

INTRODUCTION

Following is a User's Guide for the *Coastal Stormwater Supplement Site Planning and Design Worksheet*. Sections include:

- **Site Data** describes the inputs and calculations on the "Site Data" tab, which includes basic land cover and precipitation information. Site Design and Site Planning techniques are also implemented on this sheet.
- **Drainage Area Sheets** provides guidance for using these sheets, which calculate the runoff volumes, and the runoff reduction and treatment achieved in each site drainage area.
- **Runoff Reduction and Treatment** summarizes the data included on this sheet, which is designed to report the total runoff reduction and stormwater treatment provided through by the selected practices.
- **Flood Protection** describes how to use the last sheet of the worksheet, which calculates peak flows from water quantity storms, after implementation of Runoff Reduction practices.
- **Print Summary** provides a summary of the relevant data in the spreadsheet, formatted for printing.

Note: All cells highlighted in blue are user input cells. Cells highlighted in gray are calculation cells, and cells highlighted in yellow are constant values that generally should not be changed.

SITE DATA

Data are entered into the "Site Data" sheet in four separate steps, including:

- Step 1. Enter Site Information
- Step 2. Apply Better Site Planning Techniques
- Step 3. Apply Better Site Design Techniques

Step 1: Enter Site Information

1. Input the name of the proposed project on **line 6**.
2. Enter the area (in square feet) of impervious and pervious cover, by Hydrologic Soil Group (HSG) for the pre-developed condition in **cells B16 – E17**.
3. Enter the area (in square feet) of post-development impervious and pervious cover, by HSG for the post-developed condition in **cells B23 – E24**.
4. The Runoff Reduction Rainfall Event (default 1.2") is included in **cell B30**
5. The post-developed impervious cover percentage is calculated in **cell B31** as:

$$\%I = A_I / SA \times 100$$

Where:

A_I = Impervious Cover Area (acres)

SA = Site Area (acres)

The runoff coefficient is then calculated in **cell B32** as:

$$Rv = 0.05 + 0.009 \times \%I$$

6. Next, the target runoff reduction volume is calculated in acre-feet is calculated in **cell B33** as:

$$RRv_1 = P / 12 \times SA$$

Where:

P = Regulatory Rain Event (in.);

RRv_1 = Target Runoff Reduction Volume after step 1 (acre-feet)

7. In **cell B34**, the runoff reduction volume in cubic feet is calculated by multiplying the value in **cell B33** by 43,560.

Step 2: Apply Better Site Planning Techniques

Description of what this step does

1. Enter the area (in acres) of Primary and Secondary Conservation Areas in **cells B41-E42**.

The runoff reduction after Step 2), is calculated in **cell B47** as:

$$RRv_2 = P / 12 \times (SA - CA) \times Rv$$

Where:

CA = Area of Conservation Areas (acres)

RRv_2 = Target Runoff Reduction Volume after step 2 (acre-feet)

2. In **cell B48**, the runoff reduction volume in cubic feet is calculated by multiplying the value in **cell B47** by 43,560.

Step 3: Apply Better Site Design Techniques

Description of what this step does

1. Enter the area (in acres) of Undisturbed Pervious Areas in **row 61**.

- The area of each land category (by soil type, in acres) is revised and reported in **cells B66-E70**, and summed across all soil types in **column F**. The area of each land category, by soil type, is determined as follows:

Conservation Areas:

Conservation Areas, reported in **row 67** are the sum of *Primary* and *Secondary* Conservation Areas entered in **rows 41 to 42**.

Undisturbed Pervious Cover:

Undisturbed Pervious Cover, reported in **row 68** are equal to the Undisturbed Pervious Cover entered in **row 61**.

Disturbed Pervious Cover:

Disturbed Pervious Cover, reported in **row 69** is determined by the following equation:

$$DPC = A_p - CA - UPC$$

Where:

A_p = Area of Pervious Cover (acres) from **row 23**

CA = Area of Conservation Areas (acres) from **row 67**

UPC = Area of Undisturbed Pervious Areas (acres) from **row 61**

Impervious Cover

Impervious Cover, reported in **row 70** is equal to the Impervious Cover from **row 24**.

