North Carolina Stormwater Nitrogen and Phosphorus (SNAP) Tool

Version 4.1

Users' Manual

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Chapter 1: Overview

1.1. Introduction

North Carolina's Stormwater Nitrogen and Phosphorus Tool (SNAP Tool) is a Microsoft Excel-based spreadsheet that uses the Simple Method to estimate annual runoff volume and nutrient loading generated by a user-defined watershed. The Tool also allows users to estimate runoff volume and nutrient load reductions using different Stormwater Control Measures (SCMs). The type(s) and location(s) of the SCMs can be customized by users to optimize reduction of stormwater runoff from a site. The flow and pollutant load reduction provided by a given SCM is calculated using the effluent Event Mean Concentration (EMC) metric.

1.2. Purpose and Uses of the Tool

The Tool is currently approved for use in the Jordan Lake and Falls Lake watersheds for meeting the requirements of **applicable** nutrient management Rules in those watersheds. While it was initially designed for use in implementing the Jordan Lake and Falls Lake Nutrient Management Strategies, the underlying calculations and SCM characteristics may be used across the state for purposes of estimating nutrients exported from a site, including the coastal areas where design storm requirements are larger than elsewhere in the State.

In addition to calculating export of nitrogen and phosphorus from a site, the Tool can determine your export targets depending on your watershed and other variables used to assign unit-area-loading rates and buy-down thresholds in the Jordan Lake and Falls Lake Rules. With these export targets determined, it then calculates the amount of treatment still required for a site (which can be met with buy-down credits) or the amount of overtreatment provided. These latter calculations are intended for calculation of nutrient credits in existing development retrofit situations, but can also apply in new development and rebuild/expansion situations.

The following information should be considered prior to using the Tool:

1. It is the user's responsibility to know what is allowed in their jurisdiction prior to applying the Tool. The inclusion of any option or function within the Tool, such as SCM types, catchment routing options, under- or over-sizing of SCMs, etc., or even whether this Tool may be used for all or some types of development in a given jurisdiction, does not necessarily mean that its use will be approved by your governing authority.
2. When used for regulatory compliance purposes, any results obtained using the Tool require review by the applicable authority.
3. Calculations for sites in the Jordan Lake watershed are advisory for all applications except projects implemented by State and Federal entities (excluding NCDOT) and the NC Division of Mitigation Services.

4. The Tool has the ability to be used for new developments, redevelopment, expansions of development, and projects that retrofit stormwater development into existing developments.

5. The Tool is a **site-level** tool with the limitations of the Simple Method, e.g. drainage areas of 1 square mile or less, and should not be used for large watershed-scale assessments due to its underlying assumptions and methods.

6. Because Nutrient Management Strategies regulate nutrients in terms of mass and concentration of all nitrogen species combined and all phosphorus species combined, pollutant calculations in the Tool always work with "Total Nitrogen" and "Total Phosphorus" values. Where "total" is not included with "nitrogen" or "phosphorus" in the User's Manual, it should be assumed. No attempt is made to differentiate the behavior of different nitrogen and phosphorus chemical species in the governing Nutrient Management Strategies or in the Tool.

1.3. History

In 2009, the state of North Carolina developed the Jordan Lake Nutrient Management Strategy in an effort to improve the water quality of Jordan Lake, which was declared impaired in 2001 for high chlorophyll-a levels that violate state water quality standards. This Strategy included rules that required local governments within the Jordan Lake watershed to manage stormwater runoff from new and existing development. Additionally, the rules required the North Carolina Department of Environmental Quality's (then Department of Environment and Natural Resources) Division of Water Resources (then Division of Water Quality) to develop a method of estimating nutrient loading from new development, as well as quantify changes in nutrient loading associated with the implementation of stormwater best management practices (Stormwater Control Structures, or SCMs).

The result was the introduction of an accounting tool, named the Jordan Lake Stormwater Load Accounting Tool, developed by North Carolina State University's Biological and Agricultural Engineering Department in 2011. When the Falls Lake Nutrient Management Strategy was developed, the tool was re-named the Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (JFLSNAT) for version 2.0. After a year of widespread use, it became apparent that the complexity and aesthetics of the original Tool necessitated revisions. The Tool was modified in 2014 to improve the user-friendliness, transparency, and applicability of the accounting tool, resulting in version 3.0, but was not formally released due to unresolved errors and issues.

This version, 4.1, was updated to model DEMLR's new approach to calculating performance of under- and oversized stormwater control measures (SCMs), new effluent event mean concentrations (EMCs), and other changes in treatment efficiency. (Version 4.0 included delivery factors for Jordan and Falls Lakes that will not be implemented.) This version has many more SCMs available for selection and can accommodate outputs of alternative design models - HyPerMod for bioretention and permeable pavement, and Rainwater Harvester, developed by NCSU. Many changes were also made to improve usability, add calculations and outputs

related to nutrient management and nutrient credit trading, improve error checking and handling, make future updates easier, and update the internal structure for potential merging with other Stormwater calculation tools in the future. A full list of modifications made for this version can be found in **Chapter 5: Summary of Modifications**.

The Tool may be used in other parts of the State to estimate nutrient loading and stormwater treatment, such as for grant applications. It has also been revised to include the Neuse and Tar-Pamlico Nutrient Management Strategy Rules, but has not been approved for use in rule compliance.

Since it now may be applied across the state its name has been changed to the **Stormwater Nitrogen and Phosphorus Tool** (SNAP Tool). The spreadsheet has had variations in naming over the years, so throughout this document SNAP v4.1 is referred to as "the Tool".

1.4. Acknowledgments

DWR staff greatly appreciate the contributions of staff from NCSU's Bio & Ag Engineering Department and those of DEQ's Division of Energy, Mineral, and Land Resources to the revision of the Tool itself and materials that have gone into revising this Users' Manual. We also appreciate the feedback and bug reports from beta-testers in private industry and local government in the process of testing and refining the Tool.

Chapter 2: How to Use the Tool

The Tool is comprised of 7 user-oriented worksheets: *Intro*, *1. Project Info*, *2. Land Cover Characteristics*, *3. SCM Characteristics*, *4. Overall Summary*, *5. SCM Summaries*, and *Nutrient Offset*. You may navigate between these pages using the button links or by the tabs at the bottom of the page. These sheets are explained in detail below.

The Tool also contains 5 supporting worksheets where reference information is held and calculations are done: *Assignments*, *Lookup Tables*, *Project Calcs*, *SCM Calcs*, and *CSV*. You can view these sheets, but may not make edits on any of them.

A few things to note throughout the Tool:

1. In order for the "Clear" buttons, print functions, credit calculations, import/export function and any other buttons to work, **macros must be enabled**. Macros are initially disabled by Excel because this is a method of transmitting computer viruses from untrustworthy sources.
    (a) After downloading the compressed spreadsheet from the NCDEQ website, extract the file by right-clicking on it and selecting "Extract All".
    (b) When you first open the spreadsheet, just below the menu bar you will see a warning "PROTECTED VIEW", and a button to "Enable Editing". Click to go to the next step.
    (c) Next you will see "SECURITY WARNING", and a button to "Enable Content". Click this button to enable macros.
    (d) You will be asked to make this document a "Trusted Document". If you do that, you won't have to click those buttons again.
2. Cells in the spreadsheet have different colors to denote different purposes or uses:
    (a) Beige/gray-shaded cells are designed for optional data input.
    (b) Yellow-highlighted cells require data for runoff and nutrient load calculations.
    (c) Green-highlighted cells require data for nutrient export target and credit/debit calculations.
3. Double-clicking on a drop-down menu will produce a list in a larger font.
4. Hover your mouse cursor over cells with a red-orange triangle in the upper right-hand corner to show pop-up help for that cell.

Throughout this Chapter of the User Manual, icons mark out instructions:

✅ This icon indicates needed data.

ℹ️ This icon indicates helpful information or optional data.

⚠️ This icon indicates an error warning, or an action is prevented.

❌ This icon indicates something **YOU SHOULD NOT DO**.

2.1. Terms of Use

To ensure that users are aware of the limitations of using this tool for complying with nutrient management regulations, a popup window with this information comes up every time the Tool is opened:

> *For regulatory compliance purposes, any results obtained using this tool require review by the applicable authority and may require revision.*
>
> *The Tool has been subjected to rigorous testing, but in the event an error is identified in its calculation processes during the course of a regulatory approval, you may be required to abide by the corrected results.*

2.2. Intro Sheet

The Intro sheet (**Figure 2-1**) is the first page you will see after clicking through the Terms of Use. Buttons to open webpages with references and resources are located along the bottom of the sheet. Buttons at the left of the sheet allow you to navigate to the other sheets. Buttons to the right of the sheet provide assistance and additional functions. There is no data entry on this page.

A SNAP Tool users' discussion listserv has been set up to help users get extra help, report bugs, and discuss scenarios with listserv members. DENR staff are subscribed to this list and available for assistance. To subscribe, send an email to SNAPTool-request@lists.ncmail.net with only the word "subscribe" in the subject or body of the email. Make sure to check your Junk Mail box for the subscription confirmation email.

Figure 2-1: Intro Sheet.
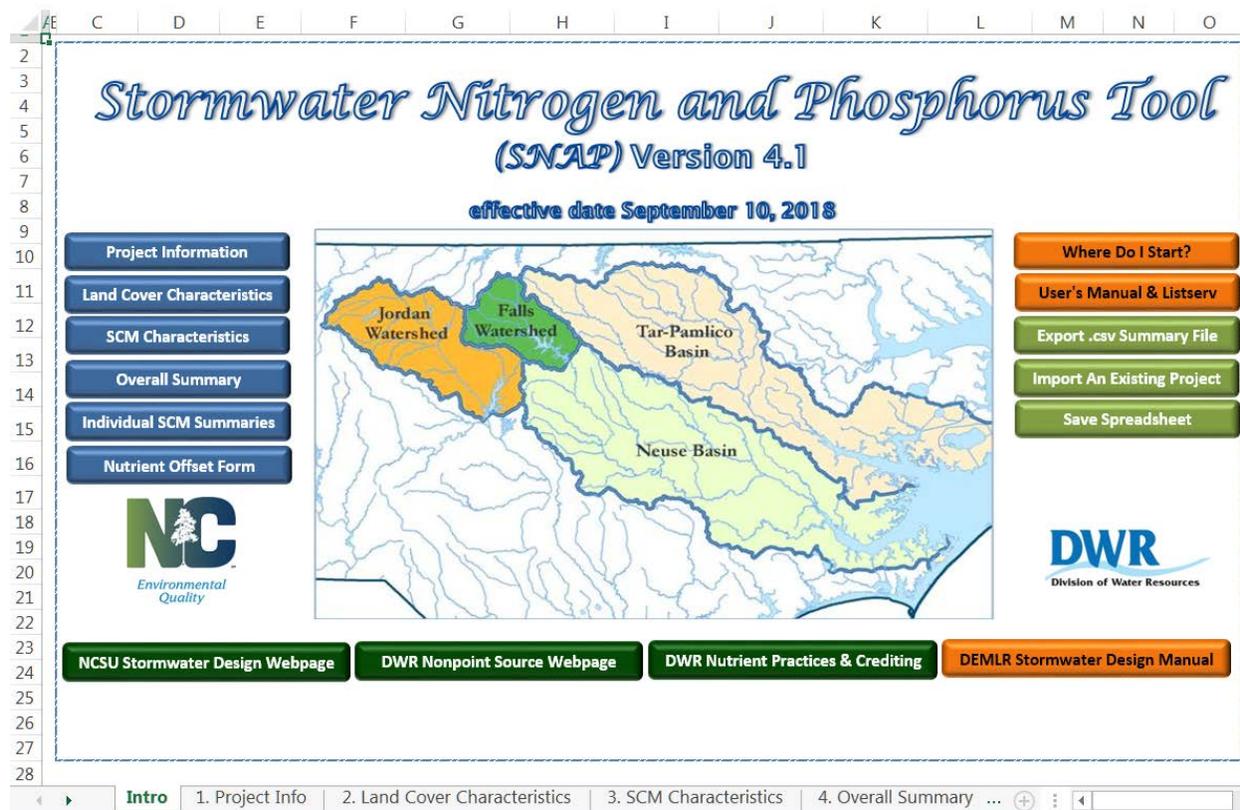
2.2.1. Where Do I Start?

✅ If you simply want to start using the Tool, click the button "Where Do I Start?".
Afterwards come back to the User's Manual to better understand the results you get.

Clicking on this button will bring up a pop-up page that has the barest essentials of what the Tool is about, applicability of the Tool, what inputs are needed, and what outputs are provided.

Data you'll need at a minimum to get nutrient runoff and treatment calculations (these critical fields show up highlighted in yellow):

1. Total project area broken down into land covers, in square feet.
2. Determination of the appropriate precipitation station data to use.
3. Total area draining to each SCM (Stormwater Control Measure), broken down into land covers, in square feet, including the area of the SCM itself.

4. Determination of the size of your SCM relative to the "full size" design requirements in your area (i.e., based on the percentage of water quality volume provided in the SCM relative to the amount required).
5. Dominant Hydrologic Soil Group where your SCM is located.

2.2.2. Saving, Exporting, and Importing

Saving

Should you wish to save a version of the Tool as a separate file, follow these instructions. This will save the tool so you can easily go back and change the data as you need to without having to re-import the data.

1. Click the *Save Spreadsheet* button.
2. Choose where you want to save it as well as what you want to name it.

Exporting

The data you enter into the Tool can be exported into a format that can be easily shared with others using the same version of the Tool. Macro-enabled Excel files are often stripped of macros, or even blocked by email servers entirely. This function creates a simple comma-separated-values file (CSV), easily read by programs such as databases, and not modified or blocked by email servers.

1. Click on the *Export .csv Summary File* button.
2. You will be prompted for what you want the file to be named and what directory to put it in. Enter the desired name and click OK or press Enter.
3. If you have already saved a file as that name, you will be asked if you want to overwrite it. Click OK to overwrite it or Cancel to cancel the process.
4. The Tool will warn you that it will close after exporting. Make sure you save beforehand.

> ⊗ Use only the Export button that is provided within the Tool to create .csv files. Do not use the *Save As (.csv)* function native to Excel as you will get unpredictable output.

For this version, the Export format has been altered to be in columnar format with field names in the far-left column, and data separated by commas to the right. This arrangement can be transposed (columns to rows, rows to columns, field names in the first row) so the data may be easily imported into database software. To transpose CSV data to have field names in the first row:

1. Copy the columns of cells that include all field names and data. Because some parts, such as the catchment information, have more than two columns, it may be easiest to do this in groups of cells.

2. In another sheet select the upper-leftmost cell. Right-click and select the Transpose paste command, or access the Transpose command through Paste Special.

> ℹ️ The .csv file is not meant to be as a user-friendly summary of project inputs and outputs; it is intended for easily sharing project information among users and agencies, such as for plan review. It may also be used to export data to databases.

Importing

As described above, it is easy to share CSV files with others, whereas sharing macro-enabled Excel files poses some difficulties. The Import function reads in CSV files and writes the data to the appropriate sheets. CSV files must have been created by the same version of the Tool as the one you are using. In the process, it runs error-checks that verify that values set by the Tool, such as EMCs and volume partitions, have not been altered by the person providing the CSV file. This preserves the integrity of the calculation rules applied and ensures all users are working with the same set of SCM attributes. To import a project:

1. Click on the *Import An Existing Project* button.
2. The file explorer window will appear. Navigate to the location where you saved the CSV file. The file type may be called "Microsoft Excel Comma Separated Values File".
3. Once you have found the file, click Open to import the CSV file into the tool.

> ⚠️ The Tool will only import CSV files created using the same version of the Tool. If you edit the CSV file, the data may not be imported correctly if at all.
>
> ❌ Do not import data into the Tool if you want to keep your currently-entered data. The Import function will overwrite any existing data in your spreadsheet upon importing.

2.3. Project Info Sheet

2.3.1. Sheet Elements and Navigation

The Project Info sheet allows you to enter pertinent information for a given project, shown in **Figure 2-3** below.

Information needed to calculate runoff and nutrient export from the project area, as well as nutrient treatment by SCMs, is highlighted in yellow. Information needed to determine target export rates and loads, buy-down loads, and treatment balance (credits/debits) based on the various Nutrient Management Watershed Rules is highlighted in green.

You can clear all entries on this sheet by clicking the "Clear Project Data" button at the top left of the worksheet. The buttons below that print out this sheet on a single side of an 8.5 x 11" piece of paper or navigate among the different worksheets.

On the right side of the sheet is a set of buttons that open 5 maps and a button that opens an ArcGIS Online map:

1. a physiographic region map (**Figure 2-2**)
2. a Jordan Lake Delivery Zones map (**Figure 2-4**)
3. an annual precipitation map (**Figure 2-5**)
4. ArcGIS Online map that helps you find the appropriate precipitation station, and determine NMS Watershed, Subwatershed, and Delivery Zones based on location (https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=633ce7f0a61a44f9997ff257e25b9a81)

Data entry in pull-down menus is limited to the list for each menu. You may enter them by selection or by typing. Warning messages on this sheet include:

1. The Project Area is checked to make sure it is no larger than 1 square mile. The Simple Method is not appropriate for larger areas.
2. Project Area is checked to make sure it is larger than zero.
3. Project Area is checked to make sure it is equal to or larger than Disturbed Area. Project Area may include areas that are undisturbed along with the Disturbed Area.
4. Precipitation Station is checked to make sure one is selected.

Figure 2-2: Map of physiographic regions within the state of North Carolina.
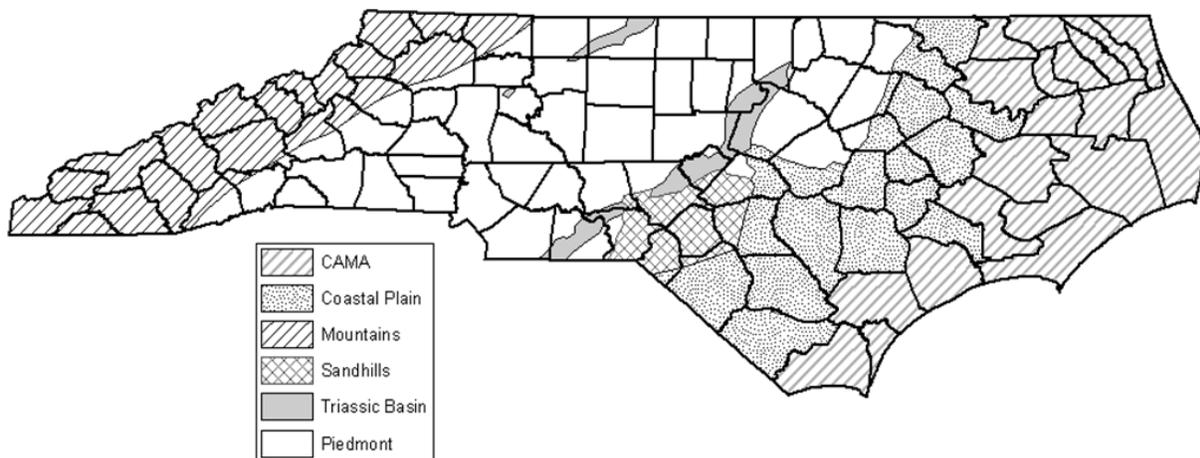
Figure 2-3: Example Project Info Sheet.

	Project Information	
Print Project Info	Project Name:	John's Surf Mart & Beach Emporium
Clear Project Data		
	Submission Date:	11/01/2018
Introduction	Project Area (ft²):	100,000 · ft²
Land Cover Characteristics	Disturbed Area (ft²):	65,000 · ft²
SCM Characteristics	Development Land Use Type:	Commercial
	Development Activity Type:	Development - New
Overall Summary	Designated Downtown Area?	no
Individual SCM Summaries	Project Location/Address:	N Pointe Drive, Durham
Nutrient Offset Form	County:	Durham
	Local Jurisdiction:	Durham
Yellow cells require data for PROJECT AREA RUNOFF and NUTRIENT TREATMENT calculations	Project Latitude Coordinates:	36.026777 · N
	Project Longitude Coordinates:	-78.916257 · W
	Precipitation Station:	Durham
	Physiographic Region:	Triassic Basin
Green cells require data for NUTRIENT TARGETS, BUYDOWN, & CREDIT/DEBIT calculations	Nutrient Management Watershed:	Falls Lake
	Subwatershed:	Falls - Upper
	Phosphorus Delivery Zone:	Falls - Upper
	Nitrogen Delivery Zone:	Falls - Upper
	Project Designer and Contact Phone Number / Email:	
	Part of Common Development Plan?	no
	Project Owner Type:	Private
	Project Description:	

Buttons (right side): **Physiographic Regions Map**, **Precipitation Stations Map**, **Jordan Delivery Zones Map**, **Online Clickable Map**

Sheet tabs: ... | **1. Project Info** | 2. Land Cover Characteristics | 3. SCM Characteristics | 4. Overall Summary | ...

Figure 2-4: Map of Jordan Lake Delivery Zones.
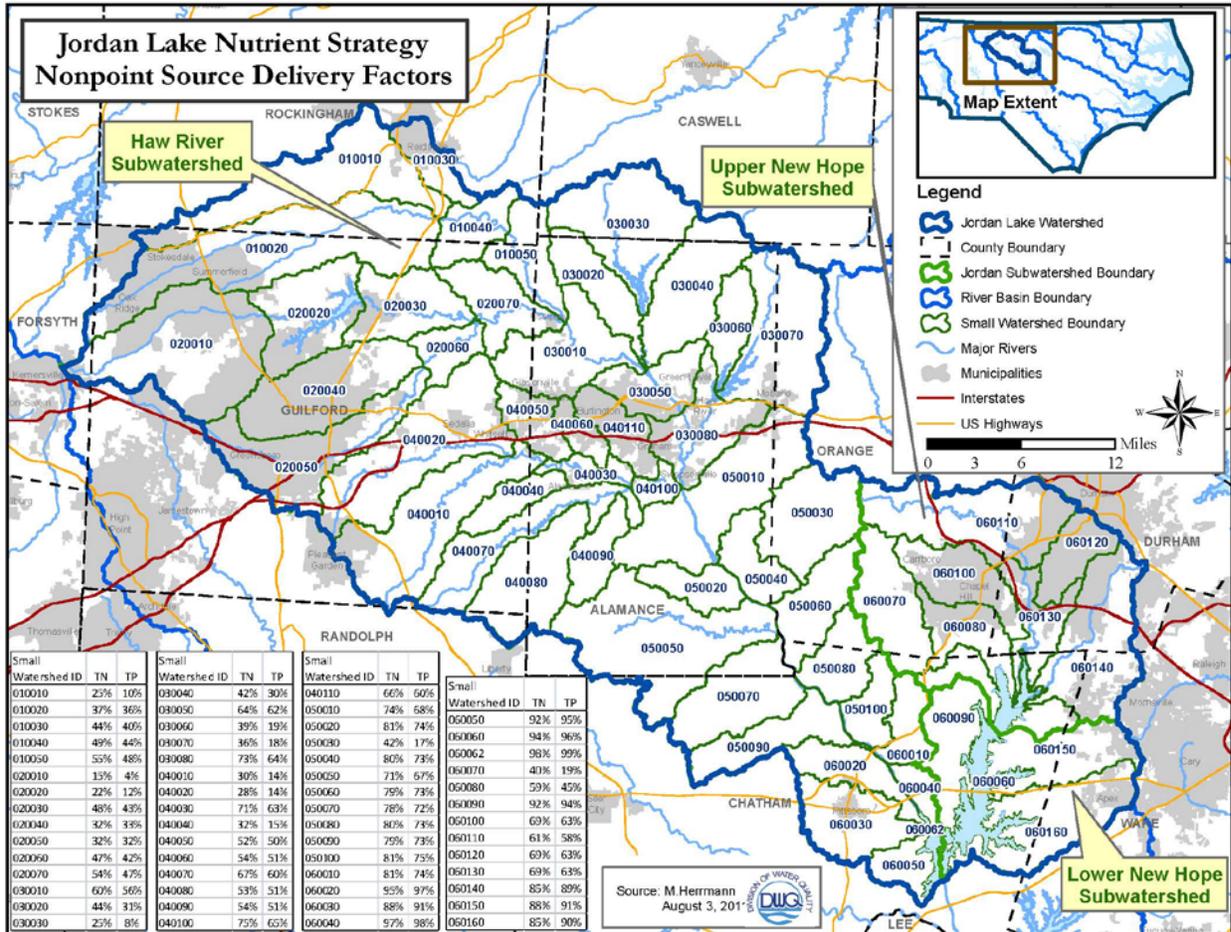
Figure 2-5: Average annual precipitation map for the state of North Carolina. Labeled towns/cities are available in the dropdown menu for Precipitation Station.
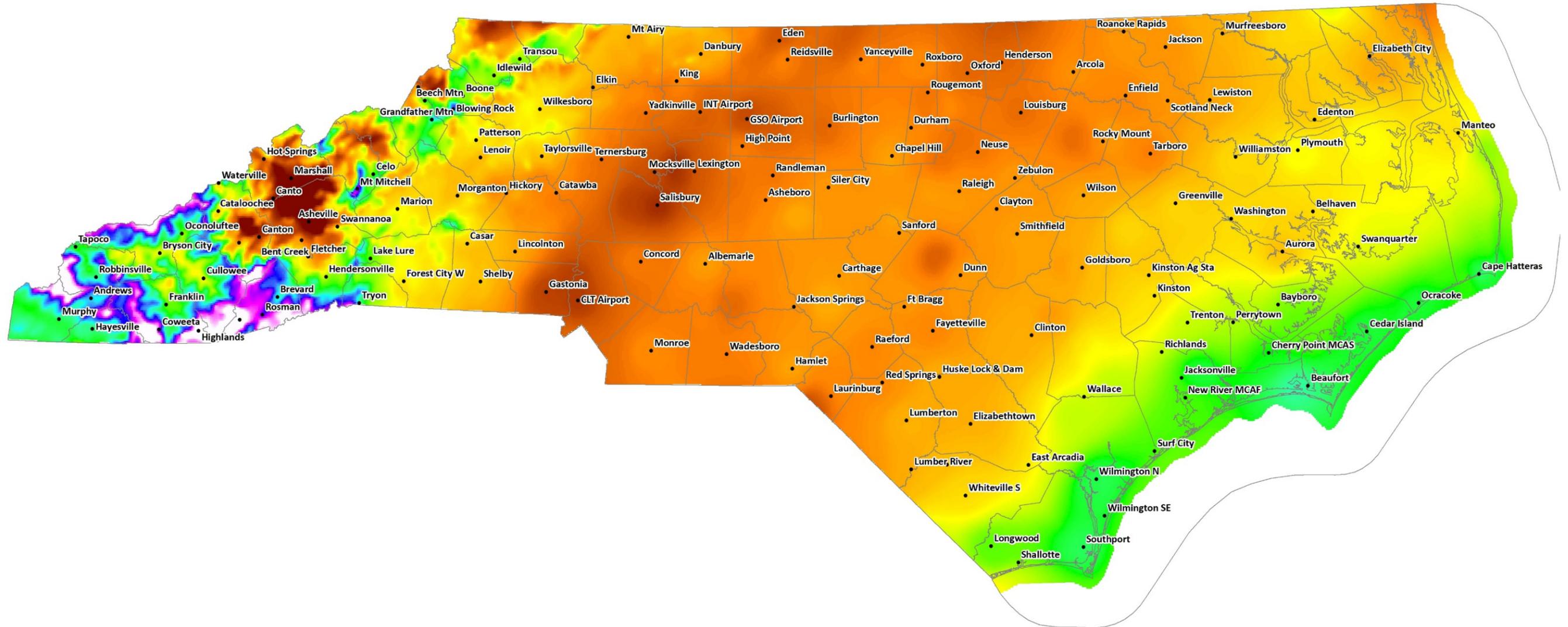
2.3.2. Minimum Requirements for Calculations

Two pieces of information are critical for the Tool to calculate project runoff and nutrient load: Project Area and Precipitation Station. These fields are highlighted in yellow on the worksheet.

The Project Area is the total number of square feet comprising the project site to be analyzed. It is important that this value equal the sum of all areas entered in the Pre- and Post-Project land cover columns on the Land Cover Characteristics sheet.

For the Precipitation Station select a location from the drop-down menu that most closely represents the rainfall patterns of the site. This station may not necessarily be the closest location to your site. If uncertain, select a nearby precipitation station with a similar background color to your location in **Figure 2-5** (precipitation map). The Tool uses the location you selected to determine stormwater runoff volumes for the site.

The entire set of precipitation stations can be viewed on an online clickable map, which also includes Nutrient Management Watershed information. It can be found online at https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=633ce7f0a61a44f9997ff257e25b9a81.

