to be agricultural-pasture with a non-DCIA Curve Number of 50 and 0.0% DCIA. The post-development land use condition is a residential subdivision with a non-DCIA Curve Number of 65 and 25% DCIA. The retention basin is to provide treatment sufficient enough to provide 75% reduction of the post-development annual nutrient loads.

1. From the introduction page click on the *Click Here to Start* button to proceed to the **General Site Information** worksheet.
   a. Select the *Reset Input for Stormwater Treatment Analysis* button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the **General Site Information** worksheet (Figure 49).
   c. Indicate the mean annual rainfall amount in the **General Site Information** worksheet
   d. Select the *Specified Removal Efficiency* option from the type of analysis drop down menu in the **General Site Information** worksheet.
   e. Specify the desired removal efficiency.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 50).
   a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.

3. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.
4. Select the **Retention Basin** button to proceed to the **Retention Basin** worksheet (Figure 51).
   
a. The Retention Basin worksheet shows the retention depth required to meet the required efficiency or the user can enter in a different depth in the cell labeled “Provided Retention Depth”
5. The user can now view a summary of the treatment achieved for the specified site conditions and BMP used by selecting the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet, and then selecting the Catchment and Treatment Summary Results button to go to the Catchment and Treatment Summary Results worksheet (Figure 52).
CATCHMENTS AND TREATMENT SUMMARY RESULTS

CALCULATION METHODS:
1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

PROJECT TITLE  
Example Problem 3  
Optional Identification

<table>
<thead>
<tr>
<th>Configuration</th>
<th>A - Single Catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP1</td>
<td>Catchment 1: Retention Basin</td>
</tr>
<tr>
<td>BMP2</td>
<td>Catchment 2:</td>
</tr>
<tr>
<td>BMP3</td>
<td>Catchment 3:</td>
</tr>
<tr>
<td>BMP4</td>
<td>Catchment 4:</td>
</tr>
</tbody>
</table>

Summary Performance

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>A - Single Catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment Nitrogen Pre Load</td>
<td>4.32</td>
</tr>
<tr>
<td>Catchment Phosphorus Pre Load</td>
<td>0.77</td>
</tr>
<tr>
<td>Catchment Nitrogen Post Load</td>
<td>26.17</td>
</tr>
<tr>
<td>Catchment Phosphorus Post Load</td>
<td>4.13</td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>75</td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>75</td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>6.54</td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>1.03</td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%)</td>
<td>75</td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%)</td>
<td>75</td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr)</td>
<td>6.54</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr)</td>
<td>1.03</td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr)</td>
<td>19.63</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr)</td>
<td>3.10</td>
</tr>
</tbody>
</table>

Figure 52 - Summary Input & Output worksheet
Example problem # 4 - wet detention - pre vs. post-development loading with harvesting

A half-acre wet detention pond is serving a 5.5-acre highway expansion from one lane in each direction to two lanes in each direction. The existing portion of highway is not served by any treatment system. The existing and proposed portion of the highway will be treated in the post-development condition. The site is located in West Palm Beach, FL on Hydrologic Soil Group D. The existing land use condition is assumed to be a highway with a non-DCIA Curve Number of 80 and 40% DCIA. The post-development land use condition is assumed to be a highway with a non-DCIA Curve Number of 80 and 85% DCIA. This will be a net improvement problem using a wet detention pond which will utilize a littoral zone (assumed 10% removal efficiency credit) in the design. An average annual residence time of 50 days was calculated for the pond.

After net improvement is assessed, if needed add a stormwater harvesting operation to obtain an 80% removal of both nitrogen and phosphorus.

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 53).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet
   d. Select the Net Improvement option from the type of analysis drop down menu in the General Site Information worksheet.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 54).
   a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.

Figure 53 - General Site Information worksheet.

Figure 54 - Watershed Characteristics worksheet.
3. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Wet Detention* button to proceed to the *Wet Detention* worksheet (Figure 55).
   a. Specify the average annual residence time. Also specify whether the littoral zone is used in the design and indicate the efficiency credit associated with it.

5. The user can now view a summary of the treatment achieved for the specified site conditions and BMP used by selecting the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet, and then selecting the *Catchment and Treatment Summary Results* button to go to the *Catchment and Treatment Summary Results* worksheet (Figure 56).
To achieve an 80% efficiency, the wet detention pond can be operated as a stormwater reuse pond. This is possible because there is a need for irrigation water adjacent to the highway. The irrigation water will follow the guidelines of the Water Management Districts and use an average of 0.86 inches per week of water over an eight and a half (8.5) acre area. Using the stormwater harvesting BMP option, the capture effectiveness can be calculated. The only change in the meteorological and catchment input data shown in Figure 53 and Figure 54 is that the BMP effectiveness is the type of analysis and not net improvement. If there is any increase in effectiveness by using stormwater harvesting, the increase can be used to satisfy compensatory treatment needs on the other parts of the highway.

The water quality or reuse volume in the wet detention pond is 0.733 Ac-Ft. Using a weighted runoff coefficient of 0.80, the available harvest volume over the EIA is 2 inches \([(12 \text{ in/foot})(0.733 \text{ ac-ft})/(5.5 \text{ ac})(0.80)]\). Selecting the stormwater harvesting BMP, the data are
entered with the option of solving for the harvesting efficiency as shown in Figure 57. The annual capture efficiency is 80.14% of the yearly runoff into the reuse pond. To provide for a continuous source of irrigation water, other supplemental water is needed (4.481 MG/Y). The pond reduces the need for irrigation water from other sources by supplying 5.841 MG/Y of the total 10.321 MG/Y [(0.86 in/week)/(8.5 ac)(1 foot/12 inches)(52 weeks/year)(0.3258)]. Also in Figure 57 is the REV curve for the watershed conditions of this problem in Zone 5 showing how changes in the water quality or runoff volume (X axis) and reuse rate (Y axis) can affect the average annual capture effectiveness for the reuse pond.

Figure 57 - Reuse or Harvesting Pond Calculation Worksheet

To calculate the pollutant removal effectiveness, the detention pond mass removal effectiveness is added as if the reuse and wet pond were in series (actually they are one in the same). The average residence time in the pond is at 50 days, which is higher than usual. With reuse, the residence time will increase as water is removed for irrigation rather than being discharged from the wet detention pond. Note however that the efficiency does not increase significantly beyond 50 days of residence time, and thus the residence time is not changed when adding the wet pond efficiency to the capture efficiency of the reuse pond. What has to be changed is the configuration from a single BMP to two in series. There are now 2 BMPS
(namely reuse and wet detention) in series. The results in the summary worksheet are shown in Figure 58.

**CATCHMENTS AND TREATMENT SUMMARY RESULTS**

**CALCULATION METHODS:**
1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example Problem 4</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment 1:</td>
<td></td>
<td>Catchment 2:</td>
</tr>
<tr>
<td>Wet Detention</td>
<td></td>
<td>Catchment 3:</td>
</tr>
<tr>
<td>Stormwater</td>
<td></td>
<td>Catchment 4:</td>
</tr>
<tr>
<td>Harvesting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary Performance of Entire Watershed**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>A - Single Catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Pre Load (kg/yr)</td>
<td>23.58</td>
</tr>
<tr>
<td>Phosphorus Pre Load (kg/yr)</td>
<td>3.16</td>
</tr>
<tr>
<td>Nitrogen Post Load (kg/yr)</td>
<td>36.50</td>
</tr>
<tr>
<td>Phosphorus Post Load (kg/yr)</td>
<td>4.90</td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>35</td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>35</td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>23.58</td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>3.16</td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>89</td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>94</td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>3.90</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>0.28</td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>32.60</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>4.62</td>
</tr>
</tbody>
</table>

**Figure 58 - Summary Input and Output Worksheet for Two BMPs in Series**

Note the overall average nitrogen annual efficiency in series using stormwater reuse with a wet detention pond increased from 46 to 89%. The average annual phosphorus efficiency increased from 71 to 94%. By example, the calculations show that a reuse pond designed consistently with wet detention pond pollution control criteria can usually meet an 80% efficiency target or provide compensatory value, or net improvement type of analysis.
Example problem # 5 - wet detention after and in series with retention system (retention basin, exfiltration trench, swales, retention tree wells, pervious pavement, etc.)

A half-acre wet detention pond preceded by a half-acre of retention pre-treatment is serving a new highway. The 6 acre watershed is located in West Palm Beach, FL on Hydrologic Soil Group D. The existing land use condition is assumed to be Wet Flatwoods with a non-DCIA Curve Number of 80 and 0% DCIA. The post-development land use condition is assumed to be highway where the non-DCIA Curve Number is 80 and DCIA is 60%. The target removal efficiency for both nitrogen and phosphorus is 80%. The wet detention pond is used for flood control with a 100 day annual average residence time. The wet detention pond also will utilize a littoral zone (assumed 10% removal efficiency credit) in the design.

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 59).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet
   d. Select the Specified Removal Efficiency option from the type of analysis drop down menu in the General Site Information worksheet.
   e. Specify the desired removal efficiency.
2. Select the **Watershed Characteristics** button to proceed to the **Watershed Characteristics** worksheet (Figure 60).

   a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.

   ![Watershed Characteristics worksheet](image)

   **Figure 60 - Watershed Characteristics worksheet.**

   Select the appropriate data in the General Site Information Page worksheet.

   ![General Site Information worksheet](image)

   **Figure 59 - General Site Information worksheet.**
3. Select the *Stormwater Treatment Analysis* button to proceed to the **Stormwater Treatment Analysis** worksheet.