- Enter the area (in acres) of the Restoration of Disturbed Pervious Surfaces in **cells B75 – B77**, including *Soil Restoration*, *Site Reforstation/Revegetation*, and *Soil Restoration w/ Site Reforestation/Revegetation*.
- The runoff reduction after Step 3), is calculated in **cell B81** as:

$$RRv_3 = P/12 \times [SA - (CA + SRVA + 0.5 \times \{UPA + SRA + RVA\})] \times Rv$$

Where:

SRVA = Area of Soil Restoration with Site Reforestation/Revegetation (acres)

UPA = Undisturbed Pervious Area (acres)

SRA = Soil Restoration Area (acres)

RVA = Reforestation/Revegetation Area (acres)

- In **cell B82**, the runoff reduction volume in cubic feet is calculated by multiplying the value in **cell B81** by 43,560.

DRAINAGE AREA SHEETS

The spreadsheet includes a worksheet for each drainage area (Drainage Areas A through J). Each of these sheets includes two sections: Drainage Area Data and Low Impact Development (LID) Practices.

Drainage Area Data

This section is located in the top 28 rows of each Drainage Area worksheet. In this section, the user enters the Pre-Developed and Post-Developed land cover in the drainage area. The pre-developed land cover is entered in **rows 9 and 10** and the post-developed land cover is entered in **rows 17 to 20**.

LID Practices

Each Drainage Area Worksheet allows the user to implement up to 5 individual practices in each practice category, using pull-down menus. Throughout all of the practice sheets, Runoff Reduction is tracked separately from Treatment Volume. For Runoff Reduction, an efficiency is applied to each practice. For treatment volume, on the other hand, practices are in many cases assumed to provide treatment for 100% of the practice volume or volume received.

The specific methodology for calculating the adjustments to the runoff reduction and treatment volumes differs depending on the practice type (Table 1). While the procedure is similar for each, the equations presented below will reference the methods identified in Table 1.

| TABLE 1. RUNOFF REDUCTION AND TREATMENT FOR LID PRACTICES | | | |
|---|------------------|---------|------------------|
| | Runoff Reduction | | Treatment |
| | Reduction (%) | Method | Method |
| Alternatives to Impervious Cover | | | |
| Green Roof | 60% | Runoff | Runoff |
| Permeable Pavement – No Underdrain | 100% | Storage | Storage |
| Permeable Pavement- Underdrain | 50% | | |
| Receiving LID Practices | | | |
| Bioretention or Dry Swale –No Underdrain All Infiltration Practices | 100% | Storage | Storage |
| Bioretention or Dry Swale – Underdrain, Stormwater Planter | 50% | | |
| Rainwater Harvesting | 75% | | |
| Undisturbed Pervious – A/B or Amended Soils | 90% | Runoff | Runoff Reduction |
| Disconnection or Vegetated Filter Strip – A/B or Amended Soils Undisturbed Pervious Area – C/D Soils | 60% | | |
| Disconnection or Vegetated Filter Strip – C/D Soils | 30% | | |
| Grass Channel – A/B or Amended Soils | 25% | | |
| Grass Channel -C/D Soils | 12.5% | | |
| Treatment Only Practices | | | |
| Ponds, Wetlands, Wet Swales, Filtration Practices, Proprietary Practices or Alum Treatment | 0% | N/A | Storage |

All LID data are entered in **rows 32 to 59** of the Drainage Area worksheets, as follows:

- 1) In **column A**, select each practice from the drop-down menu. Note that practices are divided into three categories: “Alternatives to Impervious Surfaces” (**rows 32 to 36**), “Receiving LID Practices” (**rows 38 to 52**) and “Treatment Only Practices” (**rows 54 to 58**). See Table 1 to determine which category a practice is in. In addition, note that there are five of each practice type (e.g., Green Roof 1 through Green Roof 5). This enables the user to implement five of any practice type, with only one of any practice and number combination in a given drainage area.
- 2) In **columns B and C** enter the drainage area and impervious cover (in acres) draining to each practice.
- 3) The *Direct Volume Received by Practice (cf)*, is determined in **column D** by the equation:

$$V_{direct} = \left(0.05 + 0.9 \times \frac{I}{A} \right) \times A \times P \times 3,630$$

Where:

I = Impervious Cover in Drainage Area (acres)

A = Drainage Area (acres)

Note: If the impervious area input into Column C is larger than the total contributing drainage area input into Column B, Column D will not calculate a volume. An error message will be shown instead.