> ✅ Entries for Project Area and Precipitation Station are **required** for the Tool to calculate the runoff and nutrient load shed from the site. These fields are highlighted in yellow.
>
> ✅ Choose the precipitation location that best represents the precipitation characteristics at the project site, not the location that is the closest! If uncertain, select a nearby precipitation station with a similar background color to your location in **Figure 2-5** (precipitation map).
>
> ✅ Entries needed for the Tool to calculate nutrient targets, buydown targets, and credits/debits (treatment balance) are highlighted in green.
>
> ⚠️ The worksheet will display a warning message if you have entered a Project Area larger than a square mile. The calculation method used in the Tool (Simple Method) is not designed for larger areas
>
> ⚠️ The worksheet will display a warning message if you have not selected a Precipitation Station. No calculations will be done in this case.

Another set of information, described below, is required to calculate nutrient export targets, buy-down thresholds, and nutrient treatment balance (credits/debits). Output is based on the requirements of the various Nutrient Management Watershed Rules. These fields are highlighted in green. Additional data entry fields are provided for use by project designers and governing authorities in conveying or tracking additional information regarding a project.

Disturbed Area is used to determine applicability of Nutrient Management Watershed Rules, but otherwise is not included in calculations. Your approving authority may have specific requirements, definitions, or inclusions for Disturbed Area. Disturbed Area usually is at least as large as the net change in land covers, but may be smaller in some *Existing Dev. Retrofit* and *Redevelopment* cases. For instance, Disturbed Area may equal zero if a land cover change happens, such as reforestation, that is not considered "disturbance". For *Development - Expansion*, Disturbed Area should exclude the pre-project amount of built-upon area in the area of disturbance.

Development Land Use Type includes C*ommercial*, *Industrial*, *Institutional*, *Mixed-Use*, *Duplex Residential*, *Single Family Residential*, and *Multi-Family Residential*. Recreational facilities associated with single family residential or duplex residential should be classified as one of those two land use types. If your project doesn't neatly fit one of these categories, use *Mixed-Use*.

Development Activity Type has four options: *Development - New, Redevelopment*, *Existing Dev. Retrofit*, and *Development – Expansion*. The first three categories are based on the State's definitions of "development", "redevelopment" (no net increase in built-upon area), and "existing development". The last category is for development projects with existing development where there is a net increase in built-upon area (this concept has no formal term in State statute). Projects done by the Division of Mitigation Services should be selected as *Existing Dev. Retrofit*.

Designated Downtown Area describes whether your site is located in a designated downtown area. While it is a characteristic specific to the Falls Lake Rules, the field must be filled in to calculate results regardless of your nutrient management watershed.

Local Jurisdiction is your approving authority, which may be a municipality, a county, or the State. This information is used in determining how Rules apply to your project. In the Neuse and Tar-Pamlico watersheds, this value is used to include or exclude projects from Rule requirements depending on the jurisdiction selected.

Project Latitude and Longitude Coordinates are the X-Y latitude and longitude of your project in decimal degrees. When viewing the online map showing delivery zones and precipitation stations, latitude and longitude in decimal degrees can be read from the center of the map (look for a small pair of numbers at the bottom left corner of the map that change as the map's center moves). It can be found online at https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=633ce7f0a61a44f9997ff257e25b9a81.

Nutrient Management Watershed has selections for *Jordan Lake*, *Falls Lake*, *Neuse*, *Tar-Pamlico*, and *Randleman* watersheds, but also for areas outside of these watersheds (*outside NMS watershed*), along with related Subwatershed and Nitrogen and Phosphorus Delivery Zone

fields. Subwatershed is the initial variable used to determine Rule applicability. This information allows calculation of loads delivered to nutrient management strategy waterbodies, in addition to loads leaving the site, which enables purchase of nutrient offset credits from locations in other delivery zones via the common currency of delivered loads. **The Tool is currently only approved for use in meeting applicable Nutrient Management Strategy Rules in the Jordan Lake and Falls Lake watersheds.**

If your project is in the Jordan Lake watershed, refer to the Delivery Zone Map to determine which delivery zone your project is located in. All other areas have the same zone for phosphorus and nitrogen. Delivery Zones outside of the Jordan Lake watershed have site loading rates unaltered for both Nitrogen and Phosphorus. In these areas nutrient offset credits may be restricted by 8-digit Hydrologic Unit, if applicable. If in doubt, check with your local approving authority.

All of the Nutrient Management Watersheds, Subwatersheds, and Delivery Zones can be viewed in an online clickable map. This map also includes the entire set of precipitation stations. It can be found online at https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=633ce7f0a61a44f9997ff257e25b9a81.

Part of Common Development Plan is another aspect of your project that is used to determine applicability of certain Rules.

Project Owner Type has selections for Private, Local Government, *Federal Gov't*, and *State Non-NCDOT*, since the various Nutrient Management Watershed Rules have different requirements.

> ✅ Select **both** the Nitrogen and the Phosphorus Delivery Zone for your site. Select the same zone for N and P for all areas.
>
> ℹ️ Physiographic Region is not used by any calculations; the map is simply provided for information purposes.
>
> ℹ️ The Tool does not check values selected in pulldown menus to make sure they match, such as between Nutrient Management Watershed, Subwatershed, and Local Jurisdiction, among others. Be sure to review your selections. The online map can help you select a geographically correct set of watershed information: https://ncdenr.maps.arcgis.com/apps/MapTools/index.html?appid=067b9cc0d99c4be5a6ce59794ac781bc

2.3.3. Defining the Project Area

"Project Area" in the Tool is defined as the area for which you are obtaining a development permit (for new development and expansion of development) or the area draining to a retrofitted SCM (for existing development). At a minimum, your project area usually encompasses all disturbed area according to the State's definition of "development". "Project" and "Development" are not considered synonymous, however, as "project" can include adjacent undisturbed areas that are not part of another project. Be sure to consult your permitting authority which may be very specific and particular about what counts as your project area.

For new development, project area generally is coincident with parcel boundaries, but may consist of only the disturbed area of a parcel, include some adjacent undisturbed area, comprise a full common plan of development, or even include areas outside your parcel or common plan area that drain to SCMs on your site. **For development expansions,** where there is a net increase in built-upon area (BUA), the project area and disturbed area are coincident, and should exclude any amount of pre-existing BUA in the disturbed area. **For redevelopment and existing development retrofits**, project area is at a minimum the area draining to SCMs you install and areas undergoing land cover change.

If you are using SCMs on your site you must include all area draining to those SCMs for correct calculations, whether or not all areas are part of your permit, whether or not there is "off-site run-on", and whether or not these areas are disturbed. This does not mean you are required to reduce nutrients from offsite areas, only that they need to be modeled if they flow into your SCMs. If you have a situation with "offsite run-on", you can find instructions on how to model it and split your results between on-site and off-site in **Chapter 3: Examples and Special Scenarios**.

> ❌ If SCMs are used in the project, you must include all area draining to those SCMs for correct calculations. **Do not exclude** "offsite" areas that drain to your SCMs.
>
> ℹ️ See **Chapter 3: Examples and Special Scenarios** for how to handle a variety of special scenarios including development expansion sand "offsite run-on" areas.

2.3.4. Development Activity Types

The Development Activity Type determines how nutrient strategy Rules are applied to your project. The way the Nutrient Rules are phrased, new development requirements are based on newly-disturbed area. The Simple Method, upon which the Tool's calculations are based, does not require a comparison to pre-project conditions to determine runoff and nutrient export.

Development - New: New development does not require any information about what was previously on the site; only Post-Project data must be entered, even to calculate nutrient export targets, buydown thresholds, and nutrient credits/debits. Entering Pre-Project data is optional.

You will get warnings if you don't enter Pre-Project data, and the net change in land cover will equal your entire Post-Project area, but it will not affect your output.

Development – Expansion: Expansions of development also do not require any information about what as previously on the site; only Post-Project data must be entered, similarly to new development scenarios. However, if you entered Pre-Project data, it will test that the Pre-Project BUA equals zero to make sure you have excluded any BUA that is NOT part of the net increase. Project Area should equal the Disturbed Area, which in turn should include only the net increase in BUA and associated disturbed pervious areas.

Existing Dev. Retrofit: Pre-Project data is required when modeling existing development retrofit situations. In this case, you are not adding any development or disturbing any area beyond the SCM footprint and attendant stormwater conveyances. Any increase in built-upon area (BUA) is interpreted as rebuild/expansion with an increase in BUA, and nutrient credits/debits are not calculated directly. See below.

Redevelopment: Redevelopment has a specific legislative definition that requires no net increase in built-upon area (BUA). The Tool checks that this is case, and thus requires input of both Pre-Project and Post-Project data. Where the BUA does not increase, it is treated just like Existing Development. Where net BUA increases, it does not meet the definition of "redevelopment"; you will be instructed to model this as an expansion in order to determine nutrient credits/debits.

ⓘ See **Chapter 3: Examples and Special Scenarios** for how to handle a variety of scenarios including complex expansion, mixes of expansion and redevelopment, and existing development retrofits.

2.4. Land Cover Characteristics Sheet

2.4.1. Sheet and Navigation

In the Land Cover Characteristics sheet (**Figure 2-6**) you enter all the different types of land covers, in square feet, present in the whole project area, both pre- and post-project conditions.

✅ Enter the total area in square feet within the project area for each type of land cover that is present. If a particular land cover is not present on the site, the cells may be left blank or a zero may be entered.

The TN EMC and TP EMC values listed beside each land cover are the representative *event mean concentrations* of total nitrogen (TN) and total phosphorus (TP) found in stormwater runoff leaving that type of land cover. The methods used to establish percent impervious assignments

and representative pollutant concentrations for individual land covers are described in **Section 4.5 Sources for Land Cover EMCs**.

As a reference, the equations used to calculate project area runoff and nutrient loading are listed below the Land Cover Area Check section. Below that you will find the calculation inputs and results for Pre-Project and Post-Project conditions.

Clear all entries by clicking the "Clear Land Cover Data" button at the top of the worksheet. The next button prints out this sheet on a single side of an 8.5 x 11" piece of paper. The other buttons navigate among the different worksheets.

Figure 2-6: Example Land Cover Characteristics Sheet.

PROJECT AREA LAND COVERS	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Project Area (ft^2)	Post-Project Area (ft^2)
Roof	1.18	0.11		30,000
Roadway	1.64	0.34		
Parking/Driveway/Sidewalk	1.42	0.18		30,000
Protected Forest	0.97	0.03	100,000	35,000
Other Pervious/Landscaping	2.48	1.07		
CUSTOM LAND COVER 1				
CUSTOM LAND COVER 2				
CUSTOM LAND COVER 3				
LAND TAKEN UP BY SCM	1.18	0.11		5,000

WARNING MESSAGES SHOW UP HERE IN RED

LAND COVER AREA CHECK

Net Change of Land Covers (ft^2):	65,000
Total Project Area Entered (ft^2):	100,000
Total Pre-Project Calculated Area (ft^2):	100,000
Total Post-Project Calculated Area (ft^2):	100,000

Equations Used and Project Area Calculations

SIMPLE METHOD   *Stormwater Runoff Volume Generated, V*

Runoff Coefficient, R_v

$$R_v = 0.05 + (0.009 * I)$$

where I = percent impervious (%)

$$V = P_j * Rv * (P/12) * A$$

where A = drainage area (ft^2)

P_j = fraction of rain events with runoff

P = average annual rainfall depth (in)

Average Annual Pollutant Load, L

$$L = (P_j * R_v * (P/12)) * (C * A * 2.72)$$

where C = event mean concentration (mg/L)

Pre-Project:			**Post-Project:**		
A = 2.2957	ac		A = 2.2957	ac	
P = 47.81	in.		P = 47.81	in.	
V = 17929	ft^3		V = 228592	ft^3	
I = 0%			I = 65%		
R_v = 0.05			R_v = 0.64		
P_j = 0.9			P_j = 0.9		
C_{TN} = 0.97	mg/L		C_{TN} = 1.28	mg/L	
C_{TP} = 0.03	mg/L		C_{TP} = 0.14	mg/L	
L_{TN} = 1.09	lb/yr		L_{TN} = 18.29	lb/yr	
L_{TP} = 0.03	lb/yr		L_{TP} = 1.99	lb/yr	

Intro | 1. Project Info | 2. Land Cover Characteristics | 3. SCM Characteristics | 4. Overall Sumr ...

2.4.2. Warnings and Data Checks

Data entries are checked in a variety of ways to reduce errors. The Land Cover Area Check section of the sheet summarizes your entered data. Total Project Area, the sum of Pre-Project land covers, and the sum of Post-Project land covers are compared for differences. A warning is displayed if these do not match, though results will still be calculated on this sheet.

Net change of land cover is an estimate of the minimum disturbed area based on land cover changes. To determine the net change in land covers, first the Post-Project area is subtracted from the Pre-Project area for each type of land cover. The net change is the sum of the absolute values of these subtractions, divided by 2. This is compared against the Disturbed Area value entered on the Project Information sheet to flag potential errors. This is a minimum estimate of disturbed area for most situations, but some kinds of land cover change may not be considered "disturbance", such as reforesting grassy areas.

Since Precipitation Station information is critical to do calculations on this page, an error message is displayed if a station isn't selected.

⚠ A warning message is shown if the sum of Pre-Project areas does not equal the sum of Post-Project areas. Nutrient credits/debits will be calculated for new development and expansions but will not be calculated for redevelopment or existing development retrofits.

⚠ A warning message is shown if the sum of Post-Project areas does not equal the Project Area entered on the Project Info sheet. Nutrient credits/debits will not be calculated because this is a critical error.

✅ Pre-Project data is required for calculating nutrient credits/debits for *Existing Dev. Retrofits* and *Redevelopment*, but not for *Development - New* or *Development - Expansion*.

2.4.3. Land Cover Types

Previous versions of the Tool had a broader but complex variety of land cover types to choose from. This version of the Tool has condensed that set down to simplify choices for users and establish more statistically robust concentration estimates for land covers. There are now fewer distinctions between different land covers, such as parking lots in commercial zones versus parking lots in residential zones. The following definitions can help you determine the best land cover types to use when analyzing your site:

Roof – any impervious surface covering structures that is primarily getting nutrient deposition through dust or precipitation. These surfaces are raised above vehicular traffic and not affected by adjacent landscaping practices. This does not include the area of green roofs, which are treated as Land Taken Up By SCM.

Roadway – any paved or hard-packed surface intended for motorized traffic. This includes roads, streets, highways, on-street parking, road shoulders, road pull-offs, and bike lanes on the outside edge of roadways.

Parking/Driveway/Sidewalk – Parking/Driveway is any paved or hard-packed surface intended for parking and low-speed access of motorized vehicles to parking. This includes ordinary parking lots, driveways, parking decks, and drive-throughs. This does not include on-street parking. It also does not include permeable pavement, which is treated as Land Taken Up By SCM. Sidewalk is any paved or hard-packed surface intended for non-motorized traffic. This includes ordinary sidewalks, patios, paved/masonry paths, walkways, greenways, and bike paths separated from roadways.

Other Pervious/Landscaping – any vegetated area that is not protected by easements or covenants designed to protect existing vegetation and that generally supports low- to moderate-intensity development-related uses that include one or more of animal traffic, fertilization, mowing or other intentional vegetation management/maintenance. Vegetative cover can include lawn, landscaped area, open space, parkland, garden, golf course, or wooded area with a cleared, lawn, or otherwise maintained understory. **This includes Neuse/Jordan Riparian Zone 2 whether forested or not unless it is protected as forest.** This also includes areas with non-/less-vegetated pervious covers such as landscaping gravel and mulch.

Protected Forest – this is any wooded/forested area that is neither periodically/regularly mowed nor fertilized, is not managed according to a deferment for use value under forestry or a forest management plan, and where understory and groundcover are allowed to develop. Such areas tend to have minimal use (such as pervious-surface trails) and little management other than control of invasive species and disease. For **New Development purposes**, these are woods protected by covenants, easements, or other regulations that prevent its conversion to other pervious uses. This includes forests with conservation easements, Neuse/Jordan Riparian Zone 1, forested riparian zones protected by other regulations, and protected wetlands. For **Existing Development purposes**, this is any treed or forested area that is **not** regularly/periodically mowed or fertilized. Protected areas undergoing reforestation efforts, even with occasional mowing, can be considered forested if they are allowed to develop a natural understory and groundcover layer as canopy trees mature.

CUSTOM LAND COVER – this land cover type is set aside for uncommon land covers that don't fit well in the above set. This includes land covers such as open water, small agricultural areas, dog parks, and areas of #57 stone with a geotextile layer. There are three rows to accommodate multiple custom land covers. To use this land cover type you need a value for imperviousness (between 0 and 1, with 1 being fully impervious), and values for TN and TP EMCs. These values need to be approved by your approving authority. This land cover can also be used to model SCMs existing prior to another project where SCMs are being installed. See section **Chapter 3: Examples and Special Scenarios** for how to model this.

Open water is a special land cover type that is handled using the Custom Land Cover in some situations. Where a pond is a jurisdictional waterbody, such as if it were connected to intermittent or perennial streams, it is considered part of the regulated natural drainage system. Such areas, including wide streams and rivers, should be excluded from the total project area with the exception of parts of waterbodies that have been permitted for impacts (such as piping).

Where ponds are not jurisdictional waterbodies, runoff leaving these can be intercepted for stormwater treatment if desired. Such waterbodies are considered part of the project area and a Custom Land Cover should be used to model them if they are not converted to another land cover. The impervious value should be set to zero (0). Such waterbodies may be affected by atmospheric deposition and adjacent lawn care practices similar to parking lots and sidewalks. Hence, EMCs for Parking/Driveway/Sidewalk should be used: TN 1.42mg/L and TP 0.18mg/L.

LAND TAKEN UP BY SCM – this land cover is set aside for the SCMs themselves. Most SCMs will have a land cover area greater than zero. Only underground installations that can have land covers above them can have an area equal to zero. Some SCMs have a land cover area the same as the area draining to it, such as green roofs.

2.5. SCM Characteristics Sheet

2.5.1. Sheet and Navigation

Information about the Stormwater Control Measures (SCMs) that will be used to treat runoff from the project is entered in the SCM Characteristics sheet (**Figure 2-7**). You may divide the project into as many as 6 separately-draining catchments, and each catchment may be treated with up to 3 SCMs. SCMs within a single catchment drain to each other (101 drains to 102, 102 drains to 103).

The "Clear All Entries" button at the top of the worksheet will clear all user-entered data from the sheet, including land cover areas and catchment and SCM routing. If you encounter any issues with data validation or cell formatting that may have been affected by copying and pasting from another part of the Tool, use "Clear All Entries" to clear and reset all cells.

The other buttons print out this sheet on a single side of an 8.5 x 11" piece of paper, navigate among the different worksheets, and bring up a diagram depicting what the "Hydrologic Values" mean. **For instructions on applications of specific types of SCMs**, see Section **3.2. SCM Specifics by Type and Under/Oversizing**.

2.5.2. SCM Type and EMCs

In the uppermost portion of this sheet enter information about the type of SCM, its size relative to "full size", and the predominant hydrologic soil group (HSG) in the area of the SCM. For most SCMs in the Tool, these three attributes are used to look up SCM-specific information on

effluent event mean concentrations, how the SCM partitions incoming runoff volume into treated effluent, overflow, and ET/infiltration, and other relevant characteristics.

> ✅ Fields highlighted in yellow are required for calculating the runoff and nutrient reduction for any given SCM.

First, select an SCM from the drop-down menu by double-clicking on the leftmost yellow cell in the row for "Type of SCM". To clear a SCM choice, or any other cell with a dropdown menu, click on the cell and press the 'delete' key. The full list of SCMs, with their associated event mean concentrations (EMCs), can be seen in **Table 4**. More information on how these EMCs, and other SCM characteristics, were determined can be found in DEMLR's "North Carolina Stormwater Control Measure Crediting Document" (can be found on the webpage https://deq.nc.gov/sw-bmp-manual).

> ✅ Two SCM types have custom effluent EMCs: "Custom SCM" and "Rainwater Harvesting". Make sure you enter effluent EMCs, or you will get erroneous values calculated on the Overall Summary sheet.
>
> ✅ SCMs listed in the dropdown menu as "per MDC" include SCMs designed to the older standards laid out in the 2009 NC BMP Manual.
>
> ✅ An SCM designed to standards less stringent than the current Minimum Design Criteria should be entered as "Custom SCM/BMP".

Figure 2-7: The SCM Attributes section of the SCM Characteristics sheet.

	B	C	D	E	F	G	H
	SCM Characteristics	Print SCM Characteristics	Project Information	Individual SCM Summaries	Hydrologic Values Diagram		
		Clear All Entries	Land Cover Characteristics	Nutrient Offset Form			
4		Introduction	Overall Summary	Add 2nd Catchment	Remove 2nd Catchment		Add 3rd Catchment
5			**WARNING MESSAGES SHOW UP HERE IN RED**				
6	Catchment ID	1	1	1	2	2	2
7	SCM ID	101	102	103	201	202	203
8	Type of SCM	Wet Pond per MDC	Level Spreader-Filter Strip per MDC		Bioretention with IWS per MDC		
9	Predominant hydrologic soil group at SCM location	C	C		B		
10	SCM Description						
11	Design Storm Size (inches/24hrs)						
12	Percent of Full Size	100%	400%		100%		
13	Hydrologic Value - Percent Annual Effluent	72%	54%		27%		
14	Hydrologic Value - Percent Annual Overflow	16%	10%		6%		
15	Hydrologic Value - Percent Annual ET/Infiltrated	13%	36%		67%		
16	SCM Effluent TP EMC (mg/L)	0.15	0.19		0.12		
17	SCM Effluent TN EMC (mg/L)	1.22	1.04		0.58		
18	SCM Land Cover TP EMC (mg/L)	0.11	0.11		0.11		
19	SCM Land Cover TN EMC (mg/L)	1.18	1.18		1.18		
20	Drains to SCM ID	102	0		0		

2.5.3. Hydrologic Soil Group

The next row down, select a hydrologic soil group (HSG), which should represent the predominant HSG underlying the SCM. Hydrologic soil group alters the runoff volume partitioning, shown in the cells further down the column. The default Size (described in the next section) of 100% is automatically entered when you select the HSG; you can change the Size as needed. The Tool will then look up EMCs and runoff volume partitions used to do the nutrient treatment calculations.

Table 2 lists the hydrologic soil grouping for most soil series in North Carolina. For "Urban" soil types, use HSG = C. For lined SCM applications, use HSG = D. Some soils may reside in two groups depending on the presence of a high water table that limits infiltration. If these soils are effectively drained, choose the group with lower runoff potential. For example, Cape Fear soil is classified as B/D, which indicates that it is in group B if well-drained and in group D if poorly-drained. If a soil at a given site is not listed in **Table 2**, you can use the surface layer soil texture to determine the hydrologic soil group. The texture may be determined by soil analysis or from the local soil survey. On-site soil sampling by a soil scientist may also be used to check or change the HSG.

Table 1: Four Hydrologic Soil Groups as Defined by the NRCS (USDA 1986).

HSG	Hydrologic Soil Group Definition
Group A	A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission greater than 0.30 in/hr). The textures of these soils are typically sand, loamy sand, or sandy loam.
Group B	B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). The textures of these soils are typically silt loam or loam.
Group C	C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr). The texture of these soils is typically sandy clay loam.
Group D	D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr). The textures of these soils are typically clay loam, silty clay loam, sandy clay, silty clay, or clay.

Table 2: Hydrologic soil groups for soil series found in North Carolina (Malcom, 1989).

Series Name	HSG	Series Name	HSG	Series Name	HSG	Series Name	HSG
Alaga	A	Delanco	C	Leaf	D/C	Pocalla	A
Alamance	B	Dorovan	D	Lenoir	D/B	Pocomoke	D/B
Albany	C/A	Dothan	B	Leon	C/B	Pomello	C/A
Altavista	C/B	Dragston	D/C	Liddell	D/C	Ponzer	D/C
Americus	A	Dunbar	D/B	Lloyd	B	Porters	B
Appling	B	Duplin	C/B	Lockhart	B	Portsmouth	D/C
Ashe	B	Durham	B	Louisa	B	Rabun	B
Augusta	C	Dykes	B	Louisburg	B	Rains	D/B
Avery	B	Edneyville	B	Lucy	A	Ramsey	D
Aycock	B	Elbert	D	Lumbee	D/C	Ranger	C
Barclay	C	Elioak	B	Lynchburg	C/B	Ridgeland	C
Barth	C	Elsinboro	B	Lynn Haven	D/C	Rimini	C
Bayboro	D/C	Enon	C	Madison	B	Roanoke	D
Bertie	C/B	Eustis	A	Magnolia	B	Rosman	B
Bibb	D/B	Exum	C/B	Mantachie	C/B	Rumford	B
Bladen	D/C	Faceville	B	Manteo	D	Ruston	B
Blaney	B	Fannin	B	Marlboro	B	Ruttege	D/B
Blanton	A	Fletcher	B	Masada	B	Saluda	C/B
Bowie	B	Fuquay	B	Maxton	B	Scranton	D/B
Braddock	B	Georgeville	B	Mayodan	B	Seneca	C/B
Bradley	B	Gilead	C	McColl	D/C	Starr	B
Brandywine	B	Goldsboro	C/B	Mecklenburg	C	State	B
Brevard	B	Goldston	C	Meggett	D/C	Suncook	A
Bucks	B	Granville	B	Molena	A	Surry	B
Buncombe	A	Grover	B	Musella	B	Talladega	C
Burton	B	Guin	A	Myatt	D/C	Tallepoosa	C
Byars	D	Gwinnett	B	Nahunta	C/B	Tate	B

Cahaba	B	Hartsells	B	Nason	C	Tatum	B
Cape Fear	D/B	Hatboro	D/C	Nixonton	B	Thurmont	B
Caroline	C	Hayesville	B	Norfolk	B	Toccoa	B
Cartecay	C	Haywood	B	Ochlockonee	B	Toisnot	C/B
Cataula	C	Helena	C	Ocilla	C/B	Torhuna	C/A
Cecil	B	Herndon	B	Olustee	D/C	Toxaway	D
Chandler	B	Hiwassee	B	Onslow	B	Transylvania	B
Chastain	D	Hoffman	C	Orange	D	Troup	A
Chester	B	Hulett	B	Orangeburg	B	Tuckerman	D/C
Chesterfield	B	Hyde	D/C	Osier	D	Tusquitee	B
Chewacla	C	Invershiel	C	Pacolet	B	Unison	B
Chipley	C/A	Iredell	D	Pactolus	C/A	Vance	C
Clifton	B	Iuka	C	Pamlico	D/C	Varina	C
Codurus	C	Izagora	C	Pantego	D/C	Vaucluse	C
Colfax	C	Johnston	D/B	Pasquotank	D/B	Wadesboro	B
Comus	B	Johus	C/B	Pelham	D/C	Wagram	A
Congaree	B	Kalmia	B	Pender	D	Wahee	D/C
Cowarts	C	Kenansville	A	Penn	C/B	Wake	D
Coxville	D/C	Kershaw	A	Pinkston	C	Watauga	B
Craven	C	Kinston	D/C	Plummer	D/B	Wedowee	B
Davidson	B	Lakeland	A				

2.5.4. SCM Size and Volume Partitioning

SCM Size, expressed as a percentage of the required water quality volume, is a critical, required variable for calculating any given SCM's outputs. This variable describes the size of the SCM relative to its regulatory "full size" of 100%, which is based on the design storm or water quality event. This size in turn determines how incoming runoff volume is partitioned between overflow, treated effluent, and ET/infiltration. The default is 100%. For instructions on applications of specific types of SCMs, see Section **3.2. SCM Specifics by Type and Under/Oversizing**.

Note that the following SCMs may only be 100% sized because of limited data regarding their performance at larger or smaller sizes:

1. Green Roof per MDC
2. Permeable Pavement (infiltrating) per MDC
3. Permeable Pavement (detention, unlined) per MDC
4. Permeable Pavement (detention, lined) per MDC
5. Pollutant Removal Swale per MDC – Dry
6. Pollutant Removal Swale per MDC – Wet
7. Silva Cell with IWS per MDC
8. Silva Cell without IWS per MDC

⚠️ The Tool checks the Size you have entered for your SCM against what is allowed for that SCM. If it is not allowed, the Size cell will be cleared and a notification box will pop up.

ℹ️ *Land Taken Up By SCM* is not at all connected to the Size, but corresponds to the footprint of the SCM. If you change the Size relative to 100% it will not change the area listed for *Land Taken Up By SCM*, and vice versa.