4. Select the *Wet Detention* button to proceed to the **Wet Detention** worksheet (Figure 61).
   a. Specify the average annual residence time. Also specify whether the littoral zone is used in the design and indicate the efficiency credit associated with it.
   b. Make note of the remaining treatment efficiency needed as this value will be needed to determine the required retention storage (Figure 61). In this case 61.74% for Nitrogen and 14.56% for Phosphorus. Since Nitrogen requires more additional treatment, this value will set the retention storage.
**Figure 61 - Wet Detention worksheet.**

<table>
<thead>
<tr>
<th>Wet Detention Worksheet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catchment</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

**Output for the wet detention system indicates how much additional treatment efficiency is needed for each parameter. Use as guidance in sizing of another BMP system.**

5. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

6. Select the Retention Basin button to proceed to the Retention Basin worksheet (Figure 62).
   a. Indicate the retention depth to be provided upstream of the wet detention system in the second part of the Retention Basin worksheet. This is an iterative process and the retention depth needs to be adjusted until the provided treatment efficiency of the retention basin matches the remaining treatment efficiency value from the wet detention pond.

   **Figure 62 - Retention Basin worksheet.**

7. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

8. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 63).
Figure 63 – Catchment and Treatment Summary Results worksheet.

Note: Achieved effectiveness did not meet treatment goal. This is due to the fact that most of the treatment provided by wet detention is from settling. Since this model treats all detention systems as downstream from retention systems, settling has already occurred by the time the water reaches the detention system. Therefore, for this case, the achieved treatment by the detention BMP is less for nitrogen and phosphorus when detention is used with retention.
**Example problem # 6 - retention systems in series - pre vs. post-development loading**

A half-acre exfiltration trench in series with a half-acre retention basin is serving a 6.0-acre low-intensity commercial site. The site will contain 10 tree wells along the roads. The tree wells are to be 3 feet deep with a 6 inch depth above soil column. The length and width of the tree wells are to be 4 feet for each. A 0.2 sustainable water storage capacity of the soil is to be used. The tree wells are to be treated as retention systems. The site is located in Orlando, FL on Hydrologic Soil Group C. The existing land use condition is assumed to be undeveloped-dry prairie with a non-DCIA Curve Number of 79 and 0.0% DCIA. The post-development land use condition is a low intensity commercial area with a non-DCIA Curve Number of 85 and 65% DCIA. The combination of treatment systems is to provide treatment sufficient enough to match the post-development annual nutrient loads with the pre-development annual nutrient loads.

1. From the introduction page click on the *Click Here to Start* button to proceed to the **General Site Information** worksheet.
   a. Select the *Reset Input for Stormwater Treatment Analysis* button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the **General Site Information** worksheet (Figure 64).
   c. Indicate the mean annual rainfall amount in the **General Site Information** worksheet.
   d. Select the *Net Improvement* option from the type of analysis drop down menu in the **General Site Information** worksheet.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 65).

   a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.

Figure 65 - Watershed Characteristics worksheet.
3. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Vegetated Area Example Tree Well* button to proceed to the *Vegetated Area Example Tree Well* worksheet (Figure 66).
   
   a. Fill out the input in the worksheet associated with the dimensions of the tree well and soil properties.
   
   b. Make note of the remaining treatment efficiency required for nitrogen and phosphorus (Figure 67). The remaining treatment efficiency for nitrogen and phosphorus is 63.89% and 86.94%, respectively.

<table>
<thead>
<tr>
<th>VEGETATED AREAS (Example Tree Wells):</th>
<th>V6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contributing catchment area:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Vegetated Areas (tree wells or similar) for:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Catchment 1</strong></td>
<td><strong>Catchment 2</strong></td>
</tr>
<tr>
<td><strong>Required treatment efficiency (Nitrogen):</strong></td>
<td>64.360</td>
</tr>
<tr>
<td><strong>Required treatment efficiency (Phosphorus):</strong></td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Vegetated Area (Tree Well) depth:</strong></td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Vegetated Area (Tree Well) water depth above soil column:</strong></td>
<td>4.50</td>
</tr>
<tr>
<td><strong>Vegetated Area (Tree Well) length:</strong></td>
<td>4.00</td>
</tr>
<tr>
<td><strong>Vegetated Area (Tree Well) width:</strong></td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Sustainable water storage capacity of the soil:</strong></td>
<td>0.010</td>
</tr>
<tr>
<td><strong>Number of similar Areas within watershed:</strong></td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Retention depth for provided hydraulic capture efficiency:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Is this a retention or detention system?</strong></td>
<td>Retention</td>
</tr>
<tr>
<td><strong>Type of soil augmentation:</strong></td>
<td>View Media Mixes</td>
</tr>
<tr>
<td><strong>Provided treatment efficiency (Nitrogen):</strong></td>
<td>1.307</td>
</tr>
<tr>
<td><strong>Provided treatment efficiency (Phosphorus):</strong></td>
<td>1.307</td>
</tr>
<tr>
<td><strong>Is/are the vegetated areas sufficient?</strong></td>
<td>NO</td>
</tr>
</tbody>
</table>

**Figure 66 – Vegetated Areas (Example Tree Well) worksheet.**

** REQUIRED REMAINING TREATMENT EFFICIENCIES OF TREATMENT SYSTEM IN SERIES WITH VEGETATED AREAS. USE FOR SIZING OF TREATMENT SYSTEM IN SERIES WITH VEGETATED AREAS.**

| **Remaining treatment efficiency (Nitrogen):** | 63.888 | 86.937 | |
| **Remaining treatment efficiency (Phosphorus):** | 0.000 | 0.000 | |

**Figure 67 - Required remaining treatment from the Vegetated Areas (Example Tree Well) worksheet**

5. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

6. Select the *Exfiltration Trench* button to proceed to the *Exfiltration Trench* worksheet (Figure 68).
a. Indicate the retention depth provided by the exfiltration trench in worksheet (Note: this is an iterative process).

![Exfiltration Trench Worksheet]

**Figure 68 - Exfiltration Trench worksheet.**

7. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

8. Select the *Retention Basin* button to proceed to the *Retention Basin* worksheet (Figure 69).
   a. Indicate the retention depth to be provided by the retention basin downstream of exfiltration trench.

![Retention Basin Worksheet]

**Figure 69 - Retention Basin worksheet.**

9. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

10. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 70).
**CATCHMENTS AND TREATMENT SUMMARY RESULTS**

**CALCULATION METHODS:**
1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example Problem 6</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment 1:</td>
<td>Retention Basin</td>
<td></td>
</tr>
<tr>
<td>Catchment 2:</td>
<td>Exfiltration Trench</td>
<td></td>
</tr>
<tr>
<td>Catchment 3:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catchment 4:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary Performance**

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>A - Single Catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment Nitrogen Pre Load</td>
<td>6.41</td>
</tr>
<tr>
<td>Catchment Phosphorus Pre Load</td>
<td>0.35</td>
</tr>
<tr>
<td>Catchment Nitrogen Post Load</td>
<td>18.00</td>
</tr>
<tr>
<td>Catchment Phosphorus Post Load</td>
<td>2.73</td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>64</td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>87</td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>6.41</td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>0.35</td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>87</td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>87</td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>2.32</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>0.35</td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>15.67 34.52</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>2.38 5.24</td>
</tr>
</tbody>
</table>

Figure 70 - Multiple Watersheds and Treatment Systems Analysis worksheet.

18. Change the storage of the exfiltration trench and retention basin from their worksheet page until the overall provided efficiency matches the required efficiency.

**Note:** For a single catchment for which cascading (in series) retention systems are used, the total treatment efficiency is calculated based on the sum of individual retention depths rather than the sum of the individual removal efficiencies (see Figure 71).
The combined retention depth between Tree Well, Exfiltration Trench and Retention Basin is 0.010 in + 0.57 in + 1.0 in = 1.58 in. The total treatment efficiency is calculated based on the sum of individual systems retention depths.

Figure 71 - Retention Basin worksheet illustrating retention in series.
Example problem # 7 - wet detention systems in series - pre vs. post-development loading

Two half-acre wet detention ponds in series are serving a 6.0-acre highway expansion from one lane in each direction to two lanes in each direction. The existing portion of highway is not served by any treatment system. The existing and proposed portions of the highway will be treated in the post-development condition. The site is located in Boca Raton, FL on Hydrologic Soil Group D. The existing land use condition is assumed to be a 3.0-acre highway with a non-DCIA Curve Number of 80 and 40% DCIA and 3.0-acre Wet Flatwoods with a non-DCIA Curve Number of 80 and 0% DCIA. The post-development land use condition is assumed to be a highway with a non-DCIA Curve Number of 80 and 80% DCIA. Both wet detention ponds will utilize a littoral zone (assumed 10% removal efficiency credit) and floating wetland islands (assumed 20% removal efficiency credit) in the design. The combined average annual residence time provided between the two wet detention ponds in series is to be 90 days.

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 72).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Net Improvement option from the type of analysis drop down menu in the General Site Information worksheet.
2. Select the *Watershed Characteristics* button to proceed to the *Watershed Characteristics* worksheet
   a. Select the catchment configuration, 2 catchments in series for this problem.
   b. Enter the data for the first and second catchments in the *Watershed Characteristics* worksheet (Figure 73).
   c. Indicate the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.
3. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

4. Select the Floating Islands with Wet Detention button to proceed to the Floating Islands with Wet Detention worksheet (Figure 74).

   a. Specify average annual residence time provided between the two wet detention ponds in series. Note that the permanent pool volume provided between two wet detention ponds in series should be equivalent to the minimum pond permanent pool value provided by results.

   b. Specify that the littoral zone is used in the design and indicate the efficiency credit associated with it using the drop down menus (assumed 10% removal efficiency credit).

   c. Specify that the floating islands are used in the design and indicate the efficiency credit associated with it using the drop down menus (assumed 20% removal efficiency credit).
FLOATING ISLAND WITH WET DETENTION:

FLOATING ISLAND WITH WET DETENTION SERVING:

Example Problem 7

<table>
<thead>
<tr>
<th>Catchment 1</th>
<th>Catchment 2</th>
<th>Catchment 3</th>
<th>Catchment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total pre-development catchment area: 3.000</td>
<td>Total post-development catchment area: 2.500</td>
<td>Average annual residence time (between 1 and 500 days): 30.00</td>
<td>Littoral Zone used in the design: YES</td>
</tr>
<tr>
<td>Total Nitrogen removal required: 26.195</td>
<td>Total Phosphorus removal required: 74.987</td>
<td>Average annual runoff volume: 8.475</td>
<td>Floating Wetland or Mats used in the design: YES</td>
</tr>
<tr>
<td>Total Nitrogen removal efficiency: 56.723</td>
<td>Total Phosphorous removal efficiency: 78.853</td>
<td>Wet Detention Pond Characteristics: Maximum Permanent Pool Depth: 10.785</td>
<td>Floating Wetland or Mats credit (default credit at 10%): 20.00</td>
</tr>
<tr>
<td>Total Phosphorus removal efficiency: 0.000</td>
<td>Efficiency graphs adjusted for littoral zone and floating islands credit.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average annual runoff volume: 8.475</td>
<td>Efficiency graphs adjusted for littoral zone and floating islands credit.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Pond Permanent Pool: 0.058</td>
<td>Efficiency graphs adjusted for littoral zone and floating islands credit.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE FOR TREATMENT EFFICIENCY GRAPH:

0 10 20 30 40 50 60 70 80 90 100

Treatment Efficiency (%)

0 10 20 30 40 50 60 70 80 90 100

Average Annual Residence Time (days)

Efficiency Curve (P)

Sys Eff (P) CAT 1

Sys Eff (P) CAT 2

Sys Eff (P) CAT 3

Sys Eff (P) CAT 4

Input for littoral zone and floating island credit.

Figure 74 - Floating Island with Wet Detention worksheet.

5. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

6. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 75).
The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.

1. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

2. Certain BMP treatment train combinations have not been evaluated and in practice they are not used, an example is a greenroof following a tree well.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example Problem 7</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment 1:</td>
<td>Floating Island</td>
<td>Catchment 2: Floating Island</td>
</tr>
<tr>
<td>BMP1</td>
<td></td>
<td>Catchment 3: Catchment 4:</td>
</tr>
<tr>
<td>BMP2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMP3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Summary Performance

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>B - 2 Catchment-Series</th>
<th>1/27/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment Nitrogen Pre Load</td>
<td>16.06</td>
<td></td>
</tr>
<tr>
<td>Catchment Phosphorus Pre Load</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>Catchment Nitrogen Post Load</td>
<td>34.28</td>
<td></td>
</tr>
<tr>
<td>Catchment Phosphorus Post Load</td>
<td>4.60</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>16.06</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>14.48</td>
<td>43.82</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>19.80</td>
<td>43.82</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>3.54</td>
<td>7.80</td>
</tr>
</tbody>
</table>

The overall removal efficiency and mass leaving is shown.

Figure 75 – Catchment and Treatment Summary Results for Example Problem 7
Example problem # 8 – limited area for treatment and benefits of co-mingling treatment

This example problem is a continuing area of research for incorporating the time of concentration for an upstream catchment without a BMP as it affects removal in a downstream BMP. As of July, 2014, the time of concentration effect is not endorsed by regulatory agencies.

A retention basin for a 2.5-acre addition to an existing highway is planned. The existing highway watershed is 2.0 acres but does not have any treatment system. The flow of the runoff from the existing area and the new area are in series. The pervious part of the area has a Curve Number of 50 and 0% DCIA. The location is Lakeland, FL with 50.5 inches of rain per year on average. The pre-development (pre-highway) land use condition is agricultural-citrus. The post-development land use condition is highway with a non-DCIA Curve Number of 50 and DCIA of 60%. The right-of-way area after the addition of the new highway watershed is large enough to accommodate a 2.368 inch retention area. Also assume that the highway is in an area where net improvement is required. The problem solution is divided into parts for training purposes. The first part demonstrates an assessment of removal for the new portion of the highway when the flow from the old highway is bypassing the stormwater treatment BMP.

Part 1. For the new or additional watershed area, compute the retention volume assuming no flow from the existing highway is routed to the new basin and the new highway watershed has to be treated in one retention basin:

1. From the introduction page click on the *Click Here to Start* button to proceed to the *General Site Information* worksheet.
   a. Select the *Reset Input for Stormwater Treatment Analysis* button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the *General Site Information* worksheet (Figure 76).
   c. Indicate the mean annual rainfall amount in the *General Site Information* worksheet.
   d. Select the *Net Improvement* option from the type of analysis drop down menu in the *General Site Information* worksheet.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 77).
   a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.
3. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Retention Basin* button to proceed to the *Retention Basin* worksheet (Figure 78).

Notes:

1. Required storage to achieve target (required) removal efficiency is 2.368 inches over the 2 acre watershed (assuming that 0.5 acres are used for water quality and water quantity control structures).

2. There is space to treat 2.368 inches of runoff but there is no treatment for the existing roadway. The total pounds discharged for total nitrogen (TN) and total phosphorus (TP) after treatment from the new roadway are 0.27 and 0.04 kg/year respectively. Add to this the discharge loading from the existing highway for TN and TP at 8.375 and 1.124 kg/year and the total discharge from the existing and the new highway together are 8.645 kg/year and 1.164 kg/year respectively.

3. At 2.368 inches, only a marginal increase in efficiency can be obtained with increased volume of retention basin. At first, the option to treat the runoff from the existing watershed does not appear reasonable. It may be more cost effective to seek out compensatory treatment. However, note that the marginal decrease in effectiveness caused by adding the untreated existing highway runoff may result in a greater overall loading reduction when the existing roadway runoff is co-mingled with the runoff from the new roadway.

The example problem can end at this evaluation point. However consider the situation were the runoff from the existing highway can be routed (co-mingled) to the first basin and then treated in the volume provided for the first basin. Various assumptions have to be made that may not be eligible for permit and the user is cautioned to obtain all permit requirements and structure the solution to be consistent with them.
Figure 78 - Retention Basin worksheet for required treatment of additional catchment area.

### RETENTION BASIN SERVING: Example Problem 8

<table>
<thead>
<tr>
<th>Watershed area:</th>
<th>Required Treatment Eff (Nitrogen):</th>
<th>Required Treatment Eff (Phosphorus):</th>
<th>Required retention depth over the watershed to meet required efficiency:</th>
<th>Required water quality retention volume:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.000</td>
<td>96.795</td>
<td>2.368</td>
<td>0.395</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>96.830</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RETENTION BASIN FOR MULTIPLE TREATMENT SYSTEMS (if there is a need for additional removal efficiencies in a series of BMPs):

- Retention volume based on retention depth:
  - Provided retention depth (inches over the watershed area): 2.368 in
  - Provided treatment efficiency (Nitrogen): 96.830%
  - Provided treatment efficiency (Phosphorus): 96.830%
  - Remaining treatment efficiency (Nitrogen): 0.000%
  - Remaining treatment efficiency (Phosphorus): 0.000%
  - Remaining retention depth needed: 0.000 in

**View Media Mixes**

Note also that the retention system is approaching a size where only a marginal efficiency is gained with size increase.

Note that the required retention volume if there is sufficient space for retention within the right-of-way.

**View Media Mixes**

The purpose of this graph is to help illustrate the treatment efficiency of the retention system as the function of retention depth for a system. The graph illustrates that as retention depth increases, the required retention volume also increases. Thus, the system may need additional space for retention within the right-of-way.
Part 2. Co-mingle the runoff from the existing highway with the runoff from the new highway and into the same size of retention basin that is planned for the new highway.

1. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet (Figure 79).
   a. Input the catchment configuration as B-2, the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage of the new and existing highways. Note catchment 2 must have a BMP associated with it.

   ![Watershed Characteristics V6.0](image)

   **Figure 79 - Watershed Characteristics worksheet.**

2. Select the Stormwater Treatment Analysis button for Stormwater Treatment Analysis.

3. Select the Retention Basin button to proceed to the Retention Basin worksheet (Figure 80).
   a. Indicate the retention depth for the existing highway in catchment 1 of the Retention Basin worksheet. (Note: The user should select a retention depth value that will fit into the site area and geology.)
b. The user does not have to specify a retention volume in catchment 2 because it is assumed that the runoff water from the existing catchment is co-mingled with that of the basin for the new highway catchment.

c. If a retention volume were to be specified for the existing highway, the output of the retention worksheet would be shown in Figure 80.

<table>
<thead>
<tr>
<th>RETENTION BASIN SERVING:</th>
<th>Example Problem 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watershed area:</td>
<td>Catchment 1 Catchment 2 Catchment 3 Catchment 4</td>
</tr>
<tr>
<td>Required Treatment Eff (Nitrogen):</td>
<td>2.000</td>
</tr>
<tr>
<td>Required Treatment Eff (Phosphorus):</td>
<td>0.000</td>
</tr>
<tr>
<td>Retention volume based on retention depth</td>
<td>0.000</td>
</tr>
<tr>
<td>Provided retention depth (inches over the watershed area):</td>
<td>2.000</td>
</tr>
<tr>
<td>Provided treatment efficiency (Nitrogen):</td>
<td>0.000</td>
</tr>
<tr>
<td>Provided treatment efficiency (Phosphorus):</td>
<td>0.000</td>
</tr>
<tr>
<td>Remaining treatment efficiency (Nitrogen):</td>
<td>0.000</td>
</tr>
<tr>
<td>Remaining treatment efficiency (Phosphorus):</td>
<td>0.000</td>
</tr>
<tr>
<td>Remaining retention depth needed:</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Figure 80 - Retention Basin worksheet.