The set of SCMs listed below requires user-entered values for custom volume partitioning between overflow, effluent, and ET/infiltration. The fractions you enter are based on HyPerTool outputs or negotiated with your permitting authority. You may put any size in the cell for Percent of Full Size, but it will not affect the volume partitions you have entered. You will see an error message at the top of the column if your percentages do not add up to 100%.

1. Bioretention with IWS per HyPerTool
2. Bioretention without IWS per HyPerTool
3. Custom SCM/BMP
4. Permeable Pavement per HyPerTool
5. Rainwater Harvesting

Note that the Rainwater Harvesting SCM was **not** originally modeled as a catch-and-release system in the Tool (where water is released back to natural areas or the stormwater network). For general use of this SCM it is assumed that volumes reduced by the SCM are NOT released to the landscape or stormwater network. However, you may negotiate effluent EMCs and volume partitioning with your approving authority if you are using a catch-and-release system.

✅ For Bioretention and Permeable Pavement, use the outputs of the relevant HyPerTool. Hydrologic values for Custom SCMs and Rainwater Harvesting need to be supplied another way and require approval by the permitting authority.

❌ For all these SCMs the Tool will check that your hydrologic values add up to 100%. If not, it will give you the following warning at the top of the column, "**WARNING: Hydrologic values must add up to 100%!!!**". On the Overall Summary sheet, the summary row for that SCM will be colored red.

ℹ️ For instructions on applications of specific types of SCMs, see Section **3.2. SCM Specifics by Type and Under/Oversizing**.

The Tool allows for some SCMs to be undersized to a minimum of 50% of the required design size, and some SCMs up to 400% oversized. Under-/oversizing is based on whether the SCM is a ponding type or rate-based type SCM, with 12-hour and 60-hour release for the ponding types. Based on the relative size of the SCM, the Tool uses an equation to determine the amount of overflow. Size may further alter the proportional split of treated volume between effluent and ET/infiltration. It is assumed the effluent EMCs assigned to the SCM remain the same throughout this range of sizes.

✅ To specify that a SCM is under- or oversized, enter the SCM's size relative to the design size required to capture the designated water quality depth as a whole number between 50% and 400% in the appropriate row of the worksheet.

⚠️ Under-/oversizing may be limited to SCMs used to retrofit existing development. Check with your local authority as to whether you may use under- or oversized SCMs to meet stormwater requirements for new development.

ℹ️ There are greatly diminishing returns for sizing ponding-type SCMs above 200%.

Section 4.1.3 describes the calculations behind volume partitioning and sizing, with **Table 3** listing volume partitioning for 100% sized SCMs. A more in-depth explanation of the equations used and how they were generated may be found in DEMLR's "North Carolina Stormwater Control Measure Crediting Document" (can be found on the webpage https://deq.nc.gov/sw-bmp-manual).

2.5.5. SCM Drainage Areas

Scrolling down to the lower half of the SCM Characteristics worksheet (**Figure 2-911**) you will come to SCM Drainage Area Land Covers. Enter the total area of each land cover type that drains to each SCM in the appropriate column. If you have only one SCM that treats your entire project area, you can copy-paste the Post-Project data from the Land Cover Characteristics sheet. The size of the SCM itself should be entered in the very last land cover row – "LAND TAKEN UP BY SCM".

Most SCMs must themselves have an area larger than zero in order for calculations to be done correctly. A warning will appear in the column above the cells for land cover numbers alerting you that the SCM you've chosen requires an area greater than zero.

> ✅ If you have only one SCM that treats your entire project area, you can copy-paste the data from the Land Cover Characteristics sheet.

The rightmost three columns, as shown in **Figure 2-9**, show you how much area of a given land cover are currently being treated, area available to be assigned to SCMs, and area that is untreated. The two rows below the data-entry cells show how many total acres are being treated by each SCM as well as by the series. Be aware that entering land areas for SCMs 2 or 3 in any given catchment indicate that the SCM is accepting runoff from this area **in addition to** the outflow from the previous SCM.

You do not have to treat all, or even any, of a project site by SCMs for the Tool to correctly calculate results. Without SCM data, results will only be reported for untreated areas. If you enter land cover data into the SCM Characteristics sheet, but don't have a SCM, HSG, and Size for that column, that land cover will instead be put towards the Untreated Area in calculations.

> ✅ If you put land cover data into the SCM Characteristics sheet, but don't include an SCM, HSG, and Size for that column, that land cover will be put towards untreated area in calculations. These three fields together are used for error checking. Even if the SCM doesn't rely on soil type, or only comes in 100% size, make sure all three fields are filled in.
>
> ❌ A warning will be shown if the sum of areas entered in a given land cover are greater than the total area of that land cover entered in the Land Cover Characteristics worksheet.

To ensure that the amount of a given land cover draining to an SCM adds up to less than or equal to the total area of that land cover, there is a built-in check on the SCM Characteristics sheet. If you enter a value that exceeds the total available area of that particular land cover, the Tool displays an error message and reverses your edit.

> ❌ If you have cumulatively entered more area for a given land cover in the SCM Characteristics than exists for that land cover in the Post-Project column on the Land Cover Characteristics sheet, you will get the following warning: ***At least one type of SCM land cover area exceeds the post-project area for that land cover type.*** This is a critical error to be avoided and will give you erroneous results.

Figure 2-8: The section of the SCM Characteristics sheet where you enter land cover information for SCM drainage areas

	Catchment ID	1	1	1	2	2	2
6							
7	SCM ID	101	102	103	201	202	203
28		WARNING MESSAGES SHOW UP HERE IN RED					
29	SCM ID:	101	102	103	201	202	203
30	SCM Drainage Area Land Covers	Area Draining Directly to SCM 101 (ft2)	Area Draining Directly to SCM 102 (ft2)	Area Draining Directly to SCM 103 (ft2)	Area Draining Directly to SCM 201 (ft2)	Area Draining Directly to SCM 202 (ft2)	Area Draining Directly to SCM 203 (ft2)
31	Roof	10,000			10,000		
32	Roadway						
33	Parking/Driveway/Sidewalk	20,000			10,000		
34	Protected Forest						
35	Other Pervious/Landscaping						
67	CUSTOM LAND COVER 1						
68	CUSTOM LAND COVER 2						
69	CUSTOM LAND COVER 3						
70	LAND TAKEN UP BY SCM	2,000	1,000		2,000		
71	TOTAL AREA DRAINING TO SCM (ft²):	32,000	1,000	0	22,000	0	0
72	CATCHMENT AREA (ft²):	33,000			22,000		
73		WARNING MESSAGES SHOW UP HERE IN RED					
74							

◄ ► ... | 1. Project Info | 2. Land Cover Characteristics | **3. SCM Characteristics** | 4. Overall Summary | 5. SC ... ⊕ ⋮ ◄ ☐ ►

Figure 2-9: The Land Cover Summary section of the SCM Characteristics sheet.

	Catchment ID			
6				
7	SCM ID			
28				
29	SCM ID:			
30	SCM Drainage Area Land Covers	Total Land Use Area Treated By All SCMs (ft²)	Allowable Total Land Use Area to be Treated Based on Post-Project Areas (ft²)	Post-Project Untreated Land Area (ft²)
31	Roof	20,000	30,000	10,000
32	Roadway	0	0	0
33	Parking/Driveway/Sidewalk	30,000	30,000	0
34	Protected Forest	0	35,000	35,000
35	Other Pervious/Landscaping	0	0	0
67	CUSTOM LAND COVER 1	0	0	0
68	CUSTOM LAND COVER 2	0	0	0
69	CUSTOM LAND COVER 3	0	0	0
70	LAND TAKEN UP BY SCM	5,000	5,000	0
71	TOTAL AREA DRAINING TO SCM (ft²):	55,000	100,000	45,000
72	CATCHMENT AREA (ft²):	WARNING MESSAGES SHOW UP HERE IN RED		
73				
74				

◄ ► ... | 1. Project Info | 2. Land Cover Characteristics | **3. SCM Characteristics** | 4. Overall Summary

2.5.6. SCMs in Series and Catchment Routing

The Tool is able to model up to 18 SCMs in six catchments with three SCMs in each catchment. Catchments can be routed to other catchments. When you open the SCM Characteristics page, you will only be able to see one catchment, with space for 3 SCMs in it, but you can add more. Your first SCM must be placed in the SCM ID 101 column.

The _Drains to SCM ID_ field just above the catchment routing section automatically updates whenever you add or remove SCMs, and whenever you change catchment routing. This field is provided for the purpose of making visualization (and verification) of SCM and catchment routing easier. If the ID = 0, the SCM has no other SCM receiving its outflow.

When SCMs are set up in series, each SCM can have additional area draining to it other than its own footprint. For example, if additional drainage area is designated for SCM 2 of the series, SCM 2 would treat not only the outflow from SCM 1, but also additional runoff from its own drainage area. To designate this additional drainage area, simply enter the square footage for each type of land cover within the area in the column for SCM 2.

However, it is not necessary for SCMs in series (or even by themselves) to have additional drainage area other than the area required for the SCM. SCMs can be modeled directly in series (one flowing right into the next without receiving any additional flow from an area draining only to that SCM) by entering only the next SCM's foot print (_Land Taken Up By SCM_). Even the very first SCM in a series can have a drainage area only comprising its own footprint. This is the case with green roofs and permeable pavement with no external run-on.

ⓘ If more than 1 SCM is entered into a single catchment, the SCMs are assumed to operate in series (i.e. the outflow from SCM 1 flows into SCM 2, etc.).

ⓘ An SCM with land cover data in only its LAND TAKEN UP BY SCM row is used when it is directly in series below another SCM, or when it has no drainage area contribution beyond its own footprint (such as green roof or permeable pavement).

To open up a second catchment, click the "Add 2nd Catchment" button to the bottom right of the set of buttons at the top of the sheet. You can do this for up to 6 catchments. To dismiss or remove a catchment, click the button that says "Remove (2nd) Catchment". When you dismiss catchments, the data in them is cleared out. If you click the button to "Clear All Entries" it will clear out all catchments and dismiss all but the first one.

Multiple catchments are commonly used to represent a project that is divided into distinct areas that don't flow into each other, such as a site that has several separated drainage areas, each with their own SCM. In this case, no catchments drain to other catchments. An example of this is a site centered on a hilltop draining to multiple different directions.

Multiple catchments can also model SCMs in parallel, for example, one SCM in each of several catchments, each separately flowing into yet another catchment's SCM. Multiple catchments can be used to model a treatment train involving four or more SCMs in series, as well as many combinations of series and parallel SCMs.

You can route any entire catchment to any other SCM in another catchment. The section of the SCM Characteristics sheet where you enter this information is shown in **Figure 2-10**. To indicate that an SCM is accepting the outflow from another catchment, select "yes" from the dropdown menu in the cell corresponding to the SCM that is accepting the outflow. You can only route the last SCM in series in a catchment to another catchment (i.e. if 103 is last, flow cannot be routed from 102 to the next catchment). This reflects the fact that an SCM would not be designed to split its outflow between two SCMs.

Figure 2-10: Example catchment routing with two SCMs draining into a third SCM.

	Catchment ID	1	1	1	2	2
6						
7	SCM ID	101	102	103	201	202
20	Drains to SCM ID	102	0		102	
21	Catchment Routing (Source Catchment)	Catchments Draining to SCM 101	Catchments Draining to SCM 102	Catchments Draining to SCM 103	Catchments Draining to SCM 201	Catchments Draining to SCM 202
22	Catchment 1					
23	Catchment 2		yes			
24	Catchment 3					
25	Catchment 4					
26	Catchment 5					
27	Catchment 6					

For example, if SCM 101 is accepting the outflow from Catchment 3, which has 2 SCMs, go to the SCM 101 column. Change the value in the row for Catchment 3 to "yes"; "no" is the default value. The result is that SCM 302 drains to SCM 101. In this example, if there was an SCM 102, you could route Catchment 3 to SCM 102, skipping SCM 101. SCM 302 would drain to SCM 102 instead.

Figure 2-11: Example catchment routing with five SCMs.

	Catchment ID	1	1	1	2	2
6						
7	SCM ID	101	102	103	201	202
20	Drains to SCM ID	102	103	0	202	102
21	Catchment Routing (Source Catchment)	Catchments Draining to SCM 101	Catchments Draining to SCM 102	Catchments Draining to SCM 103	Catchments Draining to SCM 201	Catchments Draining to SCM 202
22	Catchment 1					
23	Catchment 2		yes			
24	Catchment 3					
25	Catchment 4					
26	Catchment 5					
27	Catchment 6					

⚠️ Any individual catchment can only be routed to a single SCM. That is, for any Source Catchment row you can only select "yes" in one SCM column.

ℹ️ If a catchment receives flow from another catchment that has no SCMs in it, you do not need to add data and the results will not be affected.

❌ Do not route an SCM with data to a catchment with no data or incomplete SCM data. This produces large calculation errors.

2.6. Overall Summary Sheet

2.6.1. Project Summary

The first section in the Overall Summary sheet – the Project Summary (**Figure 2-12**) – summarizes general project information and shows information related to calculating load and loading rate targets, buy-down thresholds, load reductions needed, and nutrient treatment balance (i.e. nutrient "credits/debits"). The Tool compares the *Post-Project Whole Site* **with SCMs** against a "target" load (lb/yr) and loading rate (lb/ac/yr) based on which Nutrient Management Strategy Rules apply and how. Hovering over the cells with red triangles brings up a description of what the information in that cell means and how it was calculated. Buttons to the right of this section let you navigate to other sheets and print this entire summary sheet (on two landscape-oriented pages). Calculations of nutrient credits for the site, if applicable, are refreshed whenever you leave this sheet and return.

Data entered in green cells on the Project Info sheet is used to apply a decision tree covering the Rules for the five Nutrient Management Strategies (Falls, Jordan, Neuse, Tar-Pamlico, Randleman). The decision tree for determining which and how Rules apply is described in **Section 4.3. Applicability of NMS Rules** This information is required for calculations in this section to run. It is not required simply to get calculations of runoff and nutrient export.

Figure 2-12: Project Summary Section on the Overall Summary Sheet.

	A	B	C	D	E	F	G	H	I	J	K
1	**Project Summary**									Introduction	
3			Project Name:	John's Surf Mart & Beach Emporium						Project Info	
4			Project Area (ft^2):	100,000	ft^2	2.2957	acres	Submission Date:		Land Cover Characteristics	
5			Disturbed Area (ft^2):	65,000	ft^2	1.4922	acres	November 1, 2018			
6			County:	Durham			Local Jurisdiction:	Durham		SCM Characteristics	
7			Development Land Use Type:	Commercial			Owner Type:	Private		Individual SCM Summaries	
8			Development Activity Type:	Development - New		Designated Downtown Area?		no			
9			Nutrient Management Watershed:	Falls Lake			Subwatershed:	Falls - Upper		Nutrient Offset Form	
10			Phosphorus Delivery Zone:	Falls - Upper			Nitrogen Delivery Zone:	Falls - Upper		Print Summary	
11			Phosphorus Delivery Factor (%):		100%		Nitrogen Delivery Factor (%):		100%		
12			*Phosphorus Loading Rate Target (lb/ac/yr):*		*0.33*		*Nitrogen Loading Rate Target (lb/ac/yr):*		*2.20*		
13			**Phosphorus Load Target at Site (lb/yr):**		0.76		**Nitrogen Load Target at Site (lb/yr):**		5.05		
14			**Phosphorus Load Leaving Site w/SCMs (lb/yr):**		1.51		**Nitrogen Load Leaving Site w/SCMs (lb/yr):**		9.99		
15			P Offsite Buy-Down Threshold Loading Rate (lb/ac/yr):		0.92		N Offsite Buy-Down Threshold Loading Rate		7.82		
16			Total P Load Reduction Needed (lb/yr):		1.23		Total N Load Reduction Needed (lb/yr):		13.24		
17			P Load Treatment Balance at Site (lb/yr):		0.75		N Load Treatment Balance at Site (lb/yr):		4.94		
18			P Load Treatment Balance at Lake (lb/yr):		0.75		N Load Treatment Balance at Lake (lb/yr):		4.94		
19											
20		**WARNING MESSAGES SHOW UP HERE IN RED**									
21											

Credit Generation Caveat

Generation of extra nutrient credit assumes you have met any other Rule requirements such as peak flow or a minimum number of SCMs, that you have met other SCM/BMP-specific requirements for credit generation, and that you have the approval of reviewing and credit-granting authorities. Credits generated for new development compliance purposes also require execution of a Nutrient Banking Instrument or otherwise have met nutrient offset and trading requirements. In general credits are only awarded for situations where you are providing more nutrient treatment or retention than is required by Rule for your project's situation. Exporting less than the maximum stated in Rules simply by land use choices does not constitute a credit.

For instance, generation of credits in a new development situation that may be used by other new development to meet nutrient offset needs cannot be generated simply from carefully selected land uses that export less than the maximum unit-area rate. You must actually overtreat the runoff leaving your site and have set up a Nutrient Banking Instrument for the overtreatment. If you have not entered any SCMs into the Tool for the treatment of new development or expansion of development, the Tool will display credit calculation results in red text to alert you of this error.

Calculations for Development – New and Development - Expansion

Data you enter on the Project Info sheet determines which of the Nutrient Management Watershed unit-area-loading rates apply (the target loading rate in lb/ac/yr), and from that value what your target load is (lb/yr based on the total area of your project).

Where new development or expansion projects meet conditions of applicability for individual Watershed Rules:

- Loading Rate Targets = based on watershed, subwatershed, and other variables.
- Credit ("load treatment balance") = the export load *Post-Project Whole Site* **with** *SCMs* minus the target load. Target load is based on target rate. If you overtreat stormwater, your Post-Project with SCMs value will be lower than your target rate = extra credit generated (shows as negative value). Positive credit values mean you still have stormwater obligations to meet, either through onsite treatment or offsite buydown. See the above caveat on credit generation.
- Nutrient load reduction needed is a measure of how much stormwater treatment you need based on the Post-Project condition before installing SCMs. Reduction needed = the export load *Post-Project Whole Site* **without** *SCMs* minus the target load. This value is needed for the purposes of calculating buydown thresholds for Falls, which are a proportion of reduction need. For all other watersheds this info is for your information.
- Buydown thresholds for most watersheds are set values. For Falls they are based on reduction need.

Where new development or expansion projects do not meet conditions of applicability for individual Watershed Rules, based on size, location, land cover type, BUA, or part of common plan of development:

- Loading Rate Targets = *Post-Project Whole Site* **without** *SCMs* loading rate.
- Credit ("load treatment balance") = the export load *Post-Project Whole Site* **with** *SCMs* minus the export load *Post-Project Whole Site* **without** *SC*Ms *(land cover change is not involved).*
- Needed nutrient load reductions = 0
- Buydown thresholds = NULL *(none required)*

Expansion in all Watersheds (development with a net increase in BUA) has export targets based on unit-area loading rates as for new development. However, expansion is eligible for percent nutrient reduction depending on the particular Rules that apply. To determine export targets based on percent nutrient reduction: subtract the nutrient reduction amount from 100% and multiply that by the N and P loads exported from the Post-Project Whole Site Without SCMs. That gives you an export target based on reduction rather than unit-area loading rate.

Expansion scenarios can be complex situations. The Tool assumes you are at most treating runoff from net increase BUA and any associated disturbed pervious areas. Rules for new development are applied to expansion scenarios. But it can be common for runoff from undisturbed areas or disturbed non-net-increase BUA to be included in treatment, which could generate credits by treating areas not otherwise required. The best way for you to model a mixed redevelopment/expansion situation is to treat this like an "offsite run-on" situation, where "onsite" is the area of net increase of BUA and its associated disturbed pervious area, and "offsite" is the remaining area that drains to any involved SCMs. When this is the result, a popup will instruct you to use the two-model approach (see "Offsite Run-On" in **Chapter 3:**

Examples and Special Scenarios) in order to find out what the nutrient obligations are, and what credits may be generated if other areas are additionally treated.

Calculations for Existing Dev. Retrofit

For retrofits of existing development, loading rate targets are equal to the Pre-Project loading rate. Target Loads are calculated from the loading rate target times the Project Area in acres. The load reduction needed at the site is zero. A summary of calculations is as follows:

- Loading Rate Targets = the Pre-Project loading rate *("target" in this sense is what you're measuring your Post-Project condition against).*
- Credit ("load treatment balance") = the export load *Post-Project Whole Site* **with** *SCMs* minus the export load *Pre-Project Whole Site Conditions.* Negative values = credit. Automatically includes any reductions due to land cover change.
- Needed nutrient load reductions = 0
- Buydown thresholds = NULL *(none required)*

Calculations for Redevelopment

Redevelopment scenarios in all Watersheds with no increase in built-upon area (BUA) are treated just like existing development retrofits.

> ⓘ Nutrient buy-down thresholds are not provided for purposes of any calculation, but so you and your approving authority know whether a buy-down threshold for a development exists and whether it's been achieved.
>
> ⓘ Where redevelopment and expansion are mixed, the load reduction needed is too complex to calculate all at once. Export targets, buy-down thresholds, and treatment balance will not be calculated. To calculate load targets and nutrient credits/debits you need to model runoff from the additional BUA and disturbed area separately from the rest of the site, as if it were an "offsite run-on" situation. See **Chapter 3: Examples and Special Scenarios** for how to do this.
>
> ⓘ Disturbed Area, rather than Project Area, is the variable used to determine the applicability of Nutrient Management Watershed Rules. Rule language is based upon Disturbed Area rather than Project Area.

Understanding the Project Summary Results

The target loading rate is determined from which Rules apply and is converted to a target load specific to your project area.

Buy-down thresholds are also determined based on which Rules apply. Only Falls Lake has a phosphorus buy-down threshold. If the Tool was applicable in other Nutrient Management

Watersheds, you would only have to achieve (export less than) the nitrogen buy-down threshold before seeking offsite nutrient treatment credits to cover your remaining obligations.

Load reduction needed at the site is a measure of how much nutrient management needs to be provided to the Post-Project site based on the runoff and nutrient export without SCMs. This is calculated by subtracting the target load for each nutrient from the load generated by the *Post-Project Whole Site **with** SCMs*. In the Falls Lake watershed, the target loads are used to determine buy-down thresholds, which are percentages of the total reduction needed. In other areas buy-down targets are not relative to nutrient reduction needs.

Load treatment balance, the nutrient "credit generated" or "debit owed", is calculated by subtracting the target load from the total load leaving the site with SCMs (*Post-Project Whole Site **with** SCMs*). Negative values indicate overtreatment ("credits" generated). Positive values indicate that you need to either add additional stormwater treatment, or, if your current SCMs treat your site to below your buy-down threshold, you can buy nutrient offset credits to meet your treatment requirements.

In the Jordan Lake Watershed, credit trading and buying nutrient offset credits is counted in terms of how much of a nutrient is delivered to the lake, thus the load treatment balance is multiplied by the appropriate delivery factor. This "balance at lake" is a measure of credits generated or needed that can be compared to any other credits generated/needed at other points in the subwatershed in question. All other Watersheds have 100% delivery to their respective receiving areas.

If all necessary information is entered on the Project Info and Land Cover Characteristics sheet, you can calculate changes just based on land cover changes. You don't have to enter SCMs to get results. However, to actually be eligible for credits you have to be reducing the nutrient loads from the untreated state (see the credit generation caveat above). This is how you model existing development retrofits with no additional SCMs and redevelopment with no increase in built-upon area.

If you change values on another sheet, the Tool will recalculate the load targets, buy-down thresholds, and treatment balances. If your changes leave out critical information, or have a critical error, these calculations will be cleared. Warning messages will be displayed just below the Project Summary box advising you of the above errors.

⚠️ The following issues may prevent values being calculated for this section:

- If any of the information on the Project Info sheet needed to determine which Rules apply and how is missing.

- If the Project Area on the Project Info Sheet doesn't equal the Total Post-Project Calculated Area on the Land Cover Characteristics Sheet.

- If your development activity type is *Redevelopment* or *Existing Dev. Retrofit*, and your Pre- and Post-Project areas don't match.

- If your Project Area is less than your Disturbed Area.

- If the net land cover change is less than Disturbed Area. In most cases net land cover change is the minimum amount of disturbance but depending on the activity this may not be the case. This is used to alert you to unreasonably low Disturbed Area values that may result in incorrect application of the Rules.

- If your development activity is *Existing Dev. Retrofit* or *Redevelopment* but you still have an increase in BUA. You will be advised to remodel using the instructions for *Development - Expansion* with an increase in BUA.

- If any type of land cover on the SCM Characteristics sheet sums to an amount greater than on the whole-project Land Characteristics sheet.

2.6.2. Nutrient Export Summary

The Tool calculates several project-scale measures of volume and nutrient load outputs. The second section in the Overall Summary sheet – the Nutrient Export Summary - displays outputs for *Pre-Project Whole Site Conditions*, *Post-Project Whole Site without SCMs*, *Post-Project Whole Site with SCMs* included, and *Post-Project SCM-Treated* and *Untreated Areas* of the site (**Figure 2-13**). These outputs include percent impervious, percent built-upon area, annual runoff volume, TN and TP effluent EMCs (mg/L), TN and TP load (lb/yr), and TN and TP loading rate (lb/ac/yr). The Tool also calculates the percent change relative to the Pre-Project condition.

Figure 2-13: Nutrient Export Summary Section on the Overall Summary Sheet.

WARNING MESSAGES SHOW UP HERE IN RED

Nutrient Export Summary	Pre-Project Whole Site Conditions	Post-Project Whole Site without SCMs	Post-Project Whole Site with SCMs	Post-Project SCM-Treated Area	Post-Project Untreated Area
Percent Impervious (for runoff calculation) (%)	0.0%	65.0%	65.0%	100.0%	22.2%
Percent Built-Upon Area (BUA) (%)	0.0%	60.0%	60.0%	90.9%	22.2%
Annual Runoff Volume (ft³/yr)	17,929	228,592	166,963	126,623	40,340
Annual Runoff % Change (relative to pre-D)	0%	1175%	831%		
Total Nitrogen EMC (mg/L)	0.97	1.28	0.96	0.90	1.15
Total Nitrogen Load Leaving Site (lb/yr)	1.09	18.29	9.99	7.10	2.89
Total Nitrogen Loading Rate (lb/ac/yr)	0.47	7.97	4.35	5.62	2.80
Total Nitrogen % Change (relative to pre-D)	0%	1584%	820%		
Total Phosphorus EMC (mg/L)	0.03	0.14	0.14	0.16	0.10
Total Phosphorus Load Leaving Site (lb/yr)	0.03	1.99	1.51	1.26	0.25
Total Phosphorus Loading Rate (lb/ac/yr)	0.01	0.86	0.66	1.00	0.24
Total Phosphorus % Change (relative to pre-D)	0%	5812%	4390%		

The first two whole-site summary columns, *Pre-Project Whole Site Conditions* and *Post-Project Whole Site without SCMs*, are based on the data input into the Land Cover Characteristics sheet, and will be calculated these even if you enter no SCM information. The other three columns will only calculate results if you enter SCM data into the SCM Characteristics sheet. Values for the *Post-Project Whole Site with SCMs* column represents what is exported from the whole site after project completion and SCM installation.

> ✅ If you get zero results for the *Pre-Project Whole Site Conditions* column, make sure you have entered Pre-Project data on the Land Cover Characteristics Sheet.
>
> ✅ If you get zero results for the *Post-Project Whole Site* columns, make sure you have entered post-project data on the Land Cover Characteristics Sheet.

Warnings shown above the Nutrient Export Summary box are the same as those described previously for the Project Summary box.

> ℹ️ Before entering any SCM information, you will get results for the *Post-Project Whole Site with SCMs* column. These results will equal the *Post-Project Whole Site without SCMs* column. You will not get any results for the post-project SCM-treated area in this case.
>
> ℹ️ If SCMs treat the entire area of your site, your results for the *Post-Project Untreated Area* will all be zero.
>
> ❌ If you have mistakenly entered a cumulatively larger value for a land cover on the SCM Characteristics sheet than the Land Cover Characteristics sheet, you will see negative numbers in the *Post-Project Untreated Area* column and see warnings on both the SCM Characteristics sheet and the Overall Summary. This will yield erroneous calculations for the *Post-Project Whole site with SCMs* column.

2.6.3. SCM/Catchment Summary

The third section in the Overall Summary sheet – the SCM/Catchment Summary - displays various ways of measuring nutrient reduction, separated out by catchment and SCM (**Figure 2-14**). The total area treated by each SCM includes the area treated by previous SCMs in the series, including upstream catchments, as well as additional area draining to the SCM itself. The percent volume reduction shows how much that SCM reduces the inflow volume. The outflow loadings for TN and TP are displayed for each SCM.