4. The user must now check to see what the level of treatment is and the mass removal when there is co-mingling of the two catchments. This is done from the Catchment and Treatment Summary Results worksheet. Note that there is no treatment for the existing catchment.

5. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

6. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 81).
7. The pollution load discharged for TN and TP when co-mingling is 1.0 kg/year and 0.13 kg/year respectively (Figure 81). Without co-mingling the total load discharged from the existing and the new highway together are 8.645 kg/year and 1.164 kg/year respectively (see calculations of part 1 of this example problem 8). Thus a substantial decrease in the load reduction with co-mingling in this case. The overall effectiveness is 94% compared to 96.8% when only treating the runoff from the new highway, but the mass loading to the retention basin is higher. The co-mingling assumes that the runoff can be co-mingled without other substantial changes in the transport system.

![CATCHMENTS AND TREATMENT SUMMARY RESULTS](image)

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>B - 2 Catchment-Series</th>
<th>4/14/2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Pre Load (kg/yr)</td>
<td>8.81</td>
<td>BMPTRAINS MODEL</td>
</tr>
<tr>
<td>Phosphorus Pre Load (kg/yr)</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Post Load (kg/yr)</td>
<td>16.75</td>
<td></td>
</tr>
<tr>
<td>Phosphorus Post Load (kg/yr)</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>8.81</td>
<td></td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>15.76</td>
<td></td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>2.11</td>
<td></td>
</tr>
</tbody>
</table>

Note: With co-mingling, overall removal has increased compared to no treatment of the existing roadway.

Figure 81 – Catchment and Treatment Summary Results worksheet

This completes the example problem. The purpose was to demonstrate that co-mingling of off-site or adjacent catchments may increase the load reduction from both sites without increasing the size of the treatment facility. It is recognized that there are many different permit and site conditions that can modify the calculations of this problem.
Example problem # 9 - vegetated natural buffer in series with wet detention

A half-acre wet detention pond and a vegetated natural buffer (12 foot wide with a 1 foot storage depth along a 2355 foot long new highway) are used for stormwater treatment of a highway. The slope across the width of the vegetated natural buffer is 6% with the width of the area feeding the buffer equal to 25 feet. The area to be treated is 3.15 acres. The site is located in West Palm Beach, FL on Hydrologic Soil Group D and has a storage capacity of 0.20 inch/inch depth. The existing land use condition is assumed to be Wet Flatwoods with a non-DCIA Curve Number of 80 and 0% DCIA. The post-development land use condition is highway with a non-DCIA Curve Number of 80 and DCIA of 80%. The target removal efficiency for both Total Nitrogen and Total Phosphorus is 80%. The wet detention pond has 100 days average annual residence time and a littoral zone (assumed 10% removal efficiency credit).

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 82).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Specified Removal Efficiency option from the type of analysis drop down menu in the General Site Information worksheet.
   e. Specify the desired removal efficiency.
2. Select the *Go To Watershed Characteristics* button to proceed to the **Watershed Characteristics** worksheet (Figure 83). Note the input EMC data can be changed or overwritten.

a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.
3. Select the *Stormwater Treatment Analysis* button to proceed to the **Stormwater Treatment Analysis** worksheet.

4. Select the *Wet Detention* button to proceed to the **Wet Detention** worksheet (Figure 84).
   a. Specify the average annual residence time. Also specify whether the littoral zone is used in the design and indicate the efficiency credit associated with it.
Figure 84 - Wet Detention worksheet.

**Input and output for the Wet Detention worksheet**

The purpose of the treatment efficiency graphs is to help illustrate the treatment efficiency of the wet detention system as the function of average annual residence time (and permanent pool volume). The graph illustrates that there is a point of diminished return as the permanent pool volume is substantially increased. The lines are produced from the conditions of catchment one, thus other catchments are shown with the data points.

**Output for the wet detention system**

Indicates how much additional treatment efficiency is needed for each parameter. Use as a guidance in sizing of the pre-treatment vegetated natural buffer.

5. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

6. Select the *Vegetated Natural Buffer* button to proceed to the *Vegetated Natural Buffer* worksheet (Figure 85).
   a. Specify appropriate input for the vegetated natural buffer.

| VEGETATED NATURAL BUFFER SERVING: | Example Problem 9 |

<table>
<thead>
<tr>
<th>Contributing catchment area:</th>
<th>Catchment 1</th>
<th>Catchment 2</th>
<th>Catchment 3</th>
<th>Catchment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required treatment efficiency (Nitrogen):</td>
<td>2.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Required treatment efficiency (Phosphorus):</td>
<td>80.000</td>
<td>80.000</td>
<td>80.000</td>
<td>80.000</td>
</tr>
<tr>
<td>Vegetated Natural Buffer width (10 to 350 feet):</td>
<td>12.00 ft</td>
<td>12.00 ft</td>
<td>12.00 ft</td>
<td>12.00 ft</td>
</tr>
<tr>
<td>Vegetated Natural Buffer length (length should be same as buffer):</td>
<td>2355.00 ft</td>
<td>2355.00 ft</td>
<td>2355.00 ft</td>
<td>2355.00 ft</td>
</tr>
<tr>
<td>Vegetated Natural Buffer storage depth not greater than 1 foot:</td>
<td>1.00 ft</td>
<td>1.00 ft</td>
<td>1.00 ft</td>
<td>1.00 ft</td>
</tr>
<tr>
<td>Width of the area feeding the buffer:</td>
<td>25.00 ft</td>
<td>25.00 ft</td>
<td>25.00 ft</td>
<td>25.00 ft</td>
</tr>
<tr>
<td>Water storage capacity of the soil:</td>
<td>0.20 in/in</td>
<td>0.20 in/in</td>
<td>0.20 in/in</td>
<td>0.20 in/in</td>
</tr>
<tr>
<td>What is the slope of Buffer Width with no collector trench or swale (2-6%)?</td>
<td>6.00 %</td>
<td>6.00 %</td>
<td>6.00 %</td>
<td>6.00 %</td>
</tr>
<tr>
<td>Provided treatment efficiency (Nitrogen):</td>
<td>63.115</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Provided treatment efficiency (Phosphorus):</td>
<td>61.050</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Which efficiency graph do you want to view?

Input and output for the VNB. Note that the provided treatment efficiency for Nitrogen makes up the deficiency of wet detention.

7. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

8. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 86).
   a. Compare the sum of target Loads with the sum of achieved Loads. If sum of the target loads is smaller than the sum of achieved loads you must increase the size of the VNB.
## Catchments and Treatment Summary Results

**Calculation Methods:**

1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

### Summary Performance of Entire Watershed

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>A - Single Catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Pre Load (kg/yr)</td>
<td>3.64</td>
</tr>
<tr>
<td>Phosphorus Pre Load (kg/yr)</td>
<td>0.05</td>
</tr>
<tr>
<td>Nitrogen Post Load (kg/yr)</td>
<td>13.94</td>
</tr>
<tr>
<td>Phosphorus Post Load (kg/yr)</td>
<td>1.87</td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>80</td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>80</td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>2.79</td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>0.37</td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%)</td>
<td>73</td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%)</td>
<td>87</td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr)</td>
<td>3.82</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr)</td>
<td>0.23 &amp; 0.52</td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr)</td>
<td>10.12 &amp; 22.29</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr)</td>
<td>1.64 &amp; 3.60</td>
</tr>
</tbody>
</table>

**Note:** Provided overall efficiency not sufficient. Another iteration is required. The addition of another BMP may be the best option.

---

Figure 86 – Catchment and Treatment Summary Results worksheet
Example problem # 10 – Use of Rain (Bio) Gardens

Rain (Bio) Gardens have been proposed to treat a 2.0-acre low-intensity commercial development. The project location is St. Petersburg, FL. The pre-development land use condition is agricultural-pasture with a Curve Number of 78 and 0% DCIA. The post-development land use condition is low-intensity commercial with a non-DCIA Curve Number of 78 and DCIA of 50%. Assume the media in the bio area is to have dimensions of 80 ft by 30 ft with a depth of 1 foot, thereby making the volume of the media in the rain (bio) garden to be 2400 cubic feet. Assume the water storage above the rain (bio) garden is 2088 cubic feet. The sustainable void ratio for the media is 0.25. The problem solution is divided into parts for training purposes, first as a retention BMP and second as a detention one. The detention has as an option to use two media types, namely a compost, shredded paper, and sand (CPS) media and a Dade city clay, tire crumb, and sand (CTS) media. The CPS media has a sustainable void ratio of 0.20 and a depth of 24 inches. The CTS media has a sustainable void ratio of 0.20 and a depth of 12 inches. The high water table is below the media.

Part 1. Treating the Rain (Bio) Garden as a retention system:

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 87).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Net Improvement option from the type of analysis drop down menu in the General Site Information worksheet.
2. Select the *Watershed Characteristics* button to proceed to the *Watershed Characteristics* worksheet (Figure 88).

   a. Indicate the catchment configuration, pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage.
3. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Rain (Bio) Garden* button to proceed to the *Rain (Bio) Garden* worksheet (Figure 89).
Figure 89 – Rain (Bio) Garden worksheet.

5. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

6. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 90).
Figure 90 - Catchment and Treatment Summary Results

Notes: The example problem can end at this evaluation point. However consider the situation where the rain (bio) garden is a detention system rather than a retention system. Additionally, examine the use of two different pollution control media.
Part 2. Repeat assuming a detention system for two different media types. Data from the general site information worksheet and watershed characteristics worksheet will remain the same.

1. Select the Rain (Bio) Garden button to proceed to the Rain (Bio) Garden worksheet (Figure 91).

   a. Change to a detention problem from the drop down menu and select the compost, shredded paper, and sand (CPS) media mix. This media mix is to be used at a depth of 24 inches, so the media volume needs to be changed to 4800 cubic feet. Additionally, this media has a sustainable void space fraction of 0.20. Figure 91 below illustrates these changes.

   ![](Image)

   Figure 91 – Rain (Bio) Garden.
Note: The required treatment for phosphorus is met while the required treatment for nitrogen is not. Change the media type to Dade city clay, Tire crumb, and Sand (CTS) at a depth of 12 inches and rework.

2. Since the location and site characteristics remain the same no changes need to be made to any of the other sheets except the **Rain (Bio) Garden** worksheet.
   a. Select CTS from the media mix drop down list in the **Rain (Bio) Garden** worksheet (Figure 92). Also, change the media volume to 2400 cubic feet to account for the decrease in media depth, from 24 inches to 12 inches.

   ![Rain (Bio) Garden Selecting a Media Mix](image)

3. Select the **Stormwater Treatment Analysis** button to proceed to the **Stormwater Treatment Analysis** worksheet.
4. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 93).

**Figure 93 - Catchment and Treatment Summary Results**

Note: The required treatment efficiency for nitrogen and phosphorus is met for this media mix. Notice how the treatment efficiency provided for retention is based on a volume captured while the detention system is based on a concentration reduction. This is due to the fact that for a retention system the water is not being collected for surface discharge but is infiltrated, therefore the treatment efficiency is related to the hydraulic capture efficiency. For the detention systems, the water is treated with a pollution control media and then collected for discharge. This example showed that, for a detention system, media selection is important as the CPS media was twice as deep and had lower treatment...
efficiency than the CTS media. This example also showed that the retention system performed better than the detention system for both media types examined. This is due to the fact that 100% of the nitrogen and phosphorus in the infiltrated water will not be discharged downstream. This completes the example problem.
Example problem # 11 – Three Catchments

A watershed with three catchments, each having an area of 5 acres, has to be treated to meet net improvement standards. The project location is East of Brooksville, Hernando County, FL. This problem is to be worked out in two parts, one assuming the catchments are in series and one assuming the catchments are in parallel.

The first catchment pre-development condition is agricultural-pasture with a Curve Number of 78 with 0% DCIA. The post-development conditions are highway with a non-DCIA Curve Number of 78 and DCIA of 60%. A swale is to be used which is 1.11 acres. It has a 10 ft top width, swale bottom width of 2 ft, swale and highway length of 4840 ft, highway width of 20 ft, average width of pervious area of 25 ft, swale slope of 0.001, Manning’s n of 0.05, a soil infiltration rate of 5 in/hr, and a swale side slope of 5.

The second catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The post-development conditions are high-intensity commercial with a non-DCIA Curve Number of 78 and DCIA of 80%. A 1 acre retention pond is to be used for treatment and due to site limitations only 0.25 inch over the catchment area can be accommodated.

The third catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The post-development conditions are low-density residential with a non-DCIA Curve Number of 78 and DCIA of 50%. A 1 acre wet-detention pond is to be used with an average annual residence time of 30 days and littoral zone is to be used with 10% credit.

Part 1. Treating the catchments in series:

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 94).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Net Improvement option from the Type of analysis drop down menu in the General Site Information worksheet.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet.
   
a. Indicate the catchment configuration (the different catchment configurations available can be viewed by selecting the View Catchment Configurations button). For this problem, D - 3 catchments in series (Figure 95).
3. Go back to the **Watershed Characteristics** worksheet by selecting the *Go To Watershed Characteristics* button.

   a. Indicate the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage (Figure 96).
4. Select the *Stormwater Treatment Analysis* button at the top of the worksheet to proceed to the *Stormwater Treatment Analysis* worksheet.

5. Select the *Swale* button to proceed to the *Swale* worksheet (Figure 97).
   a. Enter the required input based on the problem givens.

---

Figure 96 - Watershed Characteristics worksheet.
Figure 97 – Swale worksheet.

NOTE FOR TREATMENT EFFICIENCY GRAPH:

The purpose of this graph is to help illustrate the treatment efficiency of the swale as the function of retention depth. The graph illustrates that there is diminishing effectiveness as the retention depth is increased.

Note that the provided treatment efficiency is higher than the required treatment efficiency.
6. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

7. Select the *Retention Basin* button to proceed to the *Retention Basin* worksheet.
   a. Specify a 0.25 inch retention depth (Figure 98).

<table>
<thead>
<tr>
<th>RETENTION BASIN: V6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETENTION BASIN SERVING:</td>
</tr>
<tr>
<td>Catchment 1</td>
</tr>
<tr>
<td>Watershed area:</td>
</tr>
<tr>
<td>Required Treatment Eff (Nitrogen):</td>
</tr>
<tr>
<td>Required Treatment Eff (Phosphorus):</td>
</tr>
<tr>
<td>Required retention depth over the watershed to meet required efficiency:</td>
</tr>
<tr>
<td>Required water quality retention volume:</td>
</tr>
</tbody>
</table>

**RETENTION BASIN FOR MULTIPLE TREATMENT SYSTEMS** (if there is a need for additional removal)

| Retention volume based on retention depth | 0.000 | 0.083 |
| Provided retention depth (inches over the watershed area): | 0.250 |
| Provided treatment efficiency (Nitrogen): | 0.000 | 33.064 % |
| Provided treatment efficiency (Phosphorus): | 0.000 | 33.064 % |
| Remaining treatment efficiency (Nitrogen): | 41.421 | 53.890 % |
| Remaining treatment efficiency (Phosphorus): | 22.480 | 43.057 % |
| Remaining retention depth needed: | 0.353 | 0.587 |

Figure 98 - Retention Basin worksheet.

8. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

9. Select the *Wet Detention* button to proceed to the *Wet Detention* worksheet.
   a. Specify a 30 day average annual residence time, a littoral zone (drop down menu), and a 10% efficiency credit (drop down menu) (Figure 99).

<table>
<thead>
<tr>
<th>WET DETENTION: V7.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>WET DETENTION POND SERVING:</td>
</tr>
<tr>
<td>Catchment 1</td>
</tr>
<tr>
<td>Total pre-development catchment area:</td>
</tr>
<tr>
<td>Total post-development catchment area:</td>
</tr>
<tr>
<td>Average annual residence time (between 1 and 500 days):</td>
</tr>
<tr>
<td>Littoral Zone or other improvements used?</td>
</tr>
<tr>
<td>Littoral Zone or other improvement efficiency credit:</td>
</tr>
<tr>
<td>Total Nitrogen removal required:</td>
</tr>
<tr>
<td>Total Phosphorus removal required:</td>
</tr>
<tr>
<td>Total Nitrogen removal efficiency provided:</td>
</tr>
<tr>
<td>Total Phosphorus removal efficiency provided:</td>
</tr>
<tr>
<td>Is the wet detention sufficient:</td>
</tr>
<tr>
<td>Average annual runoff volume:</td>
</tr>
</tbody>
</table>

**To Achieve the Treatment Efficiency Shown in the Graph Below, the Following Must Hold**

Minimum Pond Permanent Pool Volume: 0.656 ac-ft

Figure 99 - Wet Detention worksheet.
10. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

11. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 100).

---

**CATCHMENTS AND TREATMENT SUMMARY RESULTS**

<table>
<thead>
<tr>
<th>CALCULATION METHODS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.</td>
</tr>
<tr>
<td>2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, for example is a greenroof following a tree well.</td>
</tr>
<tr>
<td>3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.</td>
</tr>
</tbody>
</table>

**Summary Performance of Entire Watershed**

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>D - 3 Catchment-Series</th>
<th>7/8/2014</th>
<th>BMPTRAINS MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP Name</td>
<td>Optional Identification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catchment 1: Swale</td>
<td>Catchment 2: Retention Basin</td>
<td>Catchment 3: Wet Detention</td>
<td>Catchment 4:</td>
</tr>
<tr>
<td>BMP Name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMP Name</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Note that the provided treatment efficiency is higher than the required treatment efficiency.**

---

**Figure 100 - Catchment and Treatment Summary Results.**

**Part 2. Treating the catchments in Parallel:**

1. Select the *Stormwater Treatment Analysis* button to return to the *Stormwater Treatment Analysis* worksheet.

2. All of the existing data can be used for this part of the problem except the catchment configuration needs to be changed.
3. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet.
   a. Indicate the catchment configuration. For this part, E - 3 catchments in parallel (Figure 101).

   ![Figure 101 - Catchment Configuration Options worksheet](image)

   Select from the 14 different configurations
   You need to scroll down and right to see all configurations
   A - Single Catchment
   B - 2 Catchment-Series
   C - 2 Catchment-Parallel
   D - 3 Catchment-Series
   E - 3 Catchment-Parallel
   F - Mixed-3 Catchment-2 Series-Parallel (A)
   G - Mixed-3 Catchment-2 Series-Parallel (B)
   H - 4 Catchment-Series

   b. Leave the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage from the previous part (Figure 102).
4. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

5. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 103).
Figure 103 - Catchment and Treatment Summary Results.

NOTE: This example shows how catchment configurations can be easily changed to examine different configurations. This also shows the benefit of BMPs in series as opposed to parallel.
Example problem # 12 – Four Catchments

For this example problem, assume the conditions for Example problem #11 and add an additional 10 acre catchment. The problem is to be worked twice, once in each of the two configurations shown below (J and K).

The project location is St. Petersburg, FL. This problem is to be worked out assuming the catchments are in series and assuming the catchments are in parallel.

The first catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The post-development conditions are highway with a non-DCIA Curve Number of 78 and DCIA of 60%. A swale is to be used which is 1.11 acres. It has a 10 ft top width, swale bottom width of 2 ft, swale and highway length of 4840 ft, highway width of 20 ft, average width of pervious area of 25 ft, swale slope of 0.001, Manning’s n of 0.05, a soil infiltration rate of 5 in/hr, and a swale side slope of 5.