Errors that can affect the whole set of SCM calculations, but that are not specific to one SCM, are shown above the SCM/Catchment Summary box. These include whether your Pre- and Post-Project land cover areas add up to the same value (for New Development this is not

necessary), and whether areas entered for SCM drainages add up to more than the total area available for any given land cover. These can cause errors in calculations that are not readily apparent.

Figure 2-14: SCM/Catchment Summary Section on the Overall Summary Sheet.

SCM ID and Type	Volume Reduction (%)	TN Out (mg/L)	TP Out (mg/L)	TN Out (lbs/ac/yr)	TP Out (lbs/ac/yr)	TN Reduction (%)	TP Reduction (%)
Catchment 1	32.00%	1.07	0.18	6.73	1.17	45.43%	17.65%
101: Wet Pond per MDC	12.66%	1.24	0.15	10.04	1.22	18.74%	14.53%
102: Level Spreader-Filter Strip per	22.50%	1.07	0.18	6.73	1.17	33.27%	4.03%
103: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
Catchment 2	33.84%	0.64	0.12	3.96	0.75	66.99%	43.16%
201: Bioretention with IWS per MD	33.84%	0.64	0.12	3.96	0.75	66.99%	43.16%
202: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
203: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
Catchment 3	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
301: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
302: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
303: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
Catchment 4	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
401: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
402: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
403: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
Catchment 5	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
501: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
502: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
503: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
Catchment 6	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
601: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
602: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%
603: NA	0.00%	0.00	0.00	0.00	0.00	0.00%	0.00%

SCM/Catchment Summary WARNING MESSAGES SHOW UP HERE IN RED

SCM rows in red have a data entry error for the SCM that makes an error in the calculation.

◄ ► … | 1. Project Info | 2. Land Cover Characteristics | 3. SCM Characteristics | **4. Overall Summary**

This section of the worksheet also displays outflow data for each catchment. These data include outflow concentrations, loadings and percent reductions for TN and TP for each catchment. The last SCM in each of the series releases water of this quality and these values account for any catchment routing that is specified in the SCM Characteristics tabs. Note that these values are **not** the whole project outflow values – these are only pertinent to the outflow leaving each catchment treated by SCMs. Overall nutrient treatment and export is displayed in the Nutrient Export Summary section under the *Post-Project Whole Site* **with** *SCMs* column.

Any row of SCM results will be shown in red if one or more errors are detected for that SCM. These data checks include whether the SCM has no land cover area associated with it (only underground SCMs may have zero area), whether the runoff volume partitions do not add up to 100%, and whether custom EMCs are missing. Calculation results are still shown in spite of potential errors. What errors are found are shown on the SCM Characteristics sheet.

> ℹ️ If you have not entered any SCM information on the SCM Characteristics sheet, there will be no results in this summary section.

2.7. SCM Summary Sheet

The next page in the Tool provides more details about each SCM (**Figure 2-15**) and catchment (**Figure 2-16**). The governing equations for this information are displayed on the left side of the page. Each SCM or Catchment summary can be printed by itself using the print buttons throughout the page. The format of the printed page will be landscape orientation, with the supporting calculations on the left side of the page and the information summary on the right side.

Figure 2-15: Detailed SCM Summary on the SCM Summary Sheet.

	A	B	C
1			
2		**CATCHMENT 1, SCM 101**	
3	**Supporting Calculations**	**Type of SCM:**	**Wet Pond per MDC**
4	$R_v = 0.05 + (0.009 * I)$,	Area Treated by SCM (ft^2):	32,000
5	where I = percent impervious (%)	Percent Impervious of Contributing Watershed (%):	100%
6	$V = P_j * R_v * A * (P/12)$,	Runoff Coefficient, Rv:	0.95
7	where A = area of catchment (ft^2)	Inflow Volume (ft^3):	109,365
8	P = average annual rainfall depth (in)	Incoming Total Nitrogen Concentration (mg/L):	1.33
9		Annual Incoming Total Nitrogen Load (lbs):	9.08
10	$L = ((P * P_j * R_v) \div (12)) * (C * A * 2.72)$	Incoming Total Phosphorus Concentration (mg/L):	0.15
11	where L = annual pollutant loading (lbs)	Annual Incoming Total Phosphorus Load (lbs):	1.05
12	P_j = fraction of rain events that produce runoff (dec)	Total Volume Leaving SCM (ft^3):	95,516
13	C = event mean concentration of pollutant (mg/L)	Outgoing Total Nitrogen Concentration (mg/L):	1.24
14		Annual Outgoing Total Nitrogen Load (lbs):	7.38
15	$V_{out} = V_{in} * (1 - Red)$	Outgoing Total Phosphorus Concentration (mg/L):	0.15
16	where V_{in} = inflow volume (ft^3)	Annual Outgoing Total Phosphorus Load (lbs):	0.90
17	Red = volume reduction by SCM (%)	Annual Volume Reduction by SCM (ft^3):	13,849
18		Annual Volume Reduction by SCM (%):	13%
19		Annual Total Nitrogen Reduction by SCM (%):	18.74%
20	$L_{out} = V_{out} * EMC_{out} * 6.243\text{E-}5$	Annual Total Nitrogen Reduction by SCM (lb):	1.70
21	where V_{out} = outflow volume (ft^3),	Annual Total Phosphorus Reduction by SCM (%):	14.53%
22	EMC_{out} = effluent median concentration (mg/L)	Annual Total Phosphorus Reduction by SCM (lb):	0.15
23		**Print Catchment 1, SCM 101 Summary**	
24			

| ... | 3. SCM Characteristics | 4. Overall Summary | **5. SCM Summary** | Nutrient Offset | Assignment ... |

Figure 2-16: Detailed Catchment Summary on the SCM Summary Sheet.

	Supporting Calculations	CATCHMENT 1	
4	$R_v = 0.05 + (0.009 * I)$,	Cumulative Catchment Area (ft^2):	33,000
5	where I = percent impervious (%)	Composite Catchment Impervious Surface (%):	
6	$V = P_j * R_v * A * (P/12)$,	Composite Runoff Coefficient, Rv:	
7	where A = area of catchment (ft^2)	Cumulative Runoff Volume (ft^3):	112,951
8	P = average annual rainfall depth (in)	Composite Total Nitrogen Runoff Concentration (mg/L):	1.32
9		Annual Total Nitrogen Runoff Load (lbs):	9.34
10	$L = ((P * P_j * R_v) \div (12)) * (C * A * 2.72)$	Composite Total Phosphorus Runoff Concentration (mg/L):	0.15
11	where L = annual pollutant loading (lbs)	Annual Total Phosphorus Runoff Load (lbs):	1.07
12	P_j = fraction of rain events that produce runoff (dec)	Total Volume Leaving Catchment (ft^3):	76,804
13	C = event mean concentration of pollutant (mg/L)	Outgoing Total Nitrogen Concentration (mg/L):	1.07
14		Annual Outgoing Total Nitrogen Load (lbs):	5.10
15	$V_{out} = V_{in} * (1 - Red)$	Outgoing Total Phosphorus Concentration (mg/L):	0.18
16	where V_{in} = inflow volume (ft^3)	Annual Outgoing Total Phosphorus Load (lbs):	0.88
17	Red = volume reduction by SCM (%)	Annual Volume Reduction by Catchment (ft^3):	36,147
18		Annual Volume Reduction by Catchment (%):	32%
19		Annual Total Nitrogen Reduction by Catchment (%):	45.43%
20	$L_{out} = V_{out} * EMC_{out} * 6.243\text{E-}5$	Annual Total Nitrogen Reduction by Catchment (lb):	4.24
21	where V_{out} = outflow volume (ft^3),	Annual Total Phosphorus Reduction by Catchment (%):	17.65%
22	EMC_{out} = effluent median concentration (mg/L)	Annual Total Phosphorus Reduction by Catchment (lb):	0.19
23		**Print Catchment 1 Summary**	

... | 3. SCM Characteristics | 4. Overall Summary | **5. SCM Summary** | Nutrient Offset | Assignment ...

2.8. Nutrient Offset Sheet

The next page in the Tool, **Figure 2-17** is an automated form for Nutrient Offset Credit Reporting. This form will automatically fill in if sufficient information is entered to calculate the project treatment balance. It will only calculate nutrient buy-down amounts if the N or P Load Treatment Balance at the Lake is greater than zero. It fills in most of the form, but cells with heavy grey borders allow the user to enter data. As with other sheets, buttons to the side allow you to navigate to other sheets, print the form, and clear the cells where users can enter data. The "Clear Entered Data" button only clears the cells with heavy grey borders.

Figure 2-17: Nutrient Offset Reporting Form

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Nutrient Management Strategy Watershed - Nutrient Offset Credit Reporting Form**										Introduction	
2											Project Info	
3	*Please complete and submit the following information to the local government permitting your development project to characterize it and assess the need to purchase nutrient offset credits. Contact and rule implementation information can be found online at:*										Land Cover Characteristics	
4	http://deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/nutrient-offset-information										SCM Characteristics	
5				**PROJECT INFORMATION**							Overall Summary	
6	Applicant Name:										Individual SCM Summaries	
7	Project Name:	John's Surf Mart & Beach Emporium										
8	Project Address:	N Pointe Drive, Durham									Print Nutrient Offset Form	
9	Date: (mm/dd/yyyy)				Development Land Use Type:			Commercial				
10	County:	Durham			Development Activity Type:			Development - New			Clear Entered Data	
11	Pre-Project Built-Upon Area %:		0.00%			Project Latitude:		36.026777				
12	Post-Project Built-Upon Area %:		60.00%			Project Longitude:		-78.916257				
13												
14				**WATERSHED INFORMATION**								
15	Nutrient Management Watershed:		Falls Lake		N Offsite Threshold Rate (lb/ac/yr):			7.82				
16	Subwatershed:		Falls – Upper		P Offsite Threshold Rate (lb/ac/yr):			0.92				
17	Nitrogen Delivery Zone:		Falls – Upper		Nitrogen Delivery Factor:			100%				
18	Phosphorus Delivery Zone:		Falls – Upper		Phosphorus Delivery Factor:			100%				
19												
20				**NUTRIENT OFFSET REQUEST**								
21				**Nitrogen Load Offset Needs**								
22	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(L) (Where Applicable)			
23	Untreated Loading Rate	Treated Loading Rate	Loading Rate Target (lbs/ac/yr)	Reduction Need (lbs/ac/yr)	Project Size (ac)	Offset Duration (yrs)	Delivery Factor (%)	State Buy Down Amount	Local Gov't Buy Down Amount			
24				B - C				D * E * F * G				
25	7.97	4.35	2.20	2.15	2.2957	30	100%	**148.09**				
26				**Phosphorus Load Offset Needs**								
27	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(L) (Where Applicable)			
28	Untreated Load Rate (lbs/ac/yr)	Treated Load Rate (lbs/ac/yr)	Loading Rate Target (lbs/ac/yr)	Reduction Need (lbs/ac/yr)	Project Size (ac)	Offset Duration (yrs)	Delivery Factor (%)	State Buy Down Amount	Local Gov't Buy Down Amount			
29				B - C				D * E * F * G				
30	0.86	0.66	0.33	0.33	2.2957	30	100%	**22.52**				
31												
32				**LOCAL GOVERNMENT AUTHORIZATION**								
33	Local Government Name:		Durham									
34	Staff Name:						Phone:					
35	Staff Email:						Date:					
36	Local Government Authorizing Signature:											
37												

... | 3. SCM Characteristics | 4. Overall Summary | 5. SCM Summary | **Nutrient Offset** | Assignr

Chapter 3: Examples and Special Scenarios

The Tool was originally designed to model a very simple development situation – one where you are going from a fully-undeveloped state to a developed state, and the entire area draining to one (or more) SCMs was coincident with the entire project area. Most projects in real life don't work that way. This section is intended to help you model more realistic situations.

3.1. Development Examples

3.1.1. Development on Previously Undeveloped Land

Development projects involving no pre-existing built-upon area, termed "*Development – New*" projects in the Tool, are straightforward and can be modeled with only Post-Project land cover information. New development stormwater rule compliance and potential credits/debits are calculated by comparing the nutrient export of your site with SCMs to the export amounts allowed by the rule applicable to your watershed.

If your site has no SCMs installed and yet exports less than the new development stormwater rule's loading rate target for your locality, this does not mean you are generating nutrient credits you can sell. The generation of nutrient credits for use as nutrient offsets for another site or for sale as tradeable nutrient credits requires that you treat the stormwater to lower nutrient export amounts than would run off the land without treatment.

3.1.2. Development Involving Existing BUA

In development situations under a watershed new development stormwater rule where there is built-upon area already present on the project site, most of the time in the Tool, you will select *Redevelopment* or *Development – Expansion* as the Development Activity Type. In one case, you will select *Development – New*. Each of these cases is described below.

Redevelopment

In keeping with the definition of "redevelopment" in N.C. General Statutes Ch. 143-214.7, you will choose the *Redevelopment* option only when your development project involves no net increase in BUA. Since no treatment is required for new development stormwater rule compliance in this case, the Tool handles calculations for a *Redevelopment* project the same as an existing development retrofit (described further in Section 3.1.3. below). Nutrient export load and loading rate targets and, where treatment is provided, nutrient reduction credits will be calculated. However, if you enter a Post-Project BUA greater than your Pre-Project BUA, you will get a warning message and nutrient credits/debits will not be calculated, as this scenario should instead be entered as *Development – Expansion* or *Development – New*, depending on the situation.

Development – Expansion

If your project involves a net increase to pre-existing BUA, you will handle this in one of two ways in the Tool. To satisfy new development stormwater rule requirements in either scenario, you are required to provide nutrient treatment include the area of net increase in BUA, the surrounding disturbed pervious areas, and any SCMs involved.

The first net-BUA-increase development project scenario is the case where you choose to meet but not exceed rule requirements. In this case, where you treat the net increase in BUA plus disturbed pervious, you will use the *Development – Expansion* option in the Tool. In this case, you will enter no Pre-Project BUA acreage, and Post-Project acreages reflecting the net increase. The Tool will check whether the Pre-Project BUA is equal to zero. The Tool handles calculations in this case as it would a new development entered under *Development - New*.

The second case is one in which you choose to exceed rule requirements and treat more than the required net increase in BUA in your expansion project. In this case, rather than entering it under *Development – Expansion*, you will instead need to model it as an "offsite run-on" condition (described in Section 3.1.5. below), which you will enter under *Development – New*, with the "offsite" area modeled as the undisturbed areas and BUA acreage previously present on-site, and the "onsite" area modeled as only the net increase in BUA, disturbed pervious areas, and any associated SCM(s). This requires running the Tool twice as described in Section 3.1.5. below. If you attempt to enter this project under *Development – Expansion*, you will get a warning message and nutrient credits/debits will not be calculated.

3.1.3. Existing Development Retrofit

Most of the time, existing development retrofits will be undertaken toward compliance with an Existing Development Stormwater rule, but they may also be pursued as an offsite measure toward New Development rule compliance, as a point source offset or as an alternative compliance option for buffer mitigation. Here our references to existing development simply refer to the setting in which a retrofit is undertaken. Where we discuss an Existing Development rule issue, we use title case for that term in the body of the document.

Land Cover Change

The simplest kind of existing development retrofit is removal of impervious surfaces, or other changes in land cover that reduce nutrient export such as reforestation. In this situation, you only need to enter the Pre-Project and Post-Project land covers on the Land Cover Characteristics sheet. No SCMs or SCM information is needed. The Tool will automatically calculate the nutrient export reduction you've achieved just by a land cover change.

⚠ While the calculation steps for land cover changes are simple, check with your approving authority regarding what on-the-ground requirements exist to convert impervious surface to a pervious, vegetated surface.

Adding a New SCM to an Untreated Catchment

Another simple kind of existing development retrofit, and the typical example of a retrofit, is to install an SCM where one was not previously required and no other pre-existing SCMs are present. The Tool output includes the nutrient export reduction from both the treatment function of the SCM and the land cover change for the footprint of the SCM itself. Hence, the credits generated may be more than what can be inferred from inflow and outflow to/from the SCM. This depends partly on what land cover the SCM is replacing.

Where SCMs are already present in the landscape, whether uphill of the proposed new SCM, between the new SCM and the receiving waterbody, or the project is an upfit of an existing SCM, credit will need to be calculated differently. See the following section on Pre-Existing SCMs in the Landscape.

3.1.4. Pre-Existing SCMs in the Landscape

Crediting SCMs Installed at Different Times in the Same Catchment

Where a new SCM is installed either within the catchment of an existing SCM or "downstream" of one and receiving its discharge, SCMs are assigned nutrient credits in the order of their installation when not all installed at the same time. An SCM installed at a later time does not change the credits that an older SCM has been assigned; instead it is awarded the net additional nutrient removal resulting from the combined effect of the two SCMs. Subsections below provide detailed guidance on modeling all scenarios of SCMs installed at different times.

The example above raises an important distinction that can exist when looking at SCMs installed at different times - that between "nutrient treatment" provided, which is a calculation of how an SCM actually materially reduces the nutrients leaving area catchment in runoff, and "nutrient credits" assigned or awarded, which is a regulatory designation of the reduction of nutrients an SCM merits compared to a pre-existing condition toward compliance with any of several nutrient rules, or in excess of a New Development rule onsite loading rate requirement. In most Existing Development rule cases, nutrient treatment and nutrient credit will likely be the same, but in certain cases like this pre-existing SCM case, they can differ.

To illustrate the difference, when installing a new SCM below an existing SCM, the existing SCM's actual nutrient treatment is not affected by the installation of the new SCM below it, nor is its credit assignment. However, when installing a new SCM above and within the catchment draining to an existing SCM, the new SCM removes some of the nutrients that would otherwise

reach the older SCM. DWR interprets the nutrient rules to support a "first-in-time" right to reduction credit, and we want to maintain predictability of nutrient credit awards for SCMs, therefore, DWR considers the nutrient credit for the original SCM to be fixed, even though a new SCM uphill of it technically does reduce the older one's actual nutrient treatment.

The general rule for calculating nutrient treatment (and potentially nutrient credits) assigned to a new SCM in a landscape with an existing SCM is to subtract the nutrient load exported by the entire drainage area with both SCMs present from the load of the same drainage area with only the older SCM present. These calculations are complicated not only by the relative position of the new SCM, as indicated above, and by the need to use a serial reduction calculation for the load that passes through both SCMs, but also by the design of the old SCM, and whether the old SCM was approved for nutrient treatment previously. The following sections describe in detail how to do these calculations.

Determining Nutrient Treatment Provided by Pre-Existing SCMs

When planning new SCM retrofits where there are existing SCMs in the same catchment, the condition, design specifications, and installation date of existing SCMs need to be determined. Any replacement or upgrade of an existing SCM, or addition of a new SCM above or below it, requires inspection of the SCM for functionality and a comparison of the current condition to the Minimum Design Criteria, or MDC, established in rule by DEMLR in 2016. If the SCM is designed to, and through maintenance can be brought into compliance with the Minimum Design Criteria, then you can use the current version of the Tool to determine the nutrient treatment that SCM provides. If its design does not meet the MDC, or it is sufficiently damaged to require rebuilding, contact DWR to discuss appropriate calculation of nutrient treatment in this situation.

> *Was the existing SCM designed to a specification that meets the Minimum Design Criteria? Based on inspection, can the SCM be brought into compliance with Minimum Design Criteria through maintenance or repair?*

If an existing SCM was not designed/built to meet the MDC, it is not brought into compliance with MDC, and it was not assigned a nutrient load reduction value when it was permitted, then the nutrient treatment it provides will need to be determined in consultation with DWR.

However, where an existing SCM's nutrient treatment value was calculated for it using an older version of the Tool or another, older method, you need to continue to use that assigned nutrient removal value, even if the SCM meets current MDC.

If the existing SCM does meet the MDC and has been adequately maintained, or if it is now maintained or repaired to function correctly, but it did not have a nutrient credit value previously assigned to it, then the Tool can be used to calculate the nutrient credit it merits along with that of the new SCM.

Determining Nutrient Credits from Treatment Provided by an Existing SCM

Nutrient treatment provided by an existing SCM may be assigned nutrient credits if the SCM was installed after the baseline period. The baseline period for Jordan ran through 2001 and for Falls 2006.

If an existing SCM was installed after the baseline period, the nutrient treatment determined for that SCM can be assigned nutrient credit under an Existing Development rule using the existing development retrofit option. The credits calculated for that SCM have primacy relative to credits calculated for additional SCMs installed later in the same catchment.

If an existing SCM was installed before the end of the baseline period, nutrient credits cannot be assigned to that SCM even though it may be providing nutrient treatment. However, if you are upgrading an existing SCM installed prior to the end of the baseline, you may receive credit for the incremental improvement your upfit provides (see the next section).

Converting an Existing SCM to a New SCM

A more complex credit case for an existing development retrofit is replacing, upgrading, or converting an existing SCM to an improved SCM (an "upfit"). Replacing, upgrading, and converting an existing SCM to an upfit SCM all share the characteristic of changing from a pre-existing treatment with one amount of nutrient reduction to a new treatment type with a new amount of nutrient reduction. The nutrient credit for such a project is determined by subtracting the treatment provided by the old SCM from the treatment provided by the new one.

For example, an SCM may have been required to treat a development. But since that time, stormwater treatment technologies may have improved. If the pre-existing SCM was installed prior to nutrient management requirements, but is upfit to meet the MDC, then you can run the Tool twice – once for the development with the old SCM, and again for the development with the upfit SCM. The nutrient credit for the upfit is the difference between the two.

Where the pre-existing SCM was installed to meet nutrient management requirements, and therefore may have been permitted using an older version of the Tool, see the instructions below for how to handle SCMs in the Pre-Project state.

Installing New SCMs Below Older SCMs

To model installing new SCMs **below** older SCMs, you run the Tool as if you are newly installing both SCMs together. The new SCM credit will be the additional load reduction afforded. However, if your older SCM has been credited using an older version of the Tool, or otherwise has a different nutrient credit assigned, you will first need to approximate the existing SCM as a Custom Land Cover and then run the Tool with this Custom Land Cover and the new SCM. These two cases are detailed below.

The first case assumes the old SCM meets the MDC and does not have a specific nutrient credit assignment. Results are obtained by running the Tool twice including the entire drainage area that goes to and includes the new (downhill) SCM as your Project Area both times; the first time uses only the old SCM, the second time uses both SCMs. Make sure to enter Pre-Project land cover data for the first run. In the second run, the addition of the newer, downhill SCM does not affect the credits assigned to the older, uphill SCM.

For the first run, subtract the *Post-Project Whole Site **with** SCMs* runoff and nutrient loads from the Pre-Project runoff and nutrient loads to get the nutrient treatment for the older SCM. To get nutrient treatment for the new SCM, after the second run subtract the *Post-Project Whole Site **with** SCMs* runoff and nutrient loads of the second run from those of the first run.

In the latter case, where your older SCM has been credited using an older version of the Tool or otherwise has been assigned a different nutrient credit, approximate the older SCM by creating a Custom Land Cover. You will need to provide the following data:

1. The total area draining to the SCM including itself.
2. The annual volume leaving the SCM.
3. The outgoing phosphorus and nitrogen concentrations, or barring that, calculate them from the annual phosphorus and nitrogen loads using the above annual volume leaving the SCM.
4. The annual precipitation from the current version of the Tool. Don't assume it hasn't changed from when your earlier SCM was approved.
5. The P_j of the current version of the Tool. The P_j has been different in earlier versions of the Tool.

Using this information, you will come up with a composite impervious surface percentage and composite nitrogen and phosphorus "land cover" EMCs. **DO NOT USE the impervious surface percentage for the original SCM's watershed.** The SCM changes the effective impervious surface value.

First get the composite R_v using **Equation 1**. Make sure you carry to 4 significant figures for best results.

Equation 1: Calculate Composite Rv for a Pre-Existing SCM

$$R_v = (V * 12) / (P_j * P * A)$$

Where:

R_v = runoff coefficient,

V = average annual volume leaving SCM (ft^3),

A = area of SCM plus area draining to it (ft^2),

P$_j$ = fraction of rainfall events that produce runoff,

P = average annual rainfall depth (in).

Get the composite impervious cover using **Equation 2**:

Equation 2: Calculate Composite Impervious Cover for a Pre-Existing SCM

$$I \ = \ (R_v - \ 0.05)/0.9$$

Where:

I = fractional impervious cover of the SCM plus area draining to it,

R$_v$ = composite Simple Method runoff coefficient from **Equation 1**.

To calculate your phosphorus and nitrogen EMCs using **Equation 3** if you only have loads:

Equation 3: Calculate Composite EMCs from Loads

$$C \ = \ \left(\frac{L}{V}\right) * \ 16018.5 \ \ddagger$$

Where:

C = event mean concentration of phosphorus/nitrogen (mg/L),

L = average annual pollutant load (lb),

V = average annual volume leaving SCM (ft^3).

$\ddagger$Conversion factor lb/ft^3 to mg/L.

These calculated values – impervious surface, TN EMC, and TP EMC – are entered into the appropriate cells for CUSTOM LAND COVER on the Land Cover Characteristics sheet, with the CUSTOM LAND COVER drainage area and total drainage area of the new SCM in the Post-Project column. Fill in the Pre-Project land cover data including the CUSTOM LAND COVER area. As usual for retrofit projects, the area that will become the new SCM is entered as the pre-existing land cover.

Enter the new SCM in the #1 spot with all of the Project Area going to it on the SCM Characteristics sheet. This includes the CUSTOM LAND COVER area. The nutrient treatment calculated for the new SCM is the standard for an Existing Development Retrofit: subtract the *Post-Project Whole Site **with** SCMs* nutrient load from that for the *Pre-Project Whole Site Condition*.

> ℹ️ You can model three pre-existing SCM per project using Custom Land Cover, but they must drain separately, i.e. not to one another
>
> ⚠️ This method only works with putting new SCMs in series **below** older SCMs.

Installing New SCMs Above Older SCMs

To model installing new SCMs **above** older SCMs, you will first need to model the pre-retrofit state with the existing SCM, and then the post-retrofit state with the new SCM for the same catchment, finally subtracting the nutrient export of the latter from the former to get the treatment contribution of the new SCM. To make calculation easier, don't worry about entering information for the automated calculation of credits, and don't include any pre-project information. Set this up as a New Development project to minimize warning messages.

First determine the runoff and nutrient load exported with only the old SCM and its land covers from the *Post-Project Whole Site* **with** *SCMs* results in the Nutrient Export Summary. Use the Tool if the SCM meets the MDC and has not had runoff and nutrient treatment previously assigned. To get the nutrient treatment provided by this SCM, subtract the *Post-Project Whole Site* **with** *SCMs* results from the *Post-Project Whole Site* **without** *SCMs* results.

If this SCM was modeled with a different version of the Tool or otherwise was assigned different runoff and nutrient treatment values, you will need to start by approximating the runoff and nutrient export that have been assigned to this SCM. Start by writing down the volume partitioning and EMCs for an SCM similar to yours. Then switch to the Custom SCM/BMP type, enter the starting volume partitions and EMCs, and tweak the EMCs and/or volume partitions. Subtract the tweaked *Post-Project Whole Site* **with** *SCMs* results from the *Post-Project Whole Site* **without** *SCMs* results, check against your assigned values, and reiterate this tweak-and-check until your Custom SCM/BMP gives results similar to what your SCM was assigned.

Run the Tool a second time by moving the older SCM's information (if originally modeled in the current version of the Tool) or the Custom SCM/BMP (if approximating the SCM in the current version of the Tool) to the #2 SCM slot and put your new SCM in the #1 slot. You will need to change the allocation of land covers going to each SCM depending on the relative position of the two SCMs (close together or not). Subtract the *Post-Project Whole Site* **with** *SCMs* results of the second run of the Tool from those of the first run to determine the nutrient treatment provided by the new SCM.

Adding Floating Treatment Wetlands to Existing Wet Ponds

A similar example to the above is a retrofit of an existing wet pond to have floating wetlands. Start by modeling the site with just the wet pond. To make calculation easier, don't worry about the automated calculation of credits, and don't include any pre-project information. Determine

the runoff and nutrient export (load leaving the site) with just the wet pond by referring to the *Post-Project Whole Site **with** SCMs* results in the Nutrient Export Summary.

Run the Tool a second time using a wet pond with FTW. While you are not putting a new SCM ahead of the first one in the Tool as you would in the above example, in reality this is exactly what you are doing (putting FTWs upflow of the wet pond outlet). Determine the new runoff and nutrient export with the wet pond with FTWs from the *Post-Project Whole Site **with** SCMs* results. Subtract this new nutrient export from the first run of the Tool to get the nutrient treatment provided by the FTW by themselves.

If the original wet pond was installed prior to the baseline, the nutrient treatment provided by the FTW is the only nutrient credit that can be assigned. If the wet pond was installed after the baseline, but possibly by another entity (so you need to determine nutrient credits separately), then you will need to refer to the *Post-Project Whole Site **without** SCMs* results (for either one run of the Tool, they should be the same). Subtract the *Post-Project Whole Site **with** SCMs* (wet pond only) results from the *Post-Project Whole Site **without** SCMs* results to get the nutrient treatment provided by the wet pond by itself.

If the original wet pond has been credited with a different runoff and nutrient reduction than you can get with the current version of the Tool, or doesn't meet the MDC, then follow the instructions for approximating the assigned runoff and nutrient export with a Custom SCM/BMP as described in the previous section. Depending on how different the pond's design is, the most effective way to model the post-FTW condition (second run of the Tool) is to adjust the Custom SCM's EMCs by the same difference between the EMCs of wet ponds and wet ponds with FTWs.

3.1.5. Offsite Run-On

Many development projects are adjacent to older projects that have precipitation running off and onto adjacent sites, sometimes called "offsite run-on". DEMLR advises that developers route this offsite run-on around your new development project, but this may not always be achievable. Furthermore, local governments may give credit for a development that treats offsite run-on, either as a method of generating tradeable nutrient credits, or to offset treatment of runoff generated onsite that can't be treated for some reason.

Similar to this is an expansion situation, which has a net increase in built-upon area (BUA). Only the new BUA and surrounding disturbed pervious area is required to have nutrient treatment, but it can be challenging to capture only runoff from that area. This situation is handled similarly to an "offsite run-on" situation, but only the area of new BUA, disturbed pervious area, and its SCM is modeled as "onsite," and the rest of the area draining to it is modeled as "offsite".

> ❌ Do not try to model offsite run-on by using different values for area between Project Area, Pre-Project, Post-Project, or SCM drainage areas. You will get errors in calculation.
>
> ℹ️ All offsite run-on modeling guidance assumes you have sized your SCM adequately to handle offsite run-on at full buildout.

To model an offsite run-on scenario in the Tool, it depends on what information you really need to get. To get the correct results covering the export of runoff and nutrients from your SCM when treating offsite area, you need to include that offsite area as part of your project. Doing this, you will get one set of numbers that encompasses both your project area and offsite areas.

You may not need to know all of what is exported from your SCM, only what your site is responsible for. If you are only concerned about the treatment your SCM is providing for your site, yet your SCM is sized adequately to treat the offsite areas, you only have to model your project area. This is the one case where you do not have to include all area draining to your SCM(s), only that area which your project is responsible for treating.

> ✅ You can model situations with offsite run-on without offsite information, provided your SCM is sized adequately to treat runoff from offsite at buildout. In this case you only need to know what the size of your SCM relative to this buildout condition.

If you are interested in determining how much export of runoff and nutrients is from your project area versus the area of offsite run-on, you will need to model this situation twice. Once with the whole area including your project area and the offsite areas (or the entire area draining to your SCM in a rebuild/expansion situation), and again in another copy of the Tool with only your project area (or area of new BUA + SCM if it is a rebuild/expansion situation). Subtract the values calculated for the scenario using just your project area from the scenario using your project area plus the offsite areas to get the amount of treatment provided for offsite areas.

> ✅ You can model treatment for your site and offsite areas as two parallel treatment areas in a single copy of the Tool – one treatment train for just your site, another treatment train for your site plus offsite areas - but make sure you are representing your doubled Project Area in the Land Cover Characteristics and on the Project Info sheet.

If you are modeling a situation where you want to treat some offsite area to offset not treating part of your project area, you also model this as two different projects (or potentially as two parallel treatment trains). In this case, model your entire site, include untreated areas, exclude offsite treated areas. In a second copy of the Tool, model only the areas treated by your SCMs, onsite and offsite. Use the difference in the treated areas to determine what extra treatment your SCM provides and compare to the export from untreated areas.

3.2. SCM Specifics by Type and Under/Oversizing

3.2.1. General SCM Design Guidance

All SCMs listed as "per MDC" include both SCMs designed to the new Minimum Design Criteria as well as the older criteria described in the State's 2009 BMP Design Manual, with certain exceptions as listed in the Minimum Design Criteria Rules (Rules 15 NCAC 02H .1050 through .1062). However, while "100% size" is otherwise required to meet MDC, for the purposes of the Tool, "per MDC" assumes you meet all requirements other than size, and size is recorded separately to allow for alternative credit calculation. Information on those criteria, including design requirements for all SCMs, can be found online:
https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-rules/stormwater-program-rules.

DEMLR's New Stormwater Design Manual offers guidance on how to meet these Minimum Design Criteria along with several other issues and techniques: https://deq.nc.gov/sw-bmp-manual. NCSU has extensive guidance on SCM designs that are compatible with Minimum Design Criteria: https://stormwater.bae.ncsu.edu/resources/.

If you are considering hybrid or custom SCM designs, please contact DEMLR's Stormwater Permitting Unit (Annette Lucas, annette.lucas@ncdenr.gov) to discuss how your design affects nutrient crediting and to get guidance on how to model this design in the Tool.

3.2.2. Bioretention

Bioretention has four different options, two of which are simply versions designed using the Minimum Design Criteria (MDC), the other two being fully-customized with NCSU's Bioretention HyPerTool. The MDC versions require the Size to be 100% in the Tool, if you are under- or oversizing these you will need to use the HyPerTool. When using the HyPerTool, record the size you've modeled in HyPerTool in the Tool's Size field. All four also require the HSG to be set, although it's not used in calculation in the Tool for the HyPerTool versions.

The values you use from the HyPerTool are the 4 hydrologic partitions: ET, Overflow, Exfiltration, and Drainage. Use the percentage of "Drainage" for the Tool's "Effluent" partition, use the percentage of "Overflow" for the Tool's "Overflow" partition, and add the "ET" and "Exfiltration" percentages together to get the Tool's "ET/Infiltration" partition. The HyPerTool also allows you to estimate water quality results using its internal calculations, but because these do not match those in this Tool they should not be used for regulatory purposes.

The Bioretention HyPerTool can be downloaded from NCSU's Resources page – go to the "Downloads" tab and look for "NC Bioretention HyPerTool VBA" (this is the newest version): https://stormwater.bae.ncsu.edu/resources/.

✅ With Bioretention HyPerTool always make sure to use a 10% Factor of Safety.

3.2.3. Custom SCMs

Custom SCM/BMP is an SCM type made available to accommodate new DEMLR/DWR-approved SCMs that have not yet been incorporated into the Tool, as well as to accommodate other sorts of nutrient reduction methods not anticipated to be added to the Tool. Many non-SCM-type BMPs may start with calculations from the Tool, and the Tool has been set up to enable you to do as much of these calculations as possible.

Custom SCMs require that Hydrologic Soil Group and Size be entered, even though HSG doesn't matter for calculation. Size may be any non-negative value, but does not affect the runoff partitions you enter. Make sure to enter the three hydrologic values (runoff partitions), adding up to 100%. You will also need to enter effluent EMCs for this custom SCM. If your area is zero, use very small numbers for EMCs such as 0.001 or less. "Land Cover" EMCs for your custom SCM default to those for other SCMs, but these fields are editable when using Custom SCMs.

✅ In all cases where you use Custom SCMs, make sure you have reviewed the input values with your approving authority.

3.2.4. Disconnected Impervious Surface

Disconnected Impervious Surface installations, when used in a new development context, may be entered en masse for multiple separate DIS installations spread across a development. You do not need to model each one individually. Instead, you model them as one large average group. All DIS installations in a group like this must be going to the same SCM if in a treatment train, or not draining to any receiving SCM at all.

For example: You have 10 houses with 1000sqft roofs, and each house has one maximum size DIS installation treating 500sqft of roof. Provided you are not oversizing your DIS, this means you will have 2000sqft of DIS area spread amongst these 10 houses. Enter your SCM attributes and land area like so:

- SCM Type: DIS
- Size: 100%
- HSG: (must be assumed to be the same across all)
- Roof (residential)   10,000sqft
- other land covers x sqft
- Land Taken Up by SCM   2000sqft

If drainage from these lots is in turn treated by a more traditional single-site stormwater control structure, this SCM would be placed in series after this combined DIS SCM in the Tool. See DEMLR's "North Carolina Stormwater Control Measure Crediting Document" (can be found on the webpage https://deq.nc.gov/sw-bmp-manual) for how to determine minimum vegetated area and calculate percent oversize.

✅ DIS can be oversized, but not undersized. Calculate oversize amounts as the ratio between the required vegetated area and the provided vegetated area.

3.2.5. Dry Pond

Dry ponds can be sized anywhere from 50% undersized to 400% oversized.

3.2.6. Green Roof

When modeling a green roof installation, the green roof is assumed to not treat any area other than the green roof itself. In this case, the SCM's land cover is 100% of the area draining to the SCM, and must be at the top of any series of SCMs if others are involved. Green roofs can only be sized 100%.

3.2.7. Infiltration System

Infiltration systems are to be designed to infiltrate within 60 to 72 hours. As such, their actual volume is dependent on the underlying soil, and determined by the designer. When using infiltration systems with another use on top of them, the *Land Taken Up by SCM* may be essentially zero. Do include pretreatment devices in the SCM's size.

3.2.8. Level Spreader-Filter Strip

Level spreader-filter strips may be sized from 100% to 400% in the Tool, but it is possible to model "undersized" LS-FS installations. Some additional calculation is necessary, and in this situation it must be entered as a Custom SCM. This method is described below.

Full-size and oversize LS-FS use the equation in DEMLR's "North Carolina Stormwater Control Measure Crediting Document" (can be found on the webpage https://deq.nc.gov/sw-bmp-manual) to determine what is the "full-size" vegetated area. The ratio of provided vegetated area to required vegetated area gives you the size over 100%.

"Undersizing" LS-FS is possible but requires that greater than 90% of your inflow be diverted as overflow, while still meeting requirements for minimum length for the discharge. If you have an approved, undersized LS-FS you enter it as a "Custom SCM" and determine the proportion of treatment volume that is overflow based on comparing the volume of overflow of a "full-sized" LS-FS to that of your undersized LS-FS. The remaining treated volume is then apportioned

between ET/infiltration and effluent based on the hydrologic soil group. Use the HSG to select the correct equation for determining the percent of treated volume that is ET/infiltration, and convert that to the proportion of total volume to enter into the Tool. What remains out of 100% is the effluent proportion.

3.2.9. Permeable Pavement

When modeling a permeable pavement installation, the typical installation does not involve water running onto the pavement from another source (the "run-on ratio"), with the exception of screened rooftop runoff. Where no additional area drains to the pavement, the SCM's land cover is 100% of the area draining to the SCM and must be at the top of any series of SCMs if others are involved. Remember that the area of a permeable pavement installation is "Land Taken Up by SCM", and not listed under the "parking lot" or "driveway" land covers.

All permeable pavement installations designed to Minimum Design Criteria may only have a Size of 100%. Alternative permeable pavement installations may be modeled first using NCSU's PermPave HyPerMod, which calculates custom volume partitions for different arrangements, including oversize. When using HyPerMod to oversize, enter the Size you used in HyPerMod into SNAP, although that value will not be altering any calculations in the Tool. Make sure to use a 10% factor of safety in the PermPave Tool.

To oversize in HyPerMod, tool options are available for run-on ratios of 0.5, 1, 2, and 4. A run-on ratio equal to 1 has the same amount of area draining to the permeable pavement as the permeable pavement itself. In these cases, the drainage area for the permeable pavement SCM will not be coincident with the area of permeable pavement itself. SNAP data entry would include the areas outside of the pavement in the same column as the pavement land cover data.

Similar to the Bioretention HyPerTool, the values you will use from the PermPave HyPerMod are the three hydrologic partitions: "Drainage" used for the Tool's "Effluent" value, "Surface Runoff" used for the Tool's "Overflow" value, and "Exfiltration + Evaporation" for the Tool's "ET/Infiltration" value.

The PermPave HyPerMod can be downloaded from NCSU's Resources page – go to the "Downloads" tab and look for "Permeable Pavement Hydrologic Performance Model": https://stormwater.bae.ncsu.edu/resources/.

> ✅ With PermPave HyPerMod always make sure to use a 10% Factor of Safety.

3.2.10. Pollutant Removal Swale

Pollutant removal swales are one of the few SCMs that can only be sized at 100%. These swales come in "dry" and "wet" variations with different effluent EMCs. Discuss design requirements with your approving authority to design a swale to be specifically "dry" or "wet".

3.2.11. Rainwater Harvesting

Rainwater harvesting can have broad variation in application including how much water is harvested and how that water is used. For purposes of meeting stormwater regulations, at least 85% of runoff needs to be captured, but it may be more. Hence the volume partitioning for this practice is entirely user-entered. Similarly, the effluent EMC is dependent on the source of the runoff as well as how the water is being used and must also be user-entered. For most applications, use the Pre-Project Nitrogen and Phosphorus EMCs shown on the "Overall Summary" sheet (that is, use the influent EMCs). For all rainwater harvesting implementations make sure you have reviewed your volume partitioning and EMCs with the approving authority.

Where collected water is directed to the sanitary sewer, use the SNAP Tool's "ET/Infiltration" value to approximate water leaving the surface runoff system entirely. NCSU's Rainwater Harvester Tool can be used to determine the proportion of annual runoff captured in this kind of system depending on the configuration. Use Rainwater Harvester's "Total Volume Captured" for the SNAP Tool's "ET/Infiltration" hydrologic partition, and "Overflow" covers the remaining percentage. "Effluent" will be zero when water is used for another purpose, such as greywater. Rainwater Harvester can also be used to model runoff collected for landscape irrigation.

"Land Taken Up By SCM" for Rainwater Harvesting should be entered as zero area, since the collection system generally doesn't collect rain falling onto the cistern itself.

Rainwater Harvester also calculates nutrient removal, but because these calculations are not the same as those used in the Tool, the results cannot be used for regulatory purposes.

The Rainwater Harvester Tool can be downloaded from NCSU's Resources page – go to the "Downloads" tab and look for "Rainwater Harvest 3.0":
https://stormwater.bae.ncsu.edu/resources/.

3.2.12. Sand Filters

Sand filters can be sized anywhere from 50% undersized to 400% oversized. When using sand filters with another use on top of them, the Land Taken Up by SCM will be zero. These SCMs come in "open" and "closed" variations with different effluent EMCs. Discuss design requirements with your approving authority to design a sand filter to be specifically "open" or "closed".

3.2.13. Silva Cells

Silva Cells are a proprietary design but handled like bioretention cells with regard to nutrient reduction calculation. They do not have the option of alternative sizing using the Bioretention HyPerTool.

3.2.14. Stormwater Wetland

Stormwater wetlands can be sized anywhere from 50% undersized to 400% oversized.

3.2.15. Wet Pond and Floating Wetlands

Wet ponds and wet ponds with floating wetlands can be sized anywhere from 50% undersized to 400% oversized. Floating wetlands must cover at least 5% of the surface of the wet pond, clustered around the outlet structure.

Chapter 4: Calculations

4.1. Assumptions and Governing Equations

Calculations performed by the model begin with an estimate of the volume of runoff and mass of pollutant that is generated by an area, whether for the whole site or an area draining to a SCM. This estimate is provided using the Simple Method.

How much of each pollutant is removed and how much is exported when a SCM treats the incoming runoff is estimated based on runoff volume partitioning between effluent, overflow, and "lost" volumes of water, and the effluent event mean concentration for any given SCM.

How these sets of calculations are used in the Tool is described below.

4.1.1. The Simple Method

The Simple Method is a method for estimating the volume of stormwater runoff leaving a small urban catchment and the pollutant load exported with it. The Simple Method has two limitations (CWP, 2007):

1. The Simple Method should be used on catchments with areas of 1 square mile (640 acres) or less; and
2. The Simple Method only estimates pollutant loads leaving the catchment via stormwater runoff.

Runoff volume calculations are based upon impervious cover of a catchment, which is represented by the runoff coefficient R_v, as shown in **Equation 4**:

Equation 4: Simple Method Runoff Coefficient

$$R_v = 0.05 + (0.9 * I)$$

Where:

R_v = Simple Method runoff coefficient; and

I = fractional impervious cover of the catchment (from **Table 9**).

The runoff volume is a function of the runoff coefficient, R_v, the area of the catchment, and the rainfall amount. Some variations of the Simple Method are applied on an individual storm basis, in which case the precipitation value would be the depth of rainfall for the selected storm. The Tool uses average annual precipitation values in inches per year to estimate average annual runoff volume, as shown in **Equation 5**:

Equation 5: Average Annual Runoff Volume

$$V = P_j * R_v * A * (P/12)$$

Where:

V = volume of runoff (ft^3),

R_v = runoff coefficient (from **Equation 4**),

A = area of catchment (ft^2),

P_j = fraction of rainfall events that produce runoff,

P = average annual rainfall depth (in).

CWP, 2007 recommends a P_j value of 0.9, indicating that 90% of rainfall events produce runoff. To estimate the mass of pollutant that leaves the catchment on an annual basis, **Equation 6** is used.

Equation 6: Average Annual Pollutant Load

$$L = \left(\frac{P}{12}\right) * P_j * R_v * C * A_{ac} * 2.72 \ddagger$$

Where:

L = average annual pollutant load (lb),

P = average annual rainfall depth (in),

P_j = fraction of rainfall events that produce runoff,

R_v = runoff coefficient (from **Equation 4**).

C = event mean concentration of the pollutant (mg/L),

A_{ac} = area of catchment (acres).

‡Conversion factor acres to ft^2, mg/L to lb/ft^3.

4.1.2. How the Simple Method is Used in the Tool

In order to have a complete estimate of the volume of water being treated by a SCM, calculations of runoff from a catchment include the area taken up by the SCM itself. It is assumed that 100% of the precipitation that falls onto the SCM becomes part of the runoff volume treated or bypassed by the SCM. For this reason, when calculating runoff from the area taken up by the SCM itself an R_v = 1 is used.

While most SCMs are themselves not truly impervious surfaces in the sense that they prevent infiltration of water into the soil beneath them, for purposes of calculating volume reaching the SCM they need to be. Since this non-standard concept of percent impervious surface is reported in the development summary, the "built-upon area" (BUA) value is also reported to provide an equivalent to the common conception of "impervious cover". Most SCMs are not considered "built-upon area" in regulatory terms. Green roofs, being on top of buildings, are considered 100% built-upon; permeable pavement installations of all types are given a 50% "built-upon" value.

Since the area taken up by the SCM itself is considered a land cover, it has an associated event mean concentration for the precipitation "running off" of it. Most SCMs are assumed to have the same nitrogen and phosphorus EMCs as rooftops, i.e. they are receiving small coatings of pollutants through dust and atmospheric deposition. However, SCMs can have a "land cover" in addition to their acting as a SCM, such as permeable pavement. Since permeable pavement is driven upon just like other parking lots, it has the same "land cover" EMCs as parking lots.

Since there isn't a single EMC for all types of land taken up by SCMs (SCM "land covers"), calculations for the whole development site use a composite EMC for SCM "land covers". In practice, the Tool calculates the whole site's runoff and pollutant load as soon as you have entered watershed land covers, even before entering information about the SCMs themselves other than the total area taken up by them. For this reason, before any SCMs are entered, the Tool uses a default EMC for SCM "land covers" equal to that for rooftops. After information is entered about SCMs, a composite SCM "land cover" EMC is used in whole site runoff and load calculations.

Composite SCM "land cover" EMCs are not used for the individual subcatchments (drainage areas) going to individual SCMs, as each subcatchment drains to only one SCM.

Since catchments draining to SCMs (and the site as a whole) rarely have the same land cover throughout, runoff volume and the load of pollutants is calculated independently for individual land cover types that comprise the catchment and added together to determine the whole catchment's volume and pollutant load. For each land cover type, a runoff coefficient is calculated, volume is calculated, and land-cover-specific event mean concentration (EMC) is applied to get the load shed from that land cover. Composite runoff volume, load, and EMC for the entire site are calculated by adding together these sets. This requires that square footage of each land cover type across a development site be determined.

Runoff volume from the whole site is comprised of the sum of all runoff generated by each land cover type present:

Equation 7: Total Volume Draining From A Site With Multiple Land Covers

$$V_{total} = V_{LC1} + V_{LC2} + V_{LC3} \dots etc.$$

Where:

V_{total} = composite runoff volume leaving the entire site (ft^3),

V_{LC1} = volume of runoff generated by Land Cover #1,

V_{LC2} = volume of runoff generated by Land Cover #2,

V_{LC3} = volume of runoff generated by Land Cover #3.

Pollutant load leaving the whole site is comprised of the sum of loads generated by each land cover type present:

Equation 8: Total Pollutant Load Generated By A Site With Multiple Land Covers

$$L_{total} = L_{LC1} + L_{LC2} + L_{LC3} \dots etc.$$

Where:

L_{total} = pollutant load generated by the entire site (lb),

L_{LC1} = pollutant load generated by Land Cover #1,

L_{LC2} = pollutant load generated by Land Cover #2,

L_{LC3} = pollutant load generated by Land Cover #3.

As part of analyzing the incoming runoff that is treated by the SCM, a composite EMC for the whole site is calculated, as shown in **Equation 9**:

Equation 9: Composite EMC for a Site with Multiple Land Covers

$$C_{total} = \frac{(C_{LC1} * V_{LC1}) + (C_{LC2} * V_{LC2}) + (C_{LC3} * V_{LC3}) + etc}{V_{total}}$$

Where:

C_{total} = composite, whole-site event mean concentration (mg/L),

V_{total} = composite runoff volume leaving the entire site (ft^3),

C_{LC1} = pollutant EMC Land Cover #1,

C_{LC2} = pollutant EMC for Land Cover #2,

C_{LC3} = pollutant EMC for Land Cover #3,

V_{total} = composite runoff volume leaving the entire site (ft^3) (from **Equation 7**),

V_{LC1} = volume of runoff generated by Land Cover #1,

V_{LC2} = volume of runoff generated by Land Cover #2,

V_{LC3} = volume of runoff generated by Land Cover #3.

4.1.3. SCM Runoff Volume Partitioning

Runoff that enters a SCM can be treated and released as effluent/outflow, bypass the SCM as untreated overflow, or leave the SCM as evapotranspiration (ET) or infiltration into the underlying soil **Figure 4-1**. These different volume partitions of the inflowing whole mean there are different "fates" of the incoming runoff and pollutants carried into the SCM, only some of which leaves the SCM. The percentage of runoff being treated and bypassed by a SCM is a function of the SCM's characteristics and design, as is the percentage 'lost' via evapotranspiration. The percentage 'lost' via infiltration is dependent upon the type of soil underlying the SCM. Consequently, hydrologic parameters vary by SCM type and by hydrologic soil group (HSG).

Figure 4-1: Hydrologic fate of incoming water and associated pollutant concentrations, as modeled in the Tool.
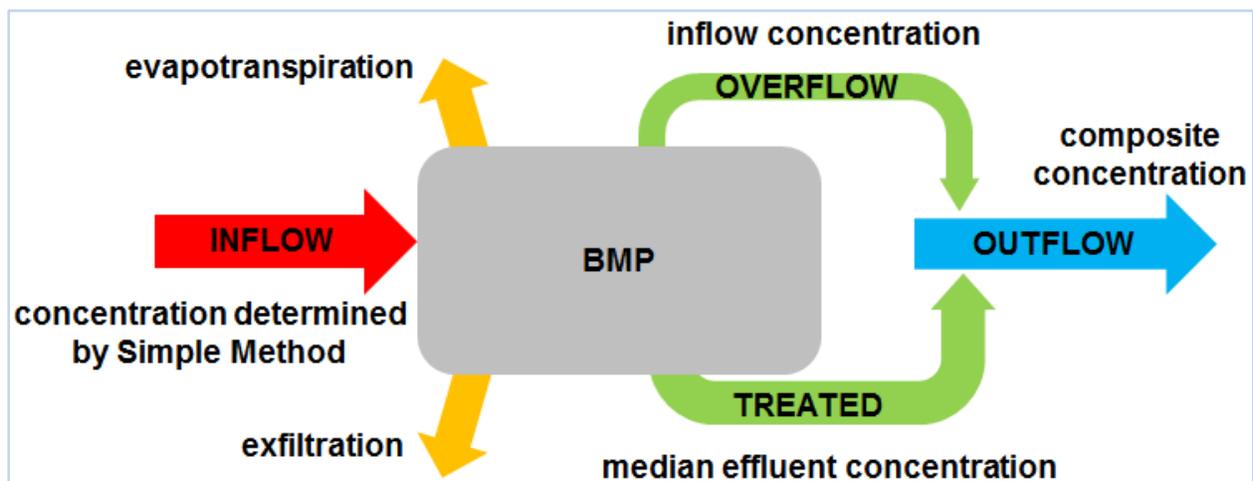
All SCMs in the Tool except "Custom", "Rainwater Harvesting", and bioretention and permeable pavement that are customized using NCSU BAE's HyPerMod Tool have predetermined apportionment of the total incoming runoff volume into an Effluent fraction, an Overflow fraction, and an Evapotranspiration/Infiltration fraction. Depending on the SCM, some of these fractions are fixed, and some of these fractions are based on the size of the SCM compared to its regulatory "full size". An initial explanation of how the Tool uses these fractions in the calculation of pollutant export starts with an assumption of "full size" SCMs. Volume partitions for all the Tool's available SCMs at "full size" are presented in **Table 3**.

Table 3: Volume Partitions (Fractions) for all "Full Size" SCMs

SCM Name	Hydrologic Soil Group	Treated Effluent Fraction	ET / Infiltration Fraction	Overflow Fraction
Bioretention with IWS per HyPerTool	A	custom	custom	custom
	B	custom	custom	custom
	C	custom	custom	custom
	D	custom	custom	custom
Bioretention with IWS per MDC	A	0.09	0.85	0.06
	B	0.27	0.67	0.06
	C	0.6	0.34	0.06
	D	0.81	0.13	0.06
Bioretention without IWS per HyPerTool	A	custom	custom	custom
	B	custom	custom	custom
	C	custom	custom	custom
	D	custom	custom	custom
Bioretention without IWS per MDC	A	0.46	0.48	0.06
	B	0.75	0.19	0.06
	C	0.84	0.1	0.06
	D	0.86	0.08	0.06
Custom SCM/BMP	A	custom	custom	custom
	B	custom	custom	custom
	C	custom	custom	custom
	D	custom	custom	custom
Disconnected Impervious Surface per MDC	A	0.31	0.59	0.1
	B	0.45	0.45	0.1
	C	0.54	0.36	0.1
	D	0.63	0.27	0.1
Dry Pond per MDC	A	0.76	0.08	0.16
	B	0.8	0.04	0.16

SCM Name	Hydrologic Soil Group	Treated Effluent Fraction	ET / Infiltration Fraction	Overflow Fraction
	C	0.84	0	0.16
	D	0.84	0	0.16
Pollutant Removal Swale per MDC - Dry	A	0.67	0.23	0.1
	B	0.76	0.14	0.1
	C	0.85	0.05	0.1
	D	0.9	0	0.1
Pollutant Removal Swale per MDC - Wet	A	0.54	0.36	0.1
	B	0.63	0.27	0.1
	C	0.72	0.18	0.1
	D	0.81	0.09	0.1
Green Roof per MDC	A	0.4	0.6	0
	B	0.4	0.6	0
	C	0.4	0.6	0
	D	0.4	0.6	0
Infiltration System per MDC	A	0	0.84	0.16
	B	0	0.84	0.16
	C	0	0.84	0.16
	D	0	0.84	0.16
Level Spreader-Filter Strip per MDC	A	0.36	0.54	0.1
	B	0.54	0.36	0.1
	C	0.67	0.23	0.1
	D	0.76	0.14	0.1
Level Spreader Filter Strip with ViroPhos	A	0.36	0.54	0.1
	B	0.54	0.36	0.1
	C	0.67	0.23	0.1
	D	0.76	0.14	0.1
	A	0.84	0	0.16

SCM Name	Hydrologic Soil Group	Treated Effluent Fraction	ET / Infiltration Fraction	Overflow Fraction
Permeable Pavement (detention, lined) per MDC	B	0.84	0	0.16
	C	0.84	0	0.16
	D	0.84	0	0.16
Permeable Pavement (detention, unlined) per MDC	A	0.76	0.08	0.16
	B	0.8	0.04	0.16
	C	0.84	0	0.16
	D	0.84	0	0.16
Permeable Pavement (infiltrating) per MDC	A	0	0.84	0.16
	B	0	0.84	0.16
	C	0	0.84	0.16
	D	0.84	0	0.16
Permeable Pavement per HyPerTool	A	custom	custom	custom
	B	custom	custom	custom
	C	custom	custom	custom
	D	custom	custom	custom
Rainwater Harvesting	A	custom	custom	custom
	B	custom	custom	custom
	C	custom	custom	custom
	D	custom	custom	custom
Sand Filter per MDC - Open	A	0.9	0	0.1
	B	0.9	0	0.1
	C	0.9	0	0.1
	D	0.9	0	0.1
Sand Filter per MDC - Closed	A	0.81	0.09	0.1
	B	0.85	0.04	0.1
	C	0.9	0	0.1
	D	0.9	0	0.1

SCM Name	Hydrologic Soil Group	Treated Effluent Fraction	ET / Infiltration Fraction	Overflow Fraction
Silva Cell with IWS per MDC	A	0.09	0.85	0.06
	B	0.27	0.67	0.06
	C	0.6	0.34	0.06
	D	0.81	0.13	0.06
Silva Cell without IWS per MDC	A	0.46	0.48	0.06
	B	0.75	0.19	0.06
	C	0.84	0.1	0.06
	D	0.86	0.08	0.06
Storm Filter per MDC	A	0.9	0	0.1
	B	0.9	0	0.1
	C	0.9	0	0.1
	D	0.9	0	0.1
Stormwater Wetland per MDC	A	0.50	0.34	0.16
	B	0.54	0.3	0.16
	C	0.59	0.25	0.16
	D	0.63	0.21	0.16
Wet Pond per MDC	A	0.63	0.21	0.16
	B	0.67	0.17	0.16
	C	0.71	0.13	0.16
	D	0.76	0.08	0.16
Wet Pond with Floating Wetlands	A	0.63	0.21	0.16
	B	0.67	0.17	0.16
	C	0.71	0.13	0.16
	D	0.76	0.08	0.16
Filterra	A	0.9	0	0.1
	B	0.9	0	0.1
	C	0.9	0	0.1

SCM Name	Hydrologic Soil Group	Treated Effluent Fraction	ET / Infiltration Fraction	Overflow Fraction
	D	0.9	0	0.1

The methods, equations, and runoff volume partitioning for all these SCMs are explained in greater detail in DEMLR's "North Carolina Stormwater Control Measure Crediting Document" (can be found on the webpage https://deq.nc.gov/sw-bmp-manual).