The second catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The post-development conditions are high-intensity commercial with a non-DCIA Curve Number of 78 and DCIA of 80%. A 1 acre retention pond is to be used for treatment and due to site limitations only 0.25 inch over the catchment area can be accommodated.

The third catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The post-development conditions are low-density residential with a non-DCIA
Curve Number of 78 and DCIA of 50%. A 1 acre wet-detention pond is to be used with an average annual residence time of 30 days and littoral zone is to be used with 10% credit.

The fourth catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The post-development conditions are light industrial with a non-DCIA Curve Number of 78 and DCIA of 60%. A 2 acre wet detention pond with an average annual residence time of 70 days is to be used. A littoral zone with 10% credit is also used.

**Part 1. Treating the catchments in configuration J:**

1. From the introduction page click on the *Click Here to Start* button to proceed to the **General Site Information** worksheet.
   a. Select the *Reset Input for Stormwater Treatment Analysis* button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the **General Site Information** worksheet (Figure 104).
   c. Indicate the mean annual rainfall amount in the **General Site Information** worksheet.
   d. Select the *Net Improvement* option from the type of analysis drop down menu in the **General Site Information** worksheet.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet.
   a. Indicate the catchment configuration. For this problem, 4 catchments configured as shown in J (Figure 105).

J - Mixed-4 Catchment-3 Series-Parallel

Figure 105 - Catchment Configuration for part 1 of this problem.
b. Indicate the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage (Figure 106).
### CATCHMENT NO.1 CHARACTERISTICS:

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area Acres</th>
<th>non DCIA CN</th>
<th>% DCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural - Pasture:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Intensity Commercial:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Catchment Characteristics input for each catchment area.**

| Total pre-development catchment area: | 5.00 AC |
| Total post-development catchment or BMP analysis area: | 5.00 AC |
| Pre-development Non DCIA CN:          | 78.00    |
| Pre-development DCIA percentage:      | 0.00 %   |
| Post-development Non DCIA CN:         | 78.00    |
| Post-development DCIA percentage:     | 80.00 %  |
| Estimated Area of BMP (used for rainfall excess not loadings) | 1.00 AC |

**CATCHMENT NO.2 CHARACTERISTICS:**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area Acres</th>
<th>non DCIA CN</th>
<th>% DCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural - Pasture:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Catchment Characteristics input for each catchment area.**

| Total pre-development catchment area: | 5.00 AC |
| Total post-development catchment or BMP analysis area: | 5.00 AC |
| Pre-development Non DCIA CN:          | 78.00    |
| Pre-development DCIA percentage:      | 0.00 %   |
| Post-development Non DCIA CN:         | 78.00    |
| Post-development DCIA percentage:     | 80.00 %  |
| Estimated Area of BMP (used for rainfall excess not loadings) | 1.00 AC |

**CATCHMENT NO.3 CHARACTERISTICS:**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area Acres</th>
<th>non DCIA CN</th>
<th>% DCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural - Pasture:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Density Residential:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total pre-development catchment area: | 5.00 AC |
| Total post-development catchment or BMP analysis area: | 5.00 AC |
| Pre-development Non DCIA CN:          | 78.00    |
| Pre-development DCIA percentage:      | 0.00 %   |
| Post-development Non DCIA CN:         | 78.00    |
| Post-development DCIA percentage:     | 80.00 %  |
| Estimated Area of BMP (used for rainfall excess not loadings) | 1.00 AC |

**CATCHMENT NO.4 CHARACTERISTICS:**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area Acres</th>
<th>non DCIA CN</th>
<th>% DCIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural - Pasture:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Industrial:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development land use:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total pre-development catchment area: | 10.00 AC |
| Total post-development catchment or BMP analysis area: | 10.00 AC |
| Pre-development Non DCIA CN:          | 78.00    |
| Pre-development DCIA percentage:      | 0.00 %   |
| Post-development Non DCIA CN:         | 78.00    |
| Post-development DCIA percentage:     | 80.00 %  |
| Estimated Area of BMP (used for rainfall excess not loadings) | 2.00 AC |

**WATERSHED CHARACTERISTICS V6.0**

**WATERSHED CHARACTERISTICS V6.0**

**SELECT CATCHMENT CONFIGURATION**

**J - Mixed-4 Catchment-3 Series-Parallel**

**GO TO STORMWATER TREATMENT ANALYSIS**
3. Select the *Stormwater Treatment Analysis* button at the top of the worksheet to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Swale* button to proceed to the *Swale* worksheet (Figure 107).
   a. Enter the required input data from the problem givens.
Figure 107 – Swale worksheet.

### Example Problem 12

<table>
<thead>
<tr>
<th>SWALE SERVING CONTRIBUTING CATCHMENT:</th>
<th>Example Problem 12</th>
</tr>
</thead>
</table>

#### Input data

<table>
<thead>
<tr>
<th>Catchment 1</th>
<th>Catchment 2</th>
<th>Catchment 3</th>
<th>Catchment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributing catchment area:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required treatment efficiency (Nitrogen):</td>
<td>41.821</td>
<td>69.136</td>
<td>33.164</td>
</tr>
<tr>
<td>Required treatment efficiency (Phosphorus):</td>
<td>41.821</td>
<td>69.136</td>
<td>33.164</td>
</tr>
<tr>
<td>Swale top width calculated for flood conditions [W]:</td>
<td>22.460</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swale bottom width (0 for triangular section) [B]:</td>
<td>10.00</td>
<td>2.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Swale length [L]:</td>
<td>4840.00</td>
<td>4840.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Average impervious length:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average impervious width (including shoulder):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average width of the pervious area to include swale width:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributing catchment area:</td>
<td>169400.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swale slope (ft drop/ft length) [S]:</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manning's N:</td>
<td>0.050</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil infiltration rate:</td>
<td>5.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side slope of swale (horizontal ft/vertical ft) [Z]:</td>
<td>5.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infiltrated storage depth:</td>
<td>1.650</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Cumulative height of the swale blocks [H]:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of the berm upstream of the crest [Lb]:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of water in swales upstream of swale blocks:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total volume:</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Provided treatment efficiency (Nitrogen):</td>
<td>86.988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provided treatment efficiency (Phosphorus):</td>
<td>86.988</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Output data

<table>
<thead>
<tr>
<th>Catchment 1</th>
<th>Catchment 2</th>
<th>Catchment 3</th>
<th>Catchment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration reduction? (if S&lt;= 1% or H&gt;= 6 in)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen efficiency</td>
<td>86.988</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Phosphorous efficiency</td>
<td>86.988</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

#### Note for Treatment Efficiency Graph:

The purpose of this graph is to help illustrate the treatment efficiency of the swale as the function of retention depth. The graph illustrates that there is diminishing effectiveness as the retention depth is increased.

Note that the provided treatment efficiency is higher than the required treatment efficiency.
5. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

6. Select the *Retention Basin* button to proceed to the *Retention Basin* worksheet.
   a. Specify a 0.25 inch retention depth (Figure 108).

<table>
<thead>
<tr>
<th>RETENTION BASIN:</th>
<th>V6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETENTION BASIN SERVING:</td>
<td>Example Problem 12</td>
</tr>
<tr>
<td>Watershed area:</td>
<td>Catchment 1</td>
</tr>
<tr>
<td>3.890</td>
<td>4.000</td>
</tr>
<tr>
<td>Required Treatment Eff (Nitrogen):</td>
<td>41.421</td>
</tr>
<tr>
<td>Required Treatment Eff (Phosphorus):</td>
<td>22.480</td>
</tr>
<tr>
<td>Required retention depth over the watershed to meet required efficiency:</td>
<td>0.348</td>
</tr>
<tr>
<td>Required water quality retention volume:</td>
<td>0.113</td>
</tr>
</tbody>
</table>

**Note that the treatment required is not met.**

Figure 108 - Retention Basin worksheet.

7. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

8. Select the *Wet Detention* button to proceed to the *Wet Detention* worksheet.
   a. Under catchment 3 specify a 30 day average annual residence time, a littoral zone (drop down menu), and a 10% efficiency credit (drop down menu) (Figure 109).
   b. Under catchment 4 specify a 70 day average annual residence time.
9. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

10. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 110).

---

**Figure 109 - Wet Detention worksheet.**

<table>
<thead>
<tr>
<th>Total pre-development catchment area:</th>
<th>Catchment 1</th>
<th>Catchment 2</th>
<th>Catchment 3</th>
<th>Catchment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total post-development catchment area:</td>
<td>5.000 ac</td>
<td>5.000 ac</td>
<td>5.000 ac</td>
<td>10.000 ac</td>
</tr>
<tr>
<td>Average annual residence time (between 1 and 500 days):</td>
<td>3.890 days</td>
<td>4.000 days</td>
<td>30.00 days</td>
<td>70.00 days</td>
</tr>
<tr>
<td>Littoral Zone or other improvements used?</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Littoral Zone or other improvement efficiency credit:</td>
<td>10.00 %</td>
<td>10.00 %</td>
<td>10.00 %</td>
<td>10.00 %</td>
</tr>
<tr>
<td>Total Nitrogen removal required:</td>
<td>33.164 %</td>
<td>22.143 %</td>
<td>33.164 %</td>
<td>22.143 %</td>
</tr>
<tr>
<td>Total Phosphorus removal required:</td>
<td>0.000 %</td>
<td>36.210 %</td>
<td>44.359 %</td>
<td>47.056 %</td>
</tr>
<tr>
<td>Total Nitrogen removal efficiency provided:</td>
<td>44.359 %</td>
<td>47.056 %</td>
<td>33.164 %</td>
<td>22.143 %</td>
</tr>
<tr>
<td>Total Phosphorous removal efficiency provided:</td>
<td>67.840 %</td>
<td>73.941 %</td>
<td>67.840 %</td>
<td>73.941 %</td>
</tr>
<tr>
<td>Is the wet detention sufficient:</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Average annual runoff volume:</td>
<td>8.934 ac-ft/yr</td>
<td>11.587 ac-ft/yr</td>
<td>7.976 ac-ft/yr</td>
<td>18.374 ac-ft/yr</td>
</tr>
</tbody>
</table>