4.1.4. SCM Effluent Event Mean Concentration

To calculate the volume of water and mass of pollutant resulting from treatment by a SCM, one must know the volume of water flowing into a SCM, the inflow concentration of the pollutant of interest, the amount of inflow volume that leaves the SCM as treated effluent and untreated overflow, as well as the outflow pollutant concentration for both of these outflow components.

Effluent concentrations may change through the course of a runoff event and subsequent treatment by a SCM. For this reason, an average level of treatment (Event Mean Concentration, or EMC) is applied to any given SCM based on its type. For calculating pollutant removal, the Tool uses the "irreducible concentrations" approach rather than a percent removal approach. An "irreducible concentration" approach assumes a SCM will release effluent at a certain pollutant concentration regardless of the incoming concentration. A percent removal approach may give erroneous results when incoming pollutant concentrations are very low or very high. The "irreducible concentrations" approach has been shown to reasonably model both low and high incoming pollutant concentrations and how a SCM treats them. The "irreducible concentration" used for a given SCM's effluent is used in the Tool as its effluent Event Mean Concentration.

The composite total nitrogen and total phosphorus concentrations of a SCM's inflow are estimated via the Simple Method (as discussed **above**). In the Tool, the inflow EMC is used for the overflow EMC, and effluent EMCs are specific to the type of SCM as shown in **Table 4**.

Table 4: SCM Effluent Event Mean Concentrations (EMCs)

SCM Name	Total Nitrogen Effluent EMC (mg/L)	Total Phosphorus Effluent EMC (mg/L)
Bioretention with IWS per HyPerTool	0.58	0.12
Bioretention with IWS per MDC	0.58	0.12
Bioretention without IWS per HyPerTool	1.20	0.12
Bioretention without IWS per MDC	1.20	0.12
Custom SCM/BMP	custom	custom

Disconnected Impervious Surface per MDC	2.44	0.76
Dry Pond per MDC	1.65	0.66
Pollutant Removal Swale per MDC - Dry	1.10	0.14
Pollutant Removal Swale per MDC - Wet	0.82	0.11
Green Roof per MDC	2.44	0.76
Infiltration System per MDC	0.001	0.001
Level Spreader-Filter Strip per MDC	1.04	0.19
Level Spreader-Filter Strip with ViroPhos	0.87	0.1
Permeable Pavement (detention, lined) per MDC	1.08	0.05
Permeable Pavement (detention, unlined) per MDC	1.08	0.05
Permeable Pavement (infiltrating) per MDC	1.08	0.05
Permeable Pavement per HyPerTool	1.08	0.05
Rainwater Harvesting	Influent EMC	Influent EMC
Sand Filter per MDC - Closed	1.20*	0.12*
Sand Filter per MDC - Open	1.20*	0.12*
Silva Cell with IWS per MDC	0.58	0.12
Silva Cell without IWS per MDC	1.20	0.12
Stormwater Wetland per MDC	1.12	0.18
Wet Pond per MDC	1.22	0.15
Wet Pond with Floating Wetlands	0.85	0.09

The Tool uses the influent EMC for a sand filter installation if it is lower than this value.

First the volumes of water leaving the SCM as treated effluent and untreated overflow are calculated, as shown in **Equation 10**:

Equation 10: Volumes of Water Leaving SCM as Effluent and Overflow

$$V_{effluent} = V_{inflow} * F_{effluent} \quad \text{and} \quad V_{overflow} = V_{inflow} * F_{overflow}$$

Where:

$V_{effluent}$ = volume of water leaving the SCM as treated effluent (ft³),

$V_{overflow}$ = volume of water leaving the SCM as untreated overflow (ft³),

V_{inflow} = volume of water entering the SCM (ft³) (= V_{total} from **Equation 7**)‡,

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$F_{effluent}$ = fraction of incoming runoff volume that leaves SCM as treated effluent (from **Table 3**),

$F_{overflow}$ = fraction of incoming runoff volume that leaves SCM as untreated overflow (from **Table 3**);

[‡]Assuming entire site drains to SCM.

Equation 11 is used to calculate total mass of pollutant leaving the SCM:

Equation 11: Mass of Pollutant Leaving SCM

$$M_{out} = (C_{effluent} * V_{effluent} * 0.000062428^{‡}) + (C_{overflow} * V_{overflow} * 0.000062428^{‡})$$

Where:

M_{out} = average annual mass of pollutant leaving the SCM (lb),

$V_{effluent}$ = volume of water leaving the SCM as treated effluent (ft^3) (from **Equation 8**),

$V_{overflow}$ = volume of water leaving the SCM as untreated overflow (ft^3) (from **Equation 8**),

$C_{effluent}$ = EMC for treated effluent portion of outflow (mg/L) (= C_{total} from **Table 4**),

$C_{overflow}$ = EMC for untreated overflow portion of outflow (mg/L) (= C_{total} from **Equation 9**).

[‡]Conversion factor mg/L to lb/ ft^3.

Equation 12 is used to calculate the percent mass removal by the SCM (SCM efficiency metric):

Equation 12: Percent Mass Removal by SCM

$$M_{\%rem} = \frac{\left((C_{inflow} * V_{inflow} * 0.000062428^{‡}) - M_{out}\right)}{(C_{inflow} * V_{inflow} * 0.000062428^{‡})} * 100$$

Where:

$M_{\%rem}$ = percent mass removal of pollutant by SCM,

C_{inflow} = event mean concentration for inflow (mg/L) (= C_{total} from **Equation 9**),

V_{inflow} = volume of water entering the SCM (ft^3) (= V_{total} from **Equation 7**).

[‡]Conversion factor mg/L to lb/ ft^3.

There are some assumptions regarding this SCM efficiency metric:

1. The effluent concentration is the median value of the concentrations exiting the SCM. This metric does not take into account maximum or minimum concentrations and the representative EMC does not vary with storm size or intensity.
2. This metric assumes the SCM is designed and constructed appropriately to capture and treat the first flush (1 inch for non-CAMA locations, 1.5 inch for CAMA locations).
3. The effluent EMC is not dependent upon the inflow EMC, nor the inflow volume or outflow volume.
4. Due to the nature of the metric, the pollutant removal is controlled primarily by the volume reduction provided by the SCM; thus, SCMs with higher volume reductions will have greater pollutant removal capabilities.

The sources and methods for determining the EMCs for all these SCMs are explained in greater detail in DEMLR's "North Carolina Stormwater Control Measure Crediting Document" (can be found on the webpage https://deq.nc.gov/sw-bmp-manual).

4.2. SCMs and Catchments in Series

4.2.1. How SCMs and Catchments in Series Work

The Tool is set up with space to model a total of 18 SCMs. However, these SCMs are grouped into six catchments of three SCMs each, with these three SCMs in series. Output from one SCM per catchment can be routed to another catchment. One catchment can receive inflow from up to five other catchments in parallel. The user does not have to use all three SCM "slots", nor all six catchments, and can route SCMs to each other in a large number of all-series, all-parallel, and mixed-series-and-parallel configurations.

Common to all of these arrangements is the underlying concept in the Tool that a SCM may or may not have additional drainage area not treated by any SCM above it. Without entering extra drainage area beyond the SCM's footprint, two SCMs in a catchment will be a simple series with no intervening drainage area.

A SCM that receives input from another SCM is getting a combination of its output volume and output pollutant load, in addition to any input from its own subcatchment drainage area. The tool separates these calculations into two major sets: calculations of the area drained solely by a given SCM, and calculations of the cumulative volume and mass inputs the SCM receives from its drainage area and any SCMs routed to it.

The calculations of the areas drained solely by a given SCM have already been described above as how the Simple Method is applied in the Tool. The next two sections explain how that information is combined with inputs from other SCMs draining into a given SCM.

4.2.2. Cumulative Runoff Volumes and EMCs

Routing and cumulative calculations are based on an arrangement in the Tool whereby cumulative values are calculated for each catchment, and these cumulative values are fed to the calculations for any receiving SCM.

In each catchment the drainage area for the first SCM is added to the cumulative drainage area for any catchments draining into this SCM. The second SCM, similar to the first, has its drainage area added to those for any catchments draining into this one, **plus** the cumulative drainage area of the first SCM in the catchment. Similar to the second SCM, the third SCM has its drainage area and area of contributing catchments added together, plus the cumulative drainage area of the second SCM. This calculation is set up to carry cumulative area values to the third SCM of each catchment regardless of whether there are zero, one, two, or three SCMs in series in that catchment. In the "SCM Calcs" spreadsheet, cells with these cumulative values have thick red borders. Cells referencing cumulative values are linked to the third SCM in each catchment.

In addition to drainage area, other attributes are calculated in a similar way: cumulative runoff volume and cumulative TN and TP load. These latter calculations specifically separate the load coming from an upstream SCM into that from effluent and that from overflow.

4.3. Applicability of NMS Rules

A set of IF-THEN statements are embedded in a macro in the Tool to determine whether and how the various Nutrient Management Strategy Watershed Rules apply. This includes determining when a site is below New Development thresholds and how target export rates and buydown thresholds are determined. Projects in the Randleman Lake watershed and t hose outside of the Nutrient Management Watersheds are treated as if they are below thresholds for Rules to apply. Only Jordan Lake Watershed has established delivery zones, all other "delivery zones" have 100% delivery.

Presently the Tool is only approved for use in the Jordan Lake and Falls Lake Watersheds.

Table 5: Disturbance Thresholds for the Different Nutrient Management Watersheds

Disturbance size	How the Rules Apply
< 0.25 ac	All watersheds below size threshold, treat like New Development below threshold
>= 0.25 ac and < 0.2754 ac	Jordan, Neuse, Tar-Pamlico below size threshold
	Falls – Federal/State non-DOT land owners only, buydown = 30% of needed reduction

>= 0.2754 ac and < 0.5 ac	Jordan, Neuse, Tar-Pamlico below size threshold
	Falls – Federal/State non-DOT and Local Government all land use types, Private non-SFR/duplex only, buydown = 30% of needed reduction
>= 0.5 ac and < 1 ac	Tar-Pamlico - applies only to non-residential (see location rules)
	Neuse – applies only to non-residential (see location rules) – Nitrogen only (P treated as below threshold)
	Jordan – Federal/State non-NCDOT and Local Government all land use types, Private non-SFR/duplex only
	Falls – applies to all land use types, buydown = 30% of needed reduction
>= 1 ac	Tar-Pamlico – applies to all land use types (see location rules), EXCEPT SFR/duplex with BUA < 10% AND not part of common dev plan
	Neuse – applies to all land use types (see location rules) – Nitrogen only (P treated as below threshold)
	Jordan – applies to all land use types
	Falls – applies to all land use types, buydown in downtown areas = 30% of needed, buydown everywhere else = 50% of needed

Table 6: Location Rules Where Different Nutrient Management Watershed Rules Apply

Watershed	Counties	Jurisdictions
Tar-Pamlico	• Beaufort • Edgecombe • Franklin • Nash • Pitt	• Greenville • Henderson • Oxford • Rocky Mount • Tarboro • Washington • aforementioned counties
Neuse	• Durham • Johnston • Wake • Orange • Wayne	• Cary • Durham • Garner • Goldsboro • Havelock • Kinston • New Bern • Raleigh • Smithfield • Wilson

		• aforementioned counties
Falls and Jordan	apply across whole watershed (no location rules)	apply across whole watershed (no location rules)

Table 7: Buydown Thresholds for the Different Nutrient Management Watersheds

Watershed	Owner Type	Residential‡ Buydown Threshold		Non-Residential‡ Buydown Threshold	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus
Tar-Pamlico	All Types	6 lb N/ac/yr	None	10 lb N/ac/yr	None
Neuse	All Types	6 lb N/ac/yr	None	10 lb N/ac/yr	None
Jordan	State & federal	4 lb N/ac/yr	None	8 lb N/ac/yr	None
	All Others	6 lb N/ac/yr	None	10 lb N/ac/yr	None
Falls	See Disturbance Threshold Table	See Disturbance Threshold Table	See Disturbance Threshold Table	See Disturbance Threshold Table	See Disturbance Threshold Table

‡ "Residential" for Tar-Pamlico and Neuse includes Single-Family, Duplex, and Multi-Family Residential. For Jordan and Falls "Residential" includes only Single Family and Duplex.

Table 8: Nutrient Export Targets for the Different Nutrient Management Watersheds

Watershed	Subwatershed	Nitrogen Export Target	Phosphorus Export Target
Tar-Pamlico	All	4 lb/ac/yr	0.4 lb/ac/yr
Neuse	All except Falls	3.6 lb/ac/yr	no P export target
Jordan	Haw	3.8 lb/ac/yr	1.43 lb/ac/yr
	Lower New Hope	4.4 lb/ac/yr	0.78 lb/ac/yr
	Upper New Hope	2.2 lb/ac/yr	0.82 lb/ac/yr
Falls	All	2.2 lb/ac/yr	0.33 lb/ac/yr

4.4. Percent Impervious and Percent Built-upon Area

As noted above, "percent Impervious" in the Tool is not a direct measure of impervious surface as we commonly know it; that is, a percentage of land area that is covered by structures, pavement, and other surfaces that prevent infiltration of water into the underlying soil. Instead, "percent impervious" in the Tool is directly related to how much runoff gets to an SCM, and thus considers land taken up by SCMs to be impervious. For this reason, the impervious values reported may be a different value than expected. Furthermore, with an $R_v = 1$ for SCMs, this further increases the effective imperviousness beyond what would be expected.

"Built-upon Area" is reported in the Tool to represent the common conception of "impervious surface" as an area preventing rainfall infiltration into the soil beneath it. It excludes all SCMs but green roofs and permeable pavement from the calculation of BUA, with permeable pavement installations having a 50% pervious value as required by regulations.

4.5. Sources for Land Cover EMCs

The land cover event mean concentration (EMC) is based on the land cover(s) that runoff is coming from, with different land covers having different pollutant concentrations. **Table 9** summarizes the percent impervious cover and TN and TP even mean concentrations assigned to all land covers included in the Tool. Impervious cover for a given land cover type is assumed to be either 100% for impervious surfaces such as pavement or rooftops or 0% for permeable surfaces such as forest or landscaping.

Table 9: Impervious Surface Proportion, Total Nitrogen EMC, and Total Phosphorus EMC for Land Covers

Land Cover	Impervious Surface Proportion	Total Nitrogen EMC (mg/L)	Total Phosphorus EMC (mg/L)
Roof	1.00	1.18	0.11
Roadway	1.00	1.64	0.34
Parking/Driveway/Sidewalk	1.00	1.42	0.18
Protected Forest	1.00	0.97	0.03
Other Pervious/Landscaping	0.00	2.48	1.07
LAND TAKEN UP BY SCM	1.00	1.18	0.11
CUSTOM LAND COVER	custom	custom	custom

A literature review with QA/QC of all calculations was conducted by NCSU to establish representative pollutant concentrations for various land cover types. The best effort was made to only use data from North Carolina. Data from outside of NC were from areas with similar weather patterns and ecoregions. With those data, winter (November to April) samples were excluded. With the exception of unpublished NCSU monitoring data, only peer-reviewed literature was considered in this endeavor; however, geographic limitations were not imposed. Only data from sampling sites with primary land uses (at least 75% of land cover of interest) were used in the analysis. Unpublished NCSU data were previously QA/QC'd when preparing data for DEMLR's SCM Credit Document. To arrive at numbers, EMCs from individual studies were averaged (see **Equation 13: Calculation of Mean EMCs for Each Study**). Then the median of the average concentrations were found to determine the TN and TP EMCs for each land cover (see **Equation 14: Calculation of Land Cover EMCs**). The median was used to avoid bias with different numbers of samples and extreme values.

Equation 13: Calculation of Mean EMCs for Each Study

$$\overline{x_i} = \frac{1}{n}\sum_{i=1}^{n} C_i$$

Where:

$\overline{x_i}$ = Average effluent concentration for site (mg/L)

n = Number of samples from site

C_i = Effluent concentration from sampling event i (mg/L)

Equation 14: Calculation of Land Cover EMCs

$$E = \frac{1}{2}\left(\sum_{i=1}^{n} \bar{x}_i + 1\right)$$

Where:

E = Median Land Cover EMC (mg/L)

n = Number of sites

$\overline{x_i}$ = Average effluent concentration for site i

Table 10 displays the study data TN and TP concentration values for the roof-type land cover, as well as the references from which the values were derived. Data were used for rooftops of any type (commercial, industrial, residential), and used Bannerman et al. (Wisconsin) and Fassman et al. (New Zealand) because of the small number of references. Winter samples were excluded from the Wisconsin study, and New Zealand rainfall patterns were compared to NC rainfall for similarity.

Table 10: Average concentrations used to compute representative pollutant concentrations for roof-type land covers.

Site	Location	Source	Number of Samples (N,P)	Ave Conc N (mg/L)	Ave Conc P (mg/L)
WCC	Goldsboro, NC	Moran 2004	5,5	2.40	0.11
Neuse	Kinston, NC	Moran 2004	4,4	0.54	0.08
Storrs	Storrs, CT	Gregoire and Clausen 2011	19,19	0.90	0.20
Whole Foods	Raleigh, NC	Wilson et al. 2014	17,17	0.84	0.02
FS 6	Raleigh, NC	DeBusk 2013	25,25	2.74	0.28
FS 8	Raleigh, NC	DeBusk 2013	27,27	2.83	0.13
FS 24	Raleigh, NC	DeBusk 2013	27,27	1.47	0.03
FS 28	Raleigh, NC	DeBusk 2013	26,26	2.02	0.08
Tamaki Control	Auckland, NZ	Fassman et al. 2013	8,8	0.47	0.13
WCC Control	Auckland, NZ	Fassman et al. 2013	8,8	0.41	0.01
Residential Roof	Madison, WI	Bannerman et al. 1993	-		0.15
Commercial Roof	Madison, WI	Bannerman et al. 1993	-		0.20
Industrial Roof	Madison, WI	Bannerman et al. 1993	-		0.11

Table 11 displays the study data TN and TP concentration values for the roadway-type land cover, as well as the references from which the values were derived. Data included any sort of roadway or street made of materials including asphalt, hot mix asphalt (HMA), and bituminous concrete. PFC does not affect nitrogen values but will affect phosphorus. Roadways with different average daily traffic (AADT) volumes were used because in theory while volume can affect nitrogen (due to exhaust), it is less of an issue for phosphorus.

Table 11:Average concentrations used to compute representative pollutant concentrations for roadway-type land covers.

Site	Location	Source	Number of Samples (N,P)	Ave Conc N (mg/L)	Ave Conc P (mg/L)
Jack Bennett	Chapel Hill, NC	Winston and Hunt 2017	5,5	1.69	0.14
Hanks Chapel	Pittsboro, NC	Winston and Hunt 2017	4,4	1.61	0.07
Goldsboro	Goldsboro, NC	Winston and Hunt 2017	7,7	1.39	0.16
Wilson	Wilson, NC	Winston and Hunt 2017	6,6	1.26	0.17
Site I	Charlotte, NC	Wu et al. 1998	10,10	3.67	0.43
Site II	Charlotte, NC	Wu et al. 1998	10,10	1.40	0.52
Site III	Charlotte, NC	Wu et al. 1998	10,10	1.14	0.47
HWY	Savage, MD	Stagge et al. 2012	6,6	5.53	0.55
HWY-CD	Savage, MD	Stagge et al. 2012	27,27	4.80	0.34
Road	Benson, NC	Powell 2015	27,0	1.02	
Site A	Johnston County, NC	Winston et al. 2012	24,0	1.48	
Site B	Johnston County, NC	Winston et al. 2012	23,0	1.66	
Site C	Sampson County, NC	Winston et al. 2012	20,0	2.03	
Site D	Duplin County, NC	Winston et al. 2012	20,0	2.60	

Table 12 displays the study data TN and TP concentration values for the parking-, driveway-, and sidewalk-type land cover, as well as the references from which the values were derived. Parking lots and driveways of all types of pavement, excluding permeable pavement. Because there was limited data for sidewalks, but were similar to those for parking, NCSU researchers decided to combine those values with parking and driveway data.

Table 12: Average concentrations used to compute representative pollutant concentrations for parking-, driveway-, and sidewalk-type land covers.

Site	Location	Source	Number of Samples (N,P)	Ave Conc N (mg/L)	Ave Conc P (mg/L)
Florida Aquarium F1	Tampa, FL	Rushton 2001	30,30	0.56	0.11
Florida Aquarium F2	Tampa, FL	Rushton 2001	30,30	0.55	0.11
Char	Charlotte, NC	Passeport and Hunt 2009	26,26	1.83	0.20
Kin1	Kinston, NC	Passeport and Hunt 2009	15,15	1.13	0.10
Kin2	Kinston, NC	Passeport and Hunt 2009	11,11	1.14	0.07
Gre	Greensboro, NC	Passeport and Hunt 2009	25,25	1.57	0.18
Gold	Goldsboro, NC	Passeport and Hunt 2009	14,14	1.52	0.20
Lou1	Louisburg, NC	Passeport and Hunt 2009	12,12	1.84	0.33
Lou2	Louisburg, NC	Passeport and Hunt 2009	16,16	2.19	0.23
Gra	Graham, NC	Passeport and Hunt 2009	23,23	1.43	0.08
Asphalt	Willoughby Hills, OH	Winston et al. 2016	18,18	1.41	0.05
Goldsboro PICP	Goldsboro, NC	Bean et al. 2007	14,14	1.33	0.13
Asphalt 1	Kinston, NC	Collins et al. 2010	20,0	1.24	
Asphalt 2	Kinston, NC	Collins et al. 2010	15,0	1.27	

SCL	Rocky Mount, NC	Brown and Hunt 2011b	11,11	1.02	0.08
Hal Marshall	Charlotte, NC	Hunt et al. 2008	23,22	1.68	0.19
Nashville	Nashville, NC	Brown and Hunt 2011a	19,19	0.94	0.07
Greensboro 1 (G-1)	Greensboro, NC	Sharkey 2006	19,19	2.85	0.22
Greensboro 2 (G-2)	Greensboro, NC	Sharkey 2006	16,15	1.65	0.21
Louisburg 1 (L-1)	Louisburg, NC	Sharkey 2006	12,12	1.84	0.33
Louisburg 2 (L-2)	Louisburg, NC	Sharkey 2006	12,12	2.19	0.15
Control	Wilmington, NC	Tillet 2016	5,5	1.30	0.18
Retrofit	Wilmington, NC	Tillet 2016	5,5	1.02	0.12
Treatment Train	Fayetteville, NC	Smolek 2016	20,16	1.52	0.25
Filterra	Fayetteville, NC	Smolek 2016	33,32	1.20	0.13
Durham	Durham, NC	Smolek 2016	29,28	2.04	0.50
Asphalt	Waterford, CT	Gilbert and Clausen 2006	0,52		0.24

Table 13 displays the study data TN and TP concentration values for the forest-type land cover, as well as the references from which the values were derived. All types of forested and wooded areas were included in analysis.

Table 13: Average concentrations used to compute representative pollutant concentrations for forest-type land covers.

Site	Location	Source	Number of Samples (N,P)	Ave Conc N (mg/L)	Ave Conc P (mg/L)
WS3_1978	Starke, FL	Riekerk 1983	-	0.89	0.03
WS3_1979	Starke, FL	Riekerk 1983	-	1.60	0.02
WS3_1980	Starke, FL	Riekerk 1983	-	1.05	0.02
Unditched	Beaufort, NC	Lebo and Herrmann 1998	-	1.21	0.05
Forested	Piedmont, NC	Lenat and Crawford 1994	-	1.70	0.09
110	Inter Coastal Plain, MD	Jordan et al. 1997	-	0.48	0.10
301	Inter Coastal Plain, MD	Jordan et al. 1997	-	0.19	0.02
307	Outer Coastal Plain, DE	Jordan et al. 1997	-	0.52	0.02

Table 14 displays the study data TN and TP concentration values for the landscaping-type land cover, as well as the references from which the values were derived. Included lawns, golf courses, and ranges. Raw data from Stillwell will be published in a future journal article.

Table 14: Average concentrations used to compute representative pollutant concentrations for landscaping-type land covers.

Site	Location	Source	Number of Samples (N,P)	Ave Conc N (mg/L)	Ave Conc P (mg/L)
DOT-1	Raleigh, NC	Skipper 2008	15,16	3.09	0.59
University Park Plot_A	University Park, PA	Harrison et al. 1993	17,15	2.59	1.87
University Park Plot_B	University Park, PA	Harrison et al. 1993	21,17	2.76	1.41
1994 Plots	University Park, PA	Linde Watschke 1997	7,0	1.93	
1995 Plots	University Park, PA	Linde Watschke 1997	8,0	1.77	
Residential Lawn	Madison, WI	Bannerman et al. 1993	-		2.67
Lifetime Fitness	Raleigh, NC	Stillwell	8,8	2.38	0.41
Golf Course	Indian River Lagoon / St. Lucie, Estuary, FL	Graves and Fike 2004	28,28	1.62	0.24
Golf Course NC	Neuse River basin, NC	Line et al. 2002	18,18	7.87	1.07
Residential Lawn	Madison, WI	Bannerman et al. 1993	--		2.67

Chapter 5: Summary of Modifications

5.1. Revisions to Produce Version 4

5.1.1. Major Changes in Calculation Methods

- Changed P_j from 1 to 0.9. In many cases P_j was "hard-coded" = 1 by leaving it out of the equation. All Simple Method equations revised to use a variable P_j. Allows for alternative P_j values.

- SCM under/oversizing now integrated with volume partitioning; uses equations for sizing 2 "ponding-types" of SCMs (12-hour drawdown and 60-hour drawdown), flow-through types, and fixed (non-sizable) types. Volume partitioning starts with determining overflow percent. The remainder is split between ET/Infiltration and Effluent (treated volume that flows through/over). This remainder is allocated using simple vectors or equations. Vectors/equations are assigned for each Hydrologic Soil Group. The resulting 3-way volume partitioning (Overflow, ET/Infiltration, and Effluent) is automatically calculated based on the size entered.

- The set of land cover types was greatly compressed down to five types plus those for SCMs and custom land covers. This was based on additional land cover EMC data and questions and experiences of users with previous land cover categories.

- Added functionality to determine which Nutrient Management Rules apply and what the results are for nutrient export targets, buydown targets, load reductions needed, and treatment balance ("credits/debits") based on other information user enters.

5.1.2. Corrections of Calculation Errors

- Tool was not correctly calculating SCMs in series. When 3 SCMs of the same type were tested in series against 3 catchments with the same SCMs and characteristics, results were not the same. Errors corrected by calculating cumulative catchment values.

- Tool was not including non-treated area in calculation of nutrient export. Post-project intermediate and summary calculations were reviewed and revised completely.

- Tool was not handling SCMs with different runoff EMCs correctly. Tool now uses composite SCM "land cover" EMCs to accommodate different SCM "land covers". Right now, most SCM's have a "land cover" EMC equal to that of rooftops. Presently only Permeable Pavement and Disconnected Impervious Surface have a different "land cover" EMC.

- Full project drainage area, SCM watershed, and catchment calculations completely reviewed and corrected for numerous small errors.

5.1.3. EMC, Rv, and related changes

- Driveway impervious value is now set = 1

- Whole set of SCM Effluent EMCs reviewed and revised by NCSU BAE and DEMLR. In some cases, SCMs split into multiple types for different EMCs.

- Correctly calculates individual SCM drainage area impervious surface % and composite Rv (using special SCM Rv = 1)

- Calculation of Built-Upon Area (BUA) added to represent "impervious surface" as it is commonly understood, in comparison to how "impervious surface" is used in the Tool (SCMs have 100% impervious surface).

- For custom SCMs requires specific data entry of all 3 volume partitions (Treated volume %, Overflow volume %, ET/Infiltration volume %) for those SCMs listed as having custom volume partitioning, and makes sure these add up to 100%

5.1.4. New Capabilities

- Nutrient Export Summary calculations: percent change relative to pre-project condition, built-upon area, post-project treated and untreated areas

- Automated Nutrient Offset Credit Reporting form, new form connected to nutrient export summaries means users do not have to fill Nutrient Offset Credit Reporting forms by hand

- Project Summary calculations include project area in acres, fields used to calculate delivery factors, nutrient export targets, buy-down thresholds and credits needed/generated, different calculations for new development, rebuild/expansion, and existing development

- Space to record necessary data: development land cover type, development activity type, designated downtown area, nutrient management watershed, subwatershed, phosphorus and nitrogen delivery zones, project owner type

- Data fields and macros added to enable credit calculation for projects in the Neuse Watershed and Tar-Pamlico Watershed, also to extend to use outside Nutrient Management Watersheds

- SCM Summary calculations: volume reduction, nitrogen reduction, phosphorus reduction

- Allows for three custom land cover types (replaces custom lot size)

- Allows user to model a pre-existing SCM approved with earlier Tool (using Custom Land Cover)

- Able to accommodate HyPerTool design variations for Bioretention and Permeable Pavement

- Able to accommodate Rainwater Harvester design tool outputs as input data

- 26 types of SCMs to choose from

- Allows up to 18 different SCMs in 6 catchments

- Custom SCMs may have custom land cover EMCs

- Space to record additional data: design storm size, disturbed area, county, local jurisdiction, submission date

- Underlying calculation sheets are visible to the user

- CSV now exports in a format with field names; pivot table of the results can be easily imported as a comma-delimited file into any database

- User's Manual has instructions on how to use Tool to model situations such as off-site run-on and a variety of new development and existing development retrofit scenarios

- Extensive data QA and feedback to the user on identified and potential erroneous data

5.1.5. User Interface

- Uses the new term "SCM" (stormwater control measure) rather than "BMP" (best management practice) throughout because all but one of the nutrient management methods is stormwater-based, also to stay coordinated with DEMLR terminology.

- "Land cover" replaces "land use". "Land use" is commonly used to refer to the aggregate activities on a piece of land (e.g. residential, commercial). "Land cover" more specifically refers to what is on the surface of the land.

- Popup "Where Do I Start?" page with the most basic instructions to get user started

- New, more aesthetic Intro page

- Consistent button appearance for navigating around the workbook, printing, etc.

- More data entry cell comments to explain what to enter and how

- Popup map for Jordan Lake Delivery Zones

- Layout resized/rearranged to be usable/legible on small screens like laptops

- Doesn't override user-entered date with current date, also includes it in export file

- Working links to webpages: DWR-Nonpoint Source Planning, DWR-Nutrient Practices and Crediting, User Manual, NCSU Stormwater Design guidance, DEMLR Stormwater BMP Manual

- Worksheets are set so user can select locked cells (for example: to copy-paste calculated values into another spreadsheet)

- Land Cover and SCM calculation worksheets ("Project Calcs" and "SCM Calcs") now visible but locked for user to see inner parts of calculation

- No more merged cells, removed extraneous "spacer" rows/columns (allows copying land covers)

- Able to copy land cover data from the "Land Cover Characteristics" sheet to the "SCM Characteristics" sheet, and copy land cover data between SCMs (land covers are in the same order on all pages)

- Reformatted printing of SCM Characteristics so all 3 SCMs for a catchment fit on two sides of an 8.5x11" page (now much more legible)

- Print setup for "Project Info" and "Land Cover Characteristics" modified for maximum legibility

- Simpler print setup for "Overall Summary"

- "Clear All SCMs" now correctly clears all SCM data and resets number of catchments to 1, also overwrites/corrects cell formats, comments, and data validation in case any copy-pasting by user may have altered it

- Bright yellow cell color for entering SCM Characteristics to know which elements need to be filled in and which are not editable

- More extensive data validation and feedback to the user, but especially checks values for data entered on "SCM Characteristics" sheet

- More drop-down menus, particularly for "Project Info", selections are limited to menu lists

- Gives user warnings on "SCM Characteristics" and "Overall Summary" sheets when the sum of post-project areas doesn't match the sum of pre-project areas, notes these warnings on both "Land Cover Characteristics" sheet and "Overall Summary" sheet

- Checks catchment routing to prevent "split" routing (catchments draining to more than one location)

- Set up for future more-flexible SCM routing (similar to Storm-EZ) – automatically keeps track of/revises "Drains to SCM ID"

- Checks order SCMs are entered in each catchment (#1 first, then #2, then #3), updates "Drains to SCM ID"

5.1.6. Data Management/QA

- QA's imported data to prevent tampering with established SCM EMCs and volume partitions (correctly implements replacement for master-client setup)

- Imports data for all 6 catchments rather than first 3, and unhides all catchments imported rather than first one only

- Puts Tool version number and export date/time in export file. Version number is checked as part of import function to ensure import of a file generated by this version. This allows expansion to importation of other versions.

- "SCM Characteristics" lookups and formatting hard-coded in Visual Basic rather than in Excel cell values (and therefore no longer subject to tampering or simple "breakage")

- Export CSV has field names and data arrangement that can be pivoted for easy import into databases such as MS Access

5.1.7. Owner Maintenance

- More robust (yet still very simple!) "owner" locking/unlocking procedure, allows opening for full debugging/programming (all pages unlocked) or limited opening for SCM and lookup table updates (limited pages unlocked to minimize accidental edits)

- VERY EASY for "owner" to update or add to SCM list and SCM properties (results immediately selectable in dropdown menus and such) – no Excel-power-user skills required

- Has a single lookup table for land covers and their EMCs, means "owner" only has to update one table rather than three; accommodates "aesthetic"/blank/non-value lines across all data entry and calculation pages (these can be reordered or removed entirely, names, EMCs and cell formats will automatically update)

- Land cover lookup table kept extra spaces from earlier versions, but the spaces are hidden; formatting throughout workbook sets values to zero if no land cover data are in the related row of the land cover lookup table

- All land cover types but CUSTOM LAND COVER and LAND TAKEN UP BY SCM are editable, those two are at the end allowing future set of shorter land covers (hide intervening cells)

- Has a single table for SCM data

- Uses structured references to allow for easy expansion of lookup tables and dropdown lists

- Less convoluted catchment and SCM drainage area runoff calculations that can be more easily followed by future maintainers, also using minimal unit conversion to reduce error

- More comments in code for future maintainers

- Changed the formal name to "Stormwater Nutrient Accounting Tool"

- New password

- Much VBA code revised to use variables to allow for easier reordering of data entry cells

- Removed extraneous modules and worksheets

5.2. Detailed Version 4 Sheet-By-Sheet Log of Changes

5.2.1. Popup Terms of Use

- Created short Terms of Use popup that is visible every time user opens workbook

5.2.2. Changes on Worksheet "Intro"

- Renamed sheet from "1. Intro" to "Intro".

- Added workbook navigation buttons.

- Put buttons for import, export, saving workbook, help & documentation on this sheet rather than "4. Overall Summary".

- Consistent button colors: dark green = webpages, blue = navigation, light green = utilities, orange = help and documentation.

- Added a "Where Do I Start?" button to open a popup with the most basic user information.

- New nutrient management strategy watersheds graphic.

- Changed name to "Stormwater Nitrogen and Phosphorus Tool", version number still noted on this page

- Layout adjusted for better visibility on laptop screens.

- Commented out VBA code for this sheet that set up debug mode.

5.2.3. Changes on Worksheet "1. Project Info"

- Removed extra spacer rows and columns.

- Button colors, sizes, and text consistent with "Intro" page buttons, no longer visible on printout.

- Date field is now user-entered rather than automatically set to current date (when current date ("Now()" in VBA) is used it will overwrite every time you open the workbook).

- Buttons for Regional Map and Physiographic Provinces Map moved to the side and colored orange as "help and documentation"-type buttons.

- Buttons (and popup map) added for Jordan Delivery Zone. Map for proposed Falls Delivery Zones is still present, but hidden.

- All fields have appropriate data formats, including commas for numerical values.

- Data validation added to numerical fields and pulldown fields.

- Button to clear project data revised to overwrite data formats, comments, data validation with an unaltered set of cells (set up because the user can accidentally remove/change data formats, comments, and data validation using copy-paste – this acts as a "reset" for the sheet).

- Layout adjusted for better visibility on laptop screens and better print layout.

- Required fields for runoff and nutrient export calculations highlighted yellow, required fields for target export rates, buydown thresholds, and credit/debit calculations highlighted green, and with color-coded notes explaining what the colors mean

- New fields added:

    o Disturbed Area (used by some jurisdictions, separate from Project Area which can include non-disturbed area)

    o Development Land Use Type, Development Activity Type, Designated Downtown Area? Added with pulldown menus, Part of Common Development Plan, Project Owner Type (used by some jurisdictions, used for calculating buydown thresholds and export targets)

    o Project Location/Address (used by some jurisdictions)

    o Project County and Local Jurisdiction

    o Nutrient Management Watershed, Subwatershed, Phosphorus Delivery Zone, Nitrogen Delivery Zone added with pulldown menus (used for calculating buydown thresholds and export targets)

- Comments added for all fields.

- All pulldown menus now use structured references (specifically, named ranges) rather than absolute ranges.

- Data for all pulldown menus located on "Lookup Tables" worksheet.

- Warning message to user if Project Area is larger than one square mile (not appropriate for Simple Method, but still allowable for special situations).

- Warning message to user if Project Area or Precipitation Station are missing.

- Warning message if Disturbed Area is larger than Project Area.

- User may select and copy locked cells on this page.

5.2.4. Changes on Worksheet "2. Land Cover Characteristics"

- Renamed to "Land Cover Characteristics" from "Watershed Characteristics" as users have been confused as to which "watershed" is being referred to.

- Points to centralized table of updated Land Cover EMCs.

- Renamed "Pre-Development" and "Post-Development" columns to "Pre-Project" and "Post-Project" to reduce confusion for Rebuild/Expand and Existing Development Retrofit situations

- List of land cover types and associated EMCs now looks up values from a table on the "Lookup Tables" sheet, rather than being hard-coded. Allows the Owner to modify the set of land covers and/or land cover values in only a single location. Only "CUSTOM LAND COVER" (1, 2, and 3) and "LAND TAKEN UP BY SCM" need to remain unchanged.

- User may copy land cover areas from one column to another; user may also copy land cover areas from this sheet to the "3. SCM Characteristics" sheet.

- Formatting of EMC and Area columns set so that rows for "spacer land covers" (not currently being used) are blank and have no borders (not shaded as data entry fields are), and have data validation so user can't enter any data into them.

- All fields have appropriate data formats, including commas for numerical values, data validation and conditional formatting added for all.

- Button to clear land cover data revised to overwrite data formats, comments, data validation with an unaltered set of cells (set up because the user can accidentally remove/change data formats, comments, and data validation using copy-paste – this acts as a "reset" for the sheet).

- Layout adjusted for better visibility on laptop screens and better print layout.

- Button colors, sizes, and text consistent with "Intro" page buttons, no longer visible on printout.

- Removed extra spacer rows and columns.

- Rearranged Supporting Calculations section to be below data entry cells and Land Cover Area Check rather than to the right (improves print legibility), separated unchanging equations from pre-project and post-project calculation results summary.

- Added calculation cells for determining Net Change of Land Covers, and added results to displayed Land Cover Area Check section.

- "Custom Lot Size" changed to "CUSTOM LAND COVER" and moved second-to-last in the list. Three "CUSTOM LAND COVER" rows now available.

- "CUSTOM LAND COVER" may be used to model a single pre-existing SCM approved under a previous version of the Tool.

- Warning messages for user if Project Area doesn't equal the sum of Post-Project areas Area (duplicated on "3. SCM Characteristics" and "4. Overall Summary" sheets because these are critical errors).

- Warning message if Precipitation Station is missing.

- Warning message if Disturbed Area is less than Net Change of Land Covers. Since Disturbed Area is now used for determining Rule applicability, need to make sure this is a realistic number. It is easy to overlook on the Overall Summary sheet. Some projects may legitimately have a low disturbance area; so Overall Summary calculations are still done when this error occurs.

- Uses a variable P_j rather than hard-coded = 1.

- VBA code for locking and unlocking workbook placed in this worksheet. Multiple types of unlocking: full debug mode and a limited SCM editing mode. Locking leaves all calculation and lookup sheets visible but locked, rather than not visible.

- User may select and copy locked cells on this page.

5.2.5. Changes on Worksheet "3. SCM Characteristics"

- Similar changes to land cover rows as for "2. Land Cover Characteristics" sheet (specifically for data validation, conditional formatting, list of land covers and order, ability to copy-paste land cover data, button to clear form resets data validation and conditional formatting, button appearance, better layout for visibility on laptop screens, warnings for non-matching project/pre-dev/post-dev areas, removal of extra spacer rows and columns).

- Changed layout from 2-columns-per-SCM to single-column layout. Makes copy-pasting possible, makes it easier to add/move rows/fields, makes updating calculations on the "SCM Calcs" page able to take advantage of native Excel behaviors (and generally easier to do). No longer requires "BMP Reset" sheet to clear data.

- Comments to guide user present on all SCM and catchment data entry cells.

- "Hydrologic Values" button moved to top and colored orange as a "help & documentation"-type button.

- Add/Remove catchment buttons all consistent in appearance and location.

- Print layout modified to show data for all 3 SCMs of a single catchment on 2 sides of a single 8.5x11 sheet (much easier to read), page break happens between catchment routing and land cover data.

- SCMs renumbered to have individual IDs, rather than 1,2,3 (part of a "SCM ID" field). Also added a "Catchment ID" field. This allows easier future import of data to databases and more flexible routing in the future.

- Data validation, conditional formatting, and underlying VBA code to check catchment routing for duplicate (split) routing.

- VBA code added to set "Drains to SCM ID" (newly added field) whenever user adds/removes SCMs, and whenever user alters any catchment routing cells. This makes it easier for user to see which SCMs drain to which, and part of a future port to a

database. Code also checks to make sure user adds SCMs in the correct order ("1"s first, then "2"s, then "3"s; the reverse for removal).

- Pulldown menu for SCM types automatically updates when Owner adds SCM on "Assignments" sheet.

- Field for Design Storm Size added. (may eventually tie into Storm-EZ through this field).

- Fields for all three hydrologic values (runoff volume partitions) added (% treated effluent, % ET/infiltration, % overflow/bypass). Depending on the SCM Type, these are automatically set, are set based on Under- or Oversized Percentage, or are open for custom data entry. Underlying VBA code checks what is allowed for any given SCM Type and sets appropriate volume partitions. Code also checks what is allowed for under/oversizing based on SCM Type.

- Added fields for "SCM Land cover EMCs". Since the area of each SCM is included in the runoff volume reaching the SCM, it is not assumed these areas contribute zero N and P. Most SCMs have N and P contributions similar to rooftops. Special SCMs, such as permeable pavement, have different N and P contributions because they have a land cover beyond being just SCMs.

- SCM Effluent and Land Cover EMCs are automatically set when user enters SCM Type, hydrologic soil group, and percent under/oversized. Fields are editable by the user for custom SCMs.

- More space for describing SCMs.

- Necessary fields are highlighted as user enters data (starts with SCM Type, HSG, and under/oversize highlighted, changes if a SCM Type with custom values is selected and indicates which field user needs to enter data for).

- Warnings for user if volume partitions don't add up to 100% for SCMs that have user-entered volumes.

- Warnings for user if Effluent EMCs are blank.

- Warnings for user if LAND TAKEN UP BY SCM is zero and is not allowed to be for that kind of SCM.

- Warnings for user if total amount of any type of land cover on SCM Characteristics page is greater than Post-Project total for that land cover on Land Cover Characteristics page.

- Totals column added for Post-Project Untreated Land Area. Makes summary calculations much easier, and update of those calculations easier.

- User may select and copy locked cells on this page.

- Underlying VBA uses variables for much of the row and column data manipulation, allowing much simpler code updates when fields are rearranged.

- VBA macro to lock or unlock cells commented out (may be removed as it's no longer referred to by other code).

5.2.6. Changes on Worksheet "4. Overall Summary"

- Removed extra spacer rows and columns.

- Button colors, sizes, and text consistent with "Intro" page buttons, no longer visible on printout.

- Layout adjusted for better visibility on laptop screens and better print layout. Entire worksheet prints out on 2 sides of 8.5x11 sheet.

- User may select and copy locked cells on this page.

- Warning messages for user if Project Area doesn't equal the sum of Post-Project areas, and if sum of Pre-Project area doesn't equal sum of Post-Project area.

- For SCM/Catchment Summary - changes in formatting and data sources to remove "N/A" errors, "#VALUE!" errors, and "#DIV/0!" errors and to improve consistency and legibility. SCM numbers changed to match SCM IDs.

- Added Overall Summary section and added/modified results:
    - Calculates export targets, buydown thresholds, load reductions needed, and treatment balances for Jordan, Falls, Neuse, Tar-Pamlico, and areas outside of Nutrient Management Watersheds.
    - Text for export loading rate targets, load targets for the whole site, and load leaving the site with SCMs colored blue to make it easier for user to compare these to blue-text results in Nutrient Export Summary.
    - Tighter, clearer layout with cell borders
    - Presents project and disturbed area in square feet and acres
    - Calculates loading rate and total load targets, which are different depending on whether existing or new development, watershed/delivery zone, land cover and activity type
    - Determines buy-down threshold
    - Calculates additional reduction needed at the site (if any), credits generated (if any), and delivery of nutrients to lake / conversion of credits to amounts delivered to the lake
    - Repeats data used for calculations (delivery zones, watershed info, land use and activity types)
    - Underlying VBA code does aforementioned calculations when user leaves and returns to sheet. Code zeroes out results if user changes values on other sheets that would give an error, or removes needed information.
    - Added comments to explain how different cells were filled in and what they mean

- Added/modified results for Nutrient Export Summary:
    - Added columns for Post-Project SCM-Treated area and Post-Project Untreated area
    - Clarified column headers for Pre- and Post-Project, with and without SCMs
    - Added calculation of Percent Built-upon Area. Added popup explanations of the difference between BUA and impervious surface.
    - Added calculations of % Change relative to Pre-Project state
    - Added comments to explain certain results

- Text in Total Nitrogen and Phosphorus, Load and Loading Rate rows have been colored bright blue to call viewer's attention to those rows.

- Modified results for SCM/Catchment Summary:

  o Created conditional formatting for SCM rows. Rows turn red if any error condition shows up for that SCM on the SCM Characteristics sheet. Errors include volume partitions not adding up to 100%, missing Effluent EMCs, and zero-land cover area for SCM (if not allowed).

  o Shows SCM ID and Type to make it easier to for user to use (user more likely to remember type of SCM rather than an assigned number).

5.2.7. Changes on Worksheet "5. SCM Summary"

- No longer uses "BMP Print" page to print out results. Column A is repeated on all printouts, which means that print ranges only need to include the two columns for a given SCM/Catchment, and no longer requires that any columns be hidden.

- Slightly different, more specific field labels. All number formats checked/made consistent.

- Added annual total runoff, phosphorus and nitrogen reductions in pounds and %.

- Some rearrangement of fields. Changes in formatting and data sources to remove "N/A" errors, "#VALUE!" errors, and "#DIV/0!" errors and to improve consistency.

- Looks up more data from "4. Overall Summary" or "SCM Calcs" rather than recalculating values on this sheet.

- Added data results for annual total nitrogen and phosphorus reduction in pounds (in addition to %).

5.2.8. Changes on Worksheet "Assignments"

- Sheet kept strictly for SCM-related data. All other data moved to "Lookup Tables" sheet.

- Single named table (structured reference) for all SCM information.

- Contains information for Effluent/Outflow EMCs, Land Cover EMCs, whether custom values are allowed for EMCs and/or volume partitioning, impervious and BUA values (for calculating those on "4. Overall Summary" sheet), zero area allowed, sizing limitations and type, overflow vectors or equations, and vectors/equations for ET/Infiltration for each of the four hydrologic soil groups.

- This table is set up such that the Owner only has to add a single line to this table for updates to cascade throughout the workbook.

- Where outflow or SCM land cover EMCs are related to a "regular" land cover EMC, direct cell references are made rather than a repeat of the value to allow tracking. Future changes to set of land covers require that SCM EMCs data be reviewed afterwards.

5.2.9. New Worksheet "Lookup Tables"

- All non-SCM-related data moved from the "Assignments" sheet to this one

- List of applicable Tar-Pamlico and Neuse Jurisdictions and Counties added

- Precipitation stations list – updated to new 1981-2010 Climate Normals dataset

- Land Cover types and data, expanded to include columns for Rv, two columns for creating field names for exporting data

- County and jurisdictions lists for whole state added

- Delivery Zone list – includes new Jordan Delivery Zones, and "100%" delivery zones for all other areas

5.2.10. New Worksheet "Nutrient Offset"

- Holds an "all-watershed" "Nutrient Management Strategy Watershed – Nutrient Offset Credit Reporting Form". Form is auto-populated by data on the "4. Overall Summary" sheet. Form currently calculates the 30-year State Buy-down amount, as is called for in current Nutrient Trading Rules (15A NCAC 02B .0240).

- Provides space for a custom local government buy-down amount.

- Only calculates buy-down if sheet "4. Overall Summary" shows a treatment debit (calculates separately for N and P).

- Sheet was designed to be easily printed out and holds all information needed for reporting nutrient offset credits.

- A few cells may have data entered by the user – outlined in thick gray lines – and can be cleared with a button.

- Contains sheet navigation buttons like other worksheets.

5.2.11. Changes on Worksheet "Project Calcs"

- Renamed "Project Calcs" from "WS Calcs" as users have been confused by the term "watershed" when referring to the entire project area.

- All calculations now reference a variable P_j, rather than a hard-coded $P_j = 1$. In some cases, P_j was left out of equation with the assumption it would continue to equal 1.

- Uses a set $R_v = 1$ for all SCMs. Assumes that all rain that falls onto a SCM "runs off into" that SCM.

- Uses a default land cover EMCs for SCMs until user enters SCM data. After this point composite SCM land cover EMCs are calculated and updated as user enters new SCM data.

- Spacer rows and columns removed.

- List of land covers refers directly to land cover list on "Lookup Tables" sheet, meaning owner only changes land cover data in one location.

- Conditional formatting set for all calculation cells to shade out calculations for "spacer land covers". (Spacer Land Covers aren't anticipated to be used much in the future if we have a limited set of land cover types, but remain available.)

- All calculations on this sheet thoroughly reviewed for errors.

- Sheet keeps rows for the entire table set aside for land cover types on "Lookup Tables" sheet, but extra (empty) rows are hidden.

5.2.12. Changes on Worksheet "SCM Calcs"

- Renamed "SCM Calcs" from "BMP Calcs"

- Similar changes for R_v, P_j, list of land covers, composite SCM land cover EMCs, spacer rows and columns, and conditional formatting for this sheet as for "Project Calcs" sheet.

- Even more extensive review of calculations on this sheet. Many scenarios run to test results, finding many small subtle errors. Cumulative and composite runoff volumes added to calculations to address errors with SCM and catchment routing. Composite R_vs for SCMs, catchments, the whole site pre- and post-project, and post-project treated and untreated areas.

- Revised calculations for whole site and treated and untreated area calculations and summaries to address extensive errors. Clear column headers to explain what is being calculated.

- Under/oversizing calculations initially set up on this sheet using a simple linear equation to under/oversize. New calculations of volume partitions are done on "3. SCM Characteristics" sheet, enabling native Excel capabilities whenever rows/columns need to be added/removed/rearranged.

- Added calculations for %BUA separate from %impervious surface (which has a specific meaning with regard to Simple Method and SCMs).

- Sheet keeps rows for the entire table set aside for land cover types on "Lookup Tables" sheet, but extra (empty) rows are hidden.

5.2.13. Worksheet and Form Additions/Deletions

- Deleted the "BMP Print" sheet, replaced functionality with direct print from "5. SCM Summary" sheet.

- Deleted the "BMP Reset" sheet, replaced worksheet reset functionality with code internal to "3. SCM Characteristics".

- Created a "Nutrient Offset" sheet to hold a "Nutrient Offset Credit Reporting Form"

- Repurposed the "Intro" popup for Terms of use; reinstated "Intro" worksheet as linked by buttons.

- Created new form for Jordan Delivery Zone popup map

- Completely revised the "PrecipitationMap" popup with new 1981-2010 Climate Normals Precipitation Stations (this list is now what's available on the "Lookup Tables" sheet), and a new whole-state annual precipitation extrapolation from these Climate Normals provided by the Oregon State University PRISM project.

- Created a quick-start popup guide ("Start") invoked from the "Intro" sheet by a "Where Do I Start?" button. Includes direct link to the Users' Manual available online.

- Split non-SCM lookup tables off from "Assignments" sheet, created new "Lookup Tables" sheet

5.2.14. Module Additions/Deletions

- Created "Reset" module that simply re-protects all sheets and the workbook and re-enables events. For use during coding for when modules crash.

- Created "Webpages" module that contains code for the "Intro" worksheet for starting up the browser and bringing up various webpages.

- Removed modules with code commented out by Lee: "Module7", which checked formats and cell information in V3 SCM Characteristics; "Module4" and "Module2" which set up some printing; "Module3" which had alternative clearing code for SCMs and Watershed data.

- Removed empty "Module11", "Module6", "Module5".

- Major content updates for "mod_App_Utilities" and "mod_Buttons" – see below.

5.2.15. Changes in Module "mod_App_Utilities"

- Global password changed. Global variable for version which is used in data import.

- Sub SetupDebugMode commented out, as new method of locking and unlocking is in "2. Land Cover Characteristics" sheet.

- Subs SetupReleaseMode, AddWholeNumberPctValidation, SetEndSCMTypeDDList, and ResetSCMTypeDDListRange commented out.

- Subs EnterSampleDataInAllSheets, AddHSGConditionalFormatting_Overflow, AddHSGConditionalFormatting_Treated, AddHSGConditionalFormatting_TN_EMC, AddHSGConditionalFormatting_TP_EMC, LockDrainageAreaLandUseHeaderRows, and ReplaceCatchmentFormulasAndValidation removed.

- Subs Credit_Calculation, ConvertToLetter, and Drains_to_SCMID, Check_Credit_Calc_Data, Clear_Credit_Calc_Data added.

- Check_Credit_Calc_Data sub reviews entries in "1. Project Info" page to make sure all data are present in order to run through set of watershed rules to calculate treatment credits/debits (Credit_Calculation sub). If anything is missing, treatment credits/debits are not calculated (cells are cleared with Clear_Credit_Calc_Data sub).

- Credit_Calculation sub runs whenever "4. Overall Summary" is the active sheet. It refreshes the calculations of treatment credits/debits by running through the set of watershed rules. Watersheds presently represented include Falls Lake, Jordan Lake, Randleman Lake, Neuse, Tar-Pamlico, and 'outside NMS watershed'.

- Drains_to_SCMID sub refreshes the ID of the "Drains to SCM ID" field on the "3. SCM Characteristics" sheet. This field notes the ID of the SCM that is receiving flow from a given SCM, and sets the value to 0 if the SCM is not draining to any other SCM.