**To Achieve the Treatment Efficiency Shown in the Graph Below, the Following Must Hold**

**Minimum Pond Permanent Pool Volume:**

![Efficiency Curve Graph]

**Efficiency graphs is to help illustrate the treatment efficiency of the wet detention system as the function of average annual residence time (and permanent pool volume). The graph illustrates that there is a point of diminished return as the permanent pool volume is substantially increased. The lines are produced from the conditions of catchment one, thus other catchments are shown with the data points.**
CATCHMENTS AND TREATMENT SUMMARY RESULTS  
V7.3

CALCULATION METHODS:
1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example Problem 12</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment 1:</td>
<td>Swale</td>
<td></td>
</tr>
<tr>
<td>Catchment 2:</td>
<td>Retention Basin</td>
<td></td>
</tr>
<tr>
<td>Catchment 3:</td>
<td>Wet Detention</td>
<td></td>
</tr>
<tr>
<td>Catchment 4:</td>
<td>Wet Detention</td>
<td></td>
</tr>
</tbody>
</table>

Summary Performance of Entire Watershed

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>J - Mixed-4 Catchment-3 Series-Parallel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Pre Load (kg/yr)</td>
<td>52.93</td>
</tr>
<tr>
<td>Phosphorus Pre Load (kg/yr)</td>
<td>8.40</td>
</tr>
<tr>
<td>Nitrogen Post Load (kg/yr)</td>
<td>95.39</td>
</tr>
<tr>
<td>Phosphorus Post Load (kg/yr)</td>
<td>15.12</td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>45</td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>38</td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>52.93</td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>9.40</td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>62</td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>81</td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>35.80</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>2.95</td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>59.60</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>12.18</td>
</tr>
</tbody>
</table>

Note that the provided treatment efficiency is sufficient.

Figure 110 - Catchment and Treatment Summary Results.

Part 2. Treating the catchments in configuration K:

1. All of the existing data can be used for this part of the problem except the catchment configuration needs to be changed.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet.
   a. Indicate the catchment configuration. For this part, 4 catchments using configuration K (Figure 111).
b. The pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage remains the same (Figure 112).
### WATERSHED CHARACTERISTICS V6.0

#### GO TO STORMWATER TREATMENT ANALYSIS

#### SELECT CATCHMENT CONFIGURATION

**K - Mixed-4 Catchment-Series (B)**

#### CATCHMENT NO.1 CHARACTERISTICS:

- **Pre-development land use:**
  - with default EMCs
  - Agricultural - Pasture: TN=3.470 TP=0.616
  - Highways: TN=1.640 TP=0.220

- **Post-development land use:**
  - with default EMCs
  - Agricultural - Pasture: TN=3.470 TP=0.616
  - Highways: TN=1.640 TP=0.220

- **Total pre-development catchment area:**
  - 5.00 AC

- **Total post-development catchment or BMP analysis area:**
  - 5.00 AC

- **Pre-development Non DCIA CN:** 78.00

- **Pre-development DCIA percentage:**
  - 0.00%

- **Post-development Non DCIA CN:** 78.00

- **Post-development DCIA percentage:**
  - 60.00%

- **Estimated Area of BMP (used for rainfall excess not loadings):**
  - 1.11 AC

**Catchment configuration for 2nd part of problem.**

#### CATCHMENT NO.2 CHARACTERISTICS:

- **Pre-development land use:**
  - Agricultural - Pasture: TN=3.470 TP=0.616
  - High-Intensity Commercial: TN=2.40 TP=0.345

- **Post-development land use:**
  - Agricultural - Pasture: TN=3.470 TP=0.616
  - High-Intensity Commercial: TN=2.40 TP=0.345

- **Total pre-development catchment area:**
  - 5.00 AC

- **Total post-development catchment or BMP analysis area:**
  - 5.00 AC

- **Pre-development Non DCIA CN:** 78.00

- **Pre-development DCIA percentage:**
  - 0.00%

- **Post-development Non DCIA CN:** 78.00

- **Post-development DCIA percentage:**
  - 80.00%

- **Estimated Area of BMP (used for rainfall excess not loadings):**
  - 1.00 AC

#### CATCHMENT NO.3 CHARACTERISTICS:

- **Pre-development land use:**
  - Agricultural - Pasture: TN=3.470 TP=0.616

- **Post-development land use:**
  - Low-Density Residential: TN=1.610 TP=0.191

- **Total pre-development catchment area:**
  - 5.00 AC

- **Total post-development catchment or BMP analysis area:**
  - 5.00 AC

- **Pre-development Non DCIA CN:** 78.00

- **Pre-development DCIA percentage:**
  - 0.00%

- **Post-development Non DCIA CN:** 78.00

- **Post-development DCIA percentage:**
  - 60.00%

- **Estimated Area of BMP (used for rainfall excess not loadings):**
  - 1.10 AC

#### CATCHMENT NO.4 CHARACTERISTICS:

- **Pre-development land use:**
  - Agricultural - Pasture: TN=3.470 TP=0.616

- **Post-development land use:**
  - Light Industrial: TN=1.200 TP=0.260

- **Total pre-development catchment area:**
  - 10.00 AC

- **Total post-development catchment or BMP analysis area:**
  - 10.00 AC

- **Pre-development Non DCIA CN:** 78.00

- **Pre-development DCIA percentage:**
  - 0.00%

- **Post-development Non DCIA CN:** 78.00

- **Post-development DCIA percentage:**
  - 50.00%

- **Estimated Area of BMP (used for rainfall excess not loadings):**
  - 2.00 AC
Figure 112 - Watershed Characteristics worksheet.

3. Select the *Stormwater Treatment Analysis* button at the top of the worksheet to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 113).

---

**CATCHMENTS AND TREATMENT SUMMARY RESULTS**

**V7.3**

**CALCULATION METHODS:**

1. The effectiveness of each BMP in a single catchment is converted to an equivalent capture volume.
2. Certain BMP treatment train combinations have not been evaluated and in practice they are at this time not used, an example is a greenroof following a tree well.
3. If multiple BMPs are used in a single catchment and one of them is detention, then it is assumed to be last in series.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Example Problem 12</th>
<th>Optional Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment 1:</td>
<td>Swale</td>
<td>Catchment 2: Retention Basin</td>
</tr>
<tr>
<td>Catchment 3:</td>
<td>Wet Detention</td>
<td>Catchment 4: Wet Detention</td>
</tr>
<tr>
<td>BMP Name</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMP Name</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Summary Performance of Entire Watershed**

<table>
<thead>
<tr>
<th>Catchment Configuration</th>
<th>K - Mixed-4 Catchment-Series (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Pre Load (kg/yr)</td>
<td>52.93</td>
</tr>
<tr>
<td>Phosphorus Pre Load (kg/yr)</td>
<td>9.40</td>
</tr>
<tr>
<td>Nitrogen Post Load (kg/yr)</td>
<td>95.39</td>
</tr>
<tr>
<td>Phosphorus Post Load (kg/yr)</td>
<td>15.12</td>
</tr>
<tr>
<td>Target Load Reduction (N) %</td>
<td>45</td>
</tr>
<tr>
<td>Target Load Reduction (P) %</td>
<td>38</td>
</tr>
<tr>
<td>Target Discharge Load, N (kg/yr)</td>
<td>52.93</td>
</tr>
<tr>
<td>Target Discharge Load, P (kg/yr)</td>
<td>9.40</td>
</tr>
<tr>
<td>Provided Overall Efficiency, N (%):</td>
<td>52</td>
</tr>
<tr>
<td>Provided Overall Efficiency, P (%):</td>
<td>77</td>
</tr>
<tr>
<td>Discharged Load, N (kg/yr &amp; lb/yr):</td>
<td>46.11</td>
</tr>
<tr>
<td>Discharged Load, P (kg/yr &amp; lb/yr):</td>
<td>3.42</td>
</tr>
<tr>
<td>Load Removed, N (kg/yr &amp; lb/yr):</td>
<td>49.29 108.56</td>
</tr>
<tr>
<td>Load Removed, P (kg/yr &amp; lb/yr):</td>
<td>11.70 25.78</td>
</tr>
</tbody>
</table>

**BMP Name**

Note that the provided treatment efficiency is sufficient.

---

Figure 113 - Catchment and Treatment Summary Results.

**NOTE:** This example shows how catchment configurations can be easily changed to examine different configurations. This also shows that different configurations can affect the overall result achieved.
Example problem # 13 – BMP Analysis

This example problem demonstrates how the model can be used to examine the effectiveness of a BMP without specifying a pre and post condition, or a specified removal. The common application would be for an existing BMP but it can also be used for new construction. The evaluation can be achieved by using one or more catchments. For BMPTRAINS model input, only post development area and CN number are specified. For this example problem, a single catchment is used and the BMP effectiveness is for a retention basin.

The project location is Orlando, FL. There is a small (20%) non highway area in the catchment that contributes and is agricultural-pasture with a Curve Number of 78. The total project area is 6 acres. The highway DCIA is 80% of the catchment. The space for retention is limited and it is desired to examine the effectiveness of a 0.25 acre retention pond.

This problem is to be treated as a BMP analysis problem.

Solution:

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 114).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the BMP Analysis option from the type of analysis drop down menu in the General Site Information worksheet.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet.
   a. Indicate the catchment configuration. For this problem, a single catchment is used as shown in the BMPTRAINS MODEL as configuration A (Figure 115).