5.2.16. Changes in Module "mod_Buttons"

- Subs Jordan_N_Map_Show, Jordan_P_Map_Show, Falls_N_P_Map_Show, and Calculate_Credits, Clear_Nutrient_Offset, ArcOnline_Map_Click added.

- Print ranges for printing subs updated, code simplified.

- Buttons to clear sheets modified to copy blank cells with correct data formats, data validation, comments, and conditional formatting.

- Subs to Add/Remove Catchments revised for changes in sheet layouts.

- Sub Import_CSV completely revised. Correctly imports all 6 catchments if present, rather than only 3. Uses SCM EMC and Volume partitions from CSV only for SCM types that use custom values, all other values are looked up and set.

- Sub Export_CSV completely revised. Exports data as columns with field names that can be imported into a database, rather than as regions on a datasheet.

- Calculate_Credits sub runs the Check_Credit_Calc_Data in the "mod_App_Utilities" module.

5.3. Revisions to Produce Version 3

5.3.1. Functional Revisions

Several functional features of the Tool were modified based upon needs identified by NCDENR DWR. Each of these modifications is described below.

- The acreages of natural wetland and riparian buffer land covers for a project were accounted for in a project's load calculations. The original version of the accounting tool did not consider these land covers when estimating runoff volumes or pollutant loadings.

- Riparian buffers were separated into two categories: Zones 1 and Zone 2. The event mean concentrations associated with forest land covers (1.47 mg/L for total nitrogen (TN) and 0.25 mg/L for total phosphorus (TP)) was assigned to the natural wetland and zone 1 riparian buffer land covers, while concentrations associated with the managed pervious land cover (2.65 mg/L TN, 0.735 mg/L TP) was assigned to the zone 2 riparian buffer land cover.

- The option to calculate composite residential development loading based upon age of development was removed. Table 1 summarizes the concentrations assigned to composite residential land covers.

- Several new BMPs were added, including: floating wetlands, detention permeable pavement with liner, detention permeable pavement without liner and infiltrating permeable pavement. The existing permeable pavement BMP was removed.

- Custom BMP options were added to the accounting tool to allow for the incorporation of current future BMP diversification study findings. This included the following BMPs: Custom bioretention with IWS, custom bioretention without IWS and other custom BMP. When a user selects either of the custom bioretention BMP options, they must enter the hydrologic parameters to be used for that BMP. The effluent concentrations associated with the existing 'bioretention with IWS' (0.95 mg/L TN, 0.12 mg/L TP) and 'bioretention

without IWS' (1 mg/L TN, 0.12 mg/L TP) BMPs were assigned to the 'custom bioretention with IWS' and 'custom bioretention without IWS' BMPs, respectively. When selecting "other custom BMP", the user must enter both the hydrologic parameters and the event mean concentrations associated with the BMP.

- The option to select the predominant underlying hydrologic soil groups (HSGs) for each BMP in a project was added. The underlying HSG determines the hydrologic mitigation provided by a BMP, whereas the original Tool used a project's physiographic region to determine a BMP's hydrologic parameters.

- The Master/Client workbook relationship that served to protect the integrity of the Tool's functions and outputs in version 2 was replaced with a more user-friendly method. This method allows users to export their project data to a .csv file, which can then be imported to the accounting tool by another person/entity. When submitting project information to local governments, users may submit only the .csv file, which would then be imported into the agency's accounting tool file. As the agency has full control over who accesses and changes their file, this ensures that the inner-workings of the accounting tool and, thus, the outputs, have not been jeopardized. This method also allows efficient recordkeeping of project data and information.

5.3.2. Aesthetic Revisions

Many modifications were made to the layout of the original Tool to improve transparency and user-friendliness. These modifications are summarized below.

- Much of the instructional verbiage was removed and replaced with cell-specific mouse-over text. This simplified the look of the tool while retaining guidance for the users. Links to additional help and documentation were added.

- An introduction screen now appears when opening the accounting tool, providing users with resources to additional information about NCDENR and the Jordan and Falls Lake Nutrient Management Strategies.

- Supporting calculations were added to the 'Watershed Characteristics' and 'Individual BMP Summary' worksheets to add transparency. Users can now easily follow the methods used by the accounting tool to generate outputs.

- Summary worksheets were simplified and reformatted. Text sizes were increased to improve readability, and concise print functions were added to fit summary sections on individual sheets of paper.

- Font sizes in cell drop-down lists were increased to improve readability.

- Space to include additional project information was added to the accounting tool, including latitude and longitude coordinates, project designer contact information and project details.

- Hide/show and conditional formatting functions were used in the "BMP Characteristics" worksheet to improve user-friendliness and reduce complexity.

Chapter 6: Comparison Across Versions

Figure 6-1: Comparison of Land Cover EMCs between Tool versions 2, 3, and 4.

Land Cover	v2 TN (mg/L)	v2 TP (mg/L)	v3 TN (mg/L)	v3 TP (mg/L)	v4 TN (mg/L)	v4 TP (mg/L)
Parking lot (commercial)	1.44	0.16	1.44	0.16	merged	merged
Roof (commercial)	1.08	0.15	1.08	0.15	merged	merged
Open/Landscaped (commercial)	2.24	0.44	2.24	0.44	merged	merged
Parking lot (industrial)	1.44	0.39	1.44	0.39	merged	merged
Roof (industrial)	1.08	0.15	1.08	0.15	merged	merged
Open/Landscaped (industrial)	2.24	0.44	2.24	0.44	merged	merged
High Density (interstate, main)	3.67	0.43	3.67	0.43	--	--
Low Density (secondary, feeder)	1.4	0.52	1.4	0.52	merged	merged
Rural (transportation)	1.14	0.47	1.14	0.47	--	--
Sidewalk	1.4	1.16	1.4	1.16	merged	merged
Managed pervious	3.06	0.59	3.06	0.59	merged	merged
Pasture	3.61	1.56	3.61	1.56	--	--
Woods	1.47	0.25	1.47	0.25	merged	merged
2-ac lots (After 1995)	2.219852	0.43777	2.219852	0.43777	--	--
1-ac lots (After 1995)	2.118338	0.425776	2.151582	0.429664	--	--
½-ac lots (After 1995)	2.059185	0.427873	2.108595	0.431187	--	--
¼-ac lots (After 1995)	2.001424	0.423854	2.066616	0.428266	--	--
⅛-ac lots (After 1995)	1.976469	0.427856	2.018731	0.429804	--	--
Townhomes (After 1995)	1.944694	0.417743	1.944694	0.417743	--	--
Multi-family (After 1995)	1.918114	0.407998	1.918114	0.407998	--	--
Custom Lot Size (After 1995)	NA	NA	NA	NA	--	--
2-ac lots (Before 1995)	2.186292	0.434062	--	--	--	--
1-ac lots (Before 1995)	2.151582	0.429664	--	--	--	--
½-ac lots (Before 1995)	2.108595	0.431187	--	--	--	--
¼-ac lots (Before 1995)	2.066616	0.428266	--	--	--	--
⅛-ac lots (Before 1995)	2.018731	0.429804	--	--	--	--
Townhomes (Before 1995)	1.943806	0.417677	--	--	--	--
Multi-family (Before 1995)	1.917146	0.407902	--	--	--	--
Custom Lot Size (Before 1995)	NA	NA	--	--	--	--
Roadway	1.4	0.52	1.4	0.52	1.64	0.34
Driveway	1.44	0.39	1.44	0.39	merged	merged
Parking lot	1.44	0.39	1.44	0.39	1.42	0.18
Roof	1.08	0.15	1.08	0.15	1.18	0.11
Sidewalk	1.4	1.16	1.4	1.16	merged	merged
Lawn	2.24	0.44	2.24	0.44	merged	merged
Managed pervious	3.06	0.59	3.06	0.59	2.48	1.07
Woods/Forest	1.47	0.25	1.47	0.25	0.97	0.03

Land Cover	v2 TN (mg/L)	v2 TP (mg/L)	v3 TN (mg/L)	v3 TP (mg/L)	v4 TN (mg/L)	v4 TP (mg/L)
LAND TAKEN UP BY SCM	1.08	0.15	1.08	0.15	1.18	0.11
Custom Lot Size (New)	custom	custom	custom	custom	--	--
CUSTOM LAND COVER	--	--	--	--	custom	custom
Natural Wetland	--	--	1.47	0.25	merged	merged
Riparian Buffer - Zone 1	--	--	1.47	0.25	merged	merged
Riparian Buffer - Zone 2	--	--	3.06	0.59	merged	merged

NOTE: "merged" in this table means that this land cover overlaps or was combined with another one.

Figure 6-2: Comparison of SCM EMCs between Tool versions 2, 3, and 4.

SCM Name	v2 TN EMC (mg/L)	v2 TP EMC (mg/L)	v3 TN EMC (mg/L)	v3 TP EMC (mg/L)	v4 TN EMC (mg/L)	v4 TP EMC (mg/L)
Custom Bioretention with IWS / Bioretention with IWS per HyPerTool	--	--	custom	custom	0.58	0.12
Bioretention with IWS / Bioretention with IWS per MDC	0.95	0.12	0.95	0.12	0.58	0.12
Custom Bioretention without IWS / Bioretention without IWS per HyPerTool	--	--	custom	custom	1.20	0.12
Bioretention without IWS / Bioretention without IWS per MDC	1	0.12	1	0.12	1.20	0.12
Other Custom SCM / Custom SCM/BMP	--	--	custom	custom	custom	custom
Unnamed SCM 1	--	--	custom	custom	--	--
Unnamed SCM 2	--	--	custom	custom	--	--
Unnamed SCM 3	--	--	custom	custom	--	--
Disconnected Impervious Surface per MDC	--	--	--	--	2.44	0.76
Dry Detention Pond / Dry Pond per MDC	1.2	0.2	1.2	0.2	1.65	0.66
Grassed Swale / Pollutant Removal Swale per MDC - Dry	1.21	0.258	1.21	0.258	1.10	0.14
Pollutant Removal Swale per MDC - Wet	--	--	--	--	0.82	0.11
Green Roof / Green Roof per MDC	1.08	0.15	1.08	0.15	2.44	0.76
Infiltration System per MDC	--	--	--	--	0.001	0.001
Level Spreader Filter Strip /Level Spreader-Filter Strip per MDC	1.2	0.154	1.2	0.154	1.04	0.19
Level Spreader-Filter Strip with ViroPhos	--	--	--	--	0.87	0.10
Permeable Pvmnt - Detention with Liner / Permeable Pavement (detention, lined) per MDC	--	--	0.95	0.11	1.08	0.05
Permeable Pvmnt - Detention without Liner / Permeable Pavement (detention, unlined) per MDC	--	--	0.95	0.11	1.08	0.05
Permeable Pvmnt - Infiltrating / Permeable Pavement (infiltrating) per MDC	1.44	0.39	0.95	0.11	1.08	0.05
Permeable Pavement per HyPerTool	--	--	--	--	1.08	0.05
Water Harvesting / Rainwater Harvesting	1.08	0.15	1.08	0.15	influent	influent
Sand Filter / Sand Filter per MDC - Closed	0.92	0.14	0.92	0.14	1.20*	0.12*
Sand Filter per MDC - Open	--	--	--	--	1.20	0.12
Silva Cell with IWS per MDC	--	--	--	--	0.58	0.12
Silva Cell without IWS per MDC	--	--	--	--	1.20	0.12
Wetland / Stormwater Wetland per MDC	1.08	0.117	1.08	0.117	1.12	0.18
Wet Detention Pond / Wet Pond per MDC	1.01	0.113	1.01	0.113	1.22	0.15
Floating Wetlands / Wet Pond with Floating Wetlands	--	--	custom	custom	0.85	0.09

The Tool uses the influent EMC for a sand filter installation if it is lower than this value.

Figure 6-3: Comparison of SCM Volume Partitions between Tool versions 2, 3, and 4.

SCM Name	v2 Region	v2 Treated Effluent	v2 ET / Infiltration	v2 Overflow	v3/4 HSG	v3 Treated Effluent	v3 ET / Infiltration	v3 Overflow	v4 Treated Effluent	v4 ET / Infiltration	v4 Overflow
Custom Bioretention with IWS / Bioretention with IWS per HyPerTool					A	cust	cust	cust	custom	custom	custom
					B	cust	cust	cust	custom	custom	custom
					C	cust	cust	cust	custom	custom	custom
					D	cust	cust	cust	custom	custom	custom
Bioretention with IWS / Bioretention with IWS per MDC	CAMA	0.1	0.8	0.1	A	0.1	0.8	0.1	0.09	0.85	0.06
	Coastal	0.1	0.8	0.1	B	0.1	0.8	0.1	0.27	0.67	0.06
	Mountains	0.4	0.5	0.1	C	0.4	0.5	0.1	0.6	0.34	0.06
	Piedmont	0.4	0.5	0.1	D	0.4	0.5	0.1	0.81	0.13	0.06
	Sandhills	0.1	0.8	0.1							
	Triassic Basin	0.55	0.35	0.1							
Custom Bioretention without IWS / Bioretention without IWS per HyPerTool					A	custom	custom	custom	custom	custom	custom
					B	custom	custom	custom	custom	custom	custom
					C	custom	custom	custom	custom	custom	custom
					D	custom	custom	custom	custom	custom	custom
Bioretention without IWS / Bioretention without IWS per MDC	CAMA	0.4	0.5	0.1	A	0.4	0.5	0.1	0.46	0.48	0.06
	Coastal	0.4	0.5	0.1	B	0.4	0.5	0.1	0.75	0.19	0.06
	Mountains	0.55	0.35	0.1	C	0.55	0.35	0.1	0.84	0.1	0.06
	Piedmont	0.55	0.35	0.1	D	0.55	0.35	0.1	0.86	0.08	0.06
	Sandhills	0.4	0.5	0.1							
	Triassic Basin	0.75	0.15	0.1							
Other Custom SCM / Custom SCM/BMP					A	custom	custom	custom	custom	custom	custom
					B	custom	custom	custom	custom	custom	custom
					C	custom	custom	custom	custom	custom	custom
					D	custom	custom	custom	custom	custom	custom
Unnamed SCM 1					A	custom	custom	custom			
					B	custom	custom	custom			
					C	custom	custom	custom			
					D	custom	custom	custom			
Unnamed SCM 2					A	custom	custom	custom			
					B	custom	custom	custom			
					C	custom	custom	custom			
					D	custom	custom	custom			
Unnamed SCM 3					A	custom	custom	custom			
					B	custom	custom	custom			
					C	custom	custom	custom			

SCM Name	v2 Region	v2 Treated Effluent	v2 ET / Infil-tration	v2 Over-flow	v3/4 HSG	v3 Treated Effluent	v3 ET / Infil-tration	v3 Over-flow	v4 Treated Effluent	v4 ET / Infil-tration	v4 Over-flow
					D	custom	custom	custom			
Disconnected Impervious Surface per MDC					A				0.31	0.59	0.1
					B				0.45	0.45	0.1
					C				0.54	0.36	0.1
					D				0.63	0.27	0.1
Dry Detention Pond / Dry Pond per MDC	CAMA	0.8	0.1	0.1	A	0.8	0.1	0.1	0.76	0.08	0.16
	Coastal	0.8	0.1	0.1	B	0.8	0.1	0.1	0.8	0.04	0.16
	Mountains	0.9	0	0.1	C	0.9	0	0.1	0.84	0	0.16
	Piedmont	0.9	0	0.1	D	0.9	0	0.1	0.84	0	0.16
	Sandhills	0.8	0.1	0.1							
	Triassic Basin	0.8	0	0.2							
Grassed Swale / Pollutant Removal Swale per MDC - Dry	CAMA	0.9	0.1	0	A	0.9	0.1	0	0.67	0.23	0.1
	Coastal	0.9	0.1	0	B	0.9	0.1	0	0.76	0.14	0.1
	Mountains	1	0	0	C	1	0	0	0.85	0.05	0.1
	Piedmont	1	0	0	D	1	0	0	0.9	0	0.1
	Sandhills	0.9	0.1	0							
	Triassic Basin	1	0	0							
Pollutant Removal Swale per MDC - Wet					A				0.54	0.36	0.1
					B				0.63	0.27	0.1
					C				0.72	0.18	0.1
					D				0.81	0.09	0.1
Green Roof / Green Roof per MDC	CAMA	0	0.5	0.5	A	0	0.5	0.5	0.4	0.6	0
	Coastal	0	0.5	0.5	B	0	0.5	0.5	0.4	0.6	0
	Mountains	0	0.5	0.5	C	0	0.5	0.5	0.4	0.6	0
	Piedmont	0	0.5	0.5	D	0	0.5	0.5	0.4	0.6	0
	Sandhills	0	0.5	0.5							
	Triassic Basin	0	0.5	0.5							
Infiltration System per MDC					A				0	0.84	0.16
					B				0	0.84	0.16
					C				0	0.84	0.16
					D				0	0.84	0.16
Level Spreader Filter Strip / Level Spreader-Filter Strip per MDC	CAMA	0.45	0.5	0.05	A	0.45	0.5	0.05	0.36	0.54	0.1
	Coastal	0.45	0.5	0.05	B	0.45	0.5	0.05	0.54	0.36	0.1
	Mountains	0.55	0.4	0.05	C	0.55	0.4	0.05	0.67	0.23	0.1
	Piedmont	0.55	0.4	0.05	D	0.55	0.4	0.05	0.76	0.14	0.1
	Sandhills	0.45	0.5	0.05							

SCM Name	v2 Region	v2 Treated Effluent	v2 ET / Infil-tration	v2 Over-flow	v3/4 HSG	v3 Treated Effluent	v3 ET / Infil-tration	v3 Over-flow	v4 Treated Effluent	v4 ET / Infil-tration	v4 Over-flow
	Triassic Basin	0.75	0.2	0.05							
Level Spreader Filter Strip with ViroPhos					A				0.36	0.54	0.1
					B				0.54	0.36	0.1
					C				0.67	0.23	0.1
					D				0.76	0.14	0.1
Permeable Pvmnt - Detention with Liner / Permeable Pavement (detention, lined) per MDC					A	custom	custom	custom	0.84	0	0.16
					B	custom	custom	custom	0.84	0	0.16
					C	custom	custom	custom	0.84	0	0.16
					D	custom	custom	custom	0.84	0	0.16
Permeable Pvmnt - Detention without Liner / Permeable Pavement (detention, unlined) per MDC					A	custom	custom	custom	0.76	0.08	0.16
					B	custom	custom	custom	0.8	0.04	0.16
					C	custom	custom	custom	0.84	0	0.16
					D	custom	custom	custom	0.84	0	0.16
Permeable Pvmnt - Infiltrating / Permeable Pavement (infiltrating) per MDC	CAMA	0.38	0.6	0.02	A	custom	custom	custom	0	0.84	0.16
	Coastal	0.38	0.6	0.02	B	custom	custom	custom	0	0.84	0.16
	Mountains	0.98	0	0.02	C	custom	custom	custom	0	0.84	0.16
	Piedmont	0.98	0	0.02	D	custom	custom	custom	0.84	0	0.16
	Sandhills	0.38	0.6	0.02							
	Triassic Basin	0.98	0	0.02							
Permeable Pavement per HyPerTool					A				custom	custom	custom
					B				custom	custom	custom
					C				custom	custom	custom
					D				custom	custom	custom
Water Harvesting / Rainwater Harvesting					A	custom	custom	custom	custom	custom	custom
					B	custom	custom	custom	custom	custom	custom
					C	custom	custom	custom	custom	custom	custom
					D	custom	custom	custom	custom	custom	custom
Sand Filter / Sand Filter per MDC - Closed	CAMA	0.85	0.05	0.1	A	0.85	0.05	0.1	0.9	0	0.1
	Coastal	0.85	0.05	0.1	B	0.85	0.05	0.1	0.9	0	0.1
	Mountains	0.85	0.05	0.1	C	0.85	0.05	0.1	0.9	0	0.1
	Piedmont	0.85	0.05	0.1	D	0.85	0.05	0.1	0.9	0	0.1

SCM Name	v2 Region	v2 Treated Effluent	v2 ET / Infil-tration	v2 Over-flow	v3/4 HSG	v3 Treated Effluent	v3 ET / Infil-tration	v3 Over-flow	v4 Treated Effluent	v4 ET / Infil-tration	v4 Over-flow
	Sandhills	0.85	0.05	0.1							
	Triassic Basin	0.85	0.05	0.1							
Sand Filter per MDC - Open					A				0.81	0.09	0.1
					B				0.85	0.04	0.1
					C				0.9	0	0.1
					D				0.9	0	0.1
Silva Cell with IWS per MDC					A				0.09	0.85	0.06
					B				0.27	0.67	0.06
					C				0.6	0.34	0.06
					D				0.81	0.13	0.06
Silva Cell without IWS per MDC					A				0.46	0.48	0.06
					B				0.75	0.19	0.06
					C				0.84	0.1	0.06
					D				0.86	0.08	0.06
Wetland / Stormwater Wetland per MDC	CAMA	0.65	0.25	0.1	A	0.65	0.25	0.1	0.51	0.34	0.16
	Coastal	0.65	0.25	0.1	B	0.65	0.25	0.1	0.55	0.3	0.16
	Mountains	0.7	0.2	0.1	C	0.7	0.2	0.1	0.59	0.25	0.16
	Piedmont	0.7	0.2	0.1	D	0.7	0.2	0.1	0.63	0.21	0.16
	Sandhills	0.65	0.25	0.1							
	Triassic Basin	0.75	0.15	0.1							
Wet Detention Pond / Wet Pond per MDC	CAMA	0.75	0.15	0.1	A	0.75	0.15	0.1	0.63	0.21	0.16
	Coastal	0.75	0.15	0.1	B	0.75	0.15	0.1	0.67	0.17	0.16
	Mountains	0.8	0.1	0.1	C	0.8	0.1	0.1	0.71	0.13	0.16
	Piedmont	0.8	0.1	0.1	D	0.8	0.1	0.1	0.76	0.08	0.16
	Sandhills	0.75	0.15	0.1							
	Triassic Basin	0.85	0.05	0.1							
Floating Wetlands / Wet Pond with Floating Wetlands					A	custom	custom	custom	0.63	0.21	0.16
					B	custom	custom	custom	0.67	0.17	0.16
					C	custom	custom	custom	0.71	0.13	0.16
					D	custom	custom	custom	0.76	0.08	0.16

Chapter 7: Glossary

Built-upon area (From N.C.G.S. 143-214.7) means impervious surface and partially impervious surface to the extent that the partially impervious surface does not allow water to infiltrate through the surface and into the subsoil. "Built-upon area" does not include a slatted deck; the water area of a swimming pool; a surface of number 57 stone, as designated by the American Society for Testing and Materials, laid at least four inches thick over a geotextile fabric; or a trail as defined in G.S. 113A-85 that is either unpaved or paved as long as the pavement is porous with a hydraulic conductivity greater than 0.001 centimeters per second (1.41 inches per hour).

CAMA refers to the region of the state where Coastal Area Management Act applies.

Common plan of development (From 15A NCAC 2H .1002(8)) means a site where multiple and distinct development activities may be taking place at different times on different schedules but governed by a single development plan regardless of ownership of the parcels. Information that may be used to determine a "common plan of development" include plats, blueprints, marketing plans, contracts, building permits, public notices of hearings, zoning requests, and infrastructure development plans.

Development (From N.C.G.S. 143-214.7) is any land-disturbing activity that increases the amount of built-upon area or that otherwise decreases the infiltration of precipitation into the subsoil. When additional development occurs at a site that has existing development, the built-upon area of the existing development shall not be included in the density calculations for additional stormwater control requirements, and stormwater control requirements cannot be applied retroactively to existing development, unless otherwise required by federal law.

Development – New, as used in the Tool, means a development project on previously undeveloped land, that is land lacking pre-existing built-upon area. This case is sometimes referred to by local planners and others as greenfield development. This case is a subset of the cases as named in the Tool that may be subject to a nutrient strategy New Development rule, the other cases being Development – Expansion and Redevelopment.

Development – Expansion, as used in the Tool, means a development project involving a net increase in built-upon area. This case is a subset of the cases as named in the Tool that may be subject to a nutrient strategy New Development rule, the other cases being Development – New and Redevelopment.

Event mean concentration or **EMC**, as used in the Tool, means the average concentration of nitrogen or phosphorus estimated for and assigned to the runoff from a given land cover type or the effluent released from a given Stormwater Control Measure. For SCMs, this value is independent of the inflow concentration. These values are developed and periodically revised in consultation with North Carolina stormwater researchers and are based on the best available, state-specific research data for the land cover or practice.

Existing development (From 15A NCAC 02H .1002) means those projects that are built or those projects that have established a vested right under North Carolina law as of the effective date of the state stormwater program or applicable local government ordinance to which the project is subject, based on at least one of the following criteria:

    a) Substantial expenditure of resources (time, labor, money) based on a good faith reliance upon having received a valid local government approval to proceed with the project;

    b) Having an outstanding valid building permit in compliance with N.C.G.S. 153A-344.1 or N.C.G.S. 160A-385.1; or

    c) Having an approved site specific or phased development plan in compliance with N.C.G.S. 153A-344.1 or N.C.G.S. 160A-385.1.

Existing Development – Retrofit, as used in the Tool, means a project that reduces loading by converting an existing developed land cover to a lower-loading type or retrofitting an SCM into a developed landscape, or by a combination of these.

Hydrologic soil group is a way of describing the hydrologic regime of a type of soil. Soils are classified into hydrologic soil groups (HSGs) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting.

Internal water storage zone means the subsurface portion of a bioretention cell that provides water storage in the bottom of the cell. Water stored in this layer is principally released by exfiltration. The IWS zone is created by elevating the underdrain, usually with a 90-degree PVC elbow.

Land-disturbing activity (From N.C.G.S. 113A-52) means any use of the land by any person in residential, industrial, educational, institutional or commercial development, highway and road construction and maintenance that results in a change in the natural cover or topography and that may cause or contribute to sedimentation.

Load is the mass of polluting material that a transporting agent, such as a stream, a glacier, or the wind, is actually carrying at a given time.

Loading rate is the concentration of polluting material that a transporting agent, such as a stream, a glacier, or the wind, is actually carrying at a given time.

Off-site stormwater systems (From 15A NCAC 02H .1002) means stormwater management systems that are located outside the boundaries of the specific project in question, but designed to control stormwater drainage from that project and other potential development sites.

On-site stormwater systems (From 15A NCAC 02H .1002) means the systems necessary to control stormwater within an individual development project and located within the project boundaries.

Physiographic region is a broad-scale subdivision based on terrain texture, rock type and geologic structure and history. In North Carolina, there are five main physiographic regions: coastal plain, sandhills, piedmont, Triassic basin, and mountains.

Project (From 15A NCAC 02H .1002(38)) means the proposed development activity for which an applicant is seeking a stormwater permit from the state or other entity in accordance with this Section. The Project shall exclude any land adjacent to the area disturbed by the project that has been counted as pervious by any other development regulated under a federal, State, or local stormwater regulation. Owners and developers of large developments consisting of many linked projects are encouraged to develop a master plan that illustrates how each project fits into the design of the large development.

Redevelopment (From N.C.G.S. 143-214.7) is any land-disturbing activity that does not result in a net increase in built-upon area and that provides greater or equal stormwater control to that of the previous development.

Runoff treatment (From 15A NCAC 02H .1002) that the volume of stormwater runoff generated from all of the built upon area of a project at build-out during a storm of the required storm depth is treated in one or more primary SCMs or a combination of Primary and Secondary SCMs that provides equal or better treatment.

Simple Method is a technique used for estimating storm pollutant export delivered from urban development sites. The technique requires a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. The Simple Method calculation is intended for use on development sites less than a square mile in area.

Water quality depth is the depth of rainfall that a SCM is designed to capture and treat (generally 1 inch for all regions except CAMA; for CAMA, it is generally 1.5 inches).

7.1. List of Acronyms

BMP   best management practice

BUA   built-upon area

CAMA   Coastal Area Management Act

CSV   comma-separated values file format

CWP   Center for Watershed Protection

DEMLR   Division of Energy, Mineral, and Land Resources

DWR   Division of Water Resources

EMC   event mean concentration

ET   evapotranspiration

HSG   hydrologic soil group

IWS   internal water storage

MDC   Minimum Design Criteria

NCAC   North Carolina Administrative Code

NCDEQ   NC Department of Environmental Quality

N.C.G.S.   North Carolina General Statutes

NCSU   NC State University

NRCS   Natural Resources Conservation Service

SCM   stormwater control measure

TN   total nitrogen

TP   total phosphorus

VBA   Visual Basic for Applications

Chapter 8: References

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