   ![A - Single Catchment](image)

   **Figure 115 - Catchment Configuration for this problem.**

   b. Indicate the BMP land use data. Since we are only interested in BMP effectiveness, only the post-development catchment areas non-DCIA Curve Number and DCIA percentage are required but the post and pre land use conditions must also be entered (Figure 116).
3. Select the Stormwater Treatment Analysis button at the top of the worksheet to proceed to the Stormwater Treatment Analysis worksheet.

4. Select the Retention Basin button to proceed to the Basin worksheet.
   
a. A retention area of 0.25 acres that is about an average of 10 feet deep exists and provides for 0.5 inch retention depth over the DCIA. Use retention depth of 0.5 inch (Figure 117).

5. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

6. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 118).

Figure 116 - Watershed Characteristics worksheet.

Figure 117 - Retention Basin worksheet.
Figure 118 - Catchment and Treatment Summary Results.

Notes: This example problem illustrates removal with a limited size of BMP, or retention basin in this example. The results show that a retention basin that treats 0.5 inches of the runoff from the watershed removes 16.44 kg/yr (36.21 lb/yr) of N and 2.21 kg/yr (4.86 lb/yr) of P discharging 15.89 kg/yr (35.00 lb/yr) of N and 2.13 kg/yr (4.69 lb/yr) of P. The efficiency for retention with the catchment land surface conditions and for the BMP size is 51%. If the retention basin can be deepened to an average of 13 feet, it would store 0.65 inches of runoff and result in a 74% efficiency (or discharge of 10.03 kg/yr of N and 1.78 kg/yr of P).
Example problem # 14 – BMP Analysis for Offsite Drainage from Natural Areas

This example problem examines the instance of offsite drainage from natural areas onto an FDOT right of way. There are two treatment options; one is to pass the offsite water into the FDOT treatment BMP, and thus two catchments in series with a BMP for the second catchment are used. The area of the second FDOT catchment is limited but the average depth for retention is 13 feet. Thus, considering treatment of the offsite area, 0.5 inch over the two catchments is the treatment depth. The other option is to examine the benefit of allowing the offsite discharge into a separate system without treatment, and can be examined using catchments in parallel.

B - 2 Catchment-Series

C - 2 Catchment-Parallel

The project location is Orlando, FL. The first catchment pre-development and post-development condition is agricultural-pasture with a Curve Number of 78. The total area is 10 acres. No Land use change is expected from pre to post development in catchment one.

This is a design problem with limited space for treatment. However, the depth of the retention pond can be up to 13 feet to accommodate offsite catchment flow. The second catchment pre-development condition is agricultural-pasture with a Curve Number of 78. The catchment area is 6 acres. The post-development conditions are highway with a non-DCIA Curve
Number of 78 and DCIA of 80%. As in the previous example problem, a 0.25 acre retention pond is to be used for treatment which is 0.5 inch of treatment over the second catchment area.

Part 1. Treating the catchments in configuration B:
1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 119).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the BMP Analysis option from the type of analysis drop down menu in the General Site Information worksheet.

Figure 119 - General Site Information worksheet.
2. Select the *Watershed Characteristics* button to proceed to the *Watershed Characteristics* worksheet.

   a. Indicate the catchment configuration. For this problem, 2 catchments configured as shown in BMPTRAINS option B (Figure 120).

   ![BMPTRAINS option B](image)

   **Figure 120 - Catchment Configuration for part 1 of this problem.**

   b. Indicate the pre- and post-development land use. Since we are only interested in BMP effectiveness, only the post-development catchment areas, non-DCIA Curve Number and DCIA percentage are required (Figure 121).
3. Select the *Stormwater Treatment Analysis* button at the top of the worksheet to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Retention Basin* button to proceed to the *Retention Basin* worksheet.

   a. Specify a 0.5 inch retention depth and note a deeper basin than used in the previous example problem to accommodate for the increased volume provided by the offsite flow.

   For the input data sheet (see Figure 122).

---

<table>
<thead>
<tr>
<th>CATCHMENT CHARACTERISTICS</th>
<th>Land use</th>
<th>Area Acres</th>
<th>Post-development Non DCIA CN</th>
<th>Pre-development DCIA percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-development land use:</td>
<td>Agricultural - Pasture: TN=3.470 TP=0.616</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development land use:</td>
<td>Agricultural - Pasture: TN=3.470 TP=0.616</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total post-development catchment area:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total post-development catchment or BMP analysis area:</td>
<td>6.00 AC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-development Non DCIA CN:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development Non DCIA CN:</td>
<td>78.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-development DCIA percentage:</td>
<td>80.00 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated Area of BMP (used for rainfall excess not loadings):</td>
<td>0.25 AC</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 121 - Watershed Characteristics worksheet.**
Comparing the removal effectiveness when offsite drainage is added to a fixed area of retention basin at the same average depth to a design with no offsite drainage shows a decrease to 68% (Figure 121) as compared without treating the offsite area or 74% (see comments under Figure 118).

5. Select the Stormwater Treatment Analysis button to proceed to the Stormwater Treatment Analysis worksheet.

6. Select the Catchment and Treatment Summary Results button to proceed to the Catchment and Treatment Summary Results worksheet (Figure 123).
Figure 123 - Catchment and Treatment Summary Results.

Notes: The N discharged is 24.39 kg/yr (53.73 lb/yr) and the P discharged is 3.64 kg/yr (8.03 lb/yr). The N and P removal is 51%. Example problem #13 has the same catchment 2 land use characteristics but no offsite drainage. The N discharged from problem 13 is lower than this problem however, treating the offsite drainage results in the removal of an additional 9.01 kg/yr (19.83 lb/yr) of N and 1.59 kg/yr (3.51 lb/yr) of P.

Part 2. Treating the catchments as parallel flow streams as shown in the BMPTRAINS model configuration C (Figure 123): The offsite flow is bypassed.

1. All of the existing data can be used for this part of the problem except the catchment configuration needs to be changed.
2. Select the *Watershed Characteristics* button to proceed to the **Watershed Characteristics** worksheet.

a. Indicate the catchment configuration. For this part, 2 catchments using configuration C of the BMPTRAINS Model (Figure 124). We are examining the flow streams separately.

![C - 2 Catchment-Parallel](image)

**Figure 124 - Catchment Configuration C.**

b. The pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage remain the same (Figure 125). Because the offsite flow is not treated and for ½” treatment, the retention basin can be 10 feet (not 13 feet) or less area (0.19 ac) is needed.
5. Select the *Stormwater Treatment Analysis* button at the top of the worksheet to proceed to the *Stormwater Treatment Analysis* worksheet.
6. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 126).

![Figure 126 - Catchment and Treatment Summary Results.](image)

**NOTES:** First, some combination of less basin area and less depth results when treating only the onsite runoff. When not treating the offsite drainage, the combined annual N discharged is 61.22 lb/yr and P discharged is 9.88 lb/yr compared to treating the offsite in a deeper pond giving 53.73 lb/yr N and 8.03 lb/yr P (series treatment, Figure 123). This differential is because the offsite land use is pasture and has a relatively high event mean concentration. If the offsite land use were Apopka forest lands, the discharge loadings of the parallel system would be reduced to only 36.54 lb/yr and 3.93 lb/yr of N and P respectively with the same soil conditions as used in this example.
Example problem # 15 – Different N and P removal efficiencies specified

This example problem presents the instance of different specified removal efficiencies for N and P removal. This can be analyzed using any number of catchments (up to 4) in any configuration.

For this example problem, one catchment will be used. The project location is in the Tallahassee, Florida area. The catchment pre-development condition is agricultural-general agricultural with a non-DCIA Curve Number of 60. The total area is 10 acres. The post-development conditions are light industrial with a non-DCIA Curve Number of 60 and DCIA of 70%. A 0.25 acre detention pond is to be used for treatment with an average annual residence time of 50 days. A littoral zone is to be used with a 15% efficiency credit assumed. This problem is to be treated as a specified removal efficiency problem. The objective is to remove 45% N and 70% P.

Solution:

1. From the introduction page click on the Click Here to Start button to proceed to the General Site Information worksheet.
   a. Select the Reset Input for Stormwater Treatment Analysis button to erase any existing data.
   b. Enter the project name and select the meteorological zone in the General Site Information worksheet (Figure 127).
   c. Indicate the mean annual rainfall amount in the General Site Information worksheet.
   d. Select the Specified Removal Efficiency option from the type of analysis drop down menu in the General Site Information worksheet and enter 45% and 70% for N and P, respectively.
2. Select the Watershed Characteristics button to proceed to the Watershed Characteristics worksheet.
   a. Indicate the catchment configuration. For this problem, 1 catchment configured as shown in A (Figure 128).

   ![A - Single Catchment](image)

   Figure 128 - Catchment Configuration for this problem.

   b. Indicate the pre- and post-development land use, catchment areas, non-DCIA Curve Number and DCIA percentage (Figure 129).
3. Select the *Stormwater Treatment Analysis* button at the top of the worksheet to proceed to the *Stormwater Treatment Analysis* worksheet.

4. Select the *Wet Detention* button to proceed to the *Wet Detention* worksheet.
   
a. Under catchment 1 specify a 50 day average annual residence time, a littoral zone (drop down menu), and a 15% efficiency credit (drop down menu) (Figure 130).

5. Select the *Stormwater Treatment Analysis* button to proceed to the *Stormwater Treatment Analysis* worksheet.

6. Select the *Catchment and Treatment Summary Results* button to proceed to the *Catchment and Treatment Summary Results* worksheet (Figure 131).
NOTE: This example shows how the user can select different target removal efficiencies for N and P. In this case, the target removal effectiveness values of 45 and 70 for N and P respectively were achieved. The target load reduction (effectiveness) is not achieved when there is no credit for littoral zones (40% for N and 68% for P). Also, the discharge loadings increase as the soil increases in clay content or in impervious cover (reflected in the non DCIA CN).
List of References