- 4) **Column E** describes the methodology for calculating Runoff Reduction for the practice.
- 5) The *Runoff Reduction Volume Received from Upstream Practices (cf)* is reported in **column G**, and is the sum of the *Remaining Runoff Reduction Volume* (calculated in step 11 below) from other practices that are directed to the practice evaluated in this row (See step 14 below).
- 6) The *Total Runoff Reduction Volume Received by the Practice (cf)* is calculated in **column H** and is the sum of the values calculated in 3) and 5) above as:

$$RRv_{received} = V_{direct} + RRv_{upstream}$$

- 7) The *Treatment Volume Received from Other Practices (cf)*, is calculated in **column I** and is equal to the sum of the *Remaining Treatment Volume* (calculated in step 13 below) from other practices that are directed to the practice evaluated in this row (See Step 14 below).
- 8) The *Total Treatment Volume Received by the Practice (cf)* is calculated in **column J** and is equal to the sum of the values calculated in 3) and 7) above as:

$$Tv_{received} = V_{direct} + Tv_{upstream}$$

- 9) If necessary (i.e., if the cell is green), enter the *Storage Volume Provided by the Practice (cf)* in **column L**, using the storage calculation method described in **column K**.
- 10) The *Adjustment to Runoff Reduction Volume (cf)* is calculated in **column M** using one of two methods, “Storage” or “Runoff” (see Table 1), as follows:

Storage

In this method, the *Adjustment to the Runoff Reduction Volume* depends on both the storage volume provided by the practice and the runoff volume received by the practice, as follows:

$$RRv_{adjust} = \text{Minimum}[(Sv \times E_{RR}), RRv_{received}]$$

Where:

- a. Sv = Storage volume (cf)
- b. E_{RR} = Runoff Reduction Efficiency (%)

Runoff

In this method, no storage volume is provided, and the Adjustment to the Runoff Reduction Volume is calculated as:

$$RRv_{adjust} = RRv_{received} \times E_{RR}$$

On each sheet, the *Total Adjustment to the Runoff Reduction Volume* for each drainage area is calculated in **cell M 59**.

- 11) The *Remaining Runoff Reduction Volume (cf)* is equal to the difference between the volume received by the practice and the runoff removed by the practice, and is calculated in **column N** as:

$$RRv_{remain} = RRv_{received} - RRv_{adjust}$$

- 12) The *Adjustment to Treatment Volume (cf)* is calculated in **column O** using one of three methods “Storage,” “Runoff Reduction” or “Runoff ” (see Table 1), as follows:

Storage

In this method, the Adjustment to the Treatment Volume depends on both the storage volume provided by the practice and the runoff volume received by the practice, as follows:

$$Tv_{adjust} = \text{Minimum}[Sv, Tv_{received}]$$

Runoff Reduction

In this method, the Adjustment to the Treatment Volume is equal to the Adjustemnet to the Runoff Reduction Volume for the practice, and is calculated as:

$$Tv_{adjust} = RRv_{adjust}$$

Runoff

This method is used only for Green Roofs, with the following calculation:

$$Tv_{adjust} = Tv_{received}$$

On each sheet, the *Total Adjustment to the Stormwater Treatment Volume* for each drainage area is calculated in **cell O 59**.

- 13) The *Remaining Treatment Volume (cf)* is equal to the difference between the volume received by the practice and the runoff removed by the practice, and is calculated in **column P** as:

$$Tv_{remain} = Tv_{received} - Tv_{adjust}$$

- 14) In **column P**, select the *Downstream Practice to be Employed* using the pull-down menus. This will direct the remaining Runoff Reduction and Treatment volumes to the practice identified. Note that you must select both the practice type *and* the practice number to identify an individual practice. Also note that an error (in red font), will appear in **column Q** until the downstream practice is selected and utilized in the drainage area. For example, if “Bioretention 1” is indicated as a downstream practice in **column P**, but the practice is not selected in **column A**, an error will be reported in **column Q** until that practice is entered.

RUNOFF REDUCTION AND TREATMENT

This sheet summarizes the runoff reduction and stormwater treatment volume provided and the remaining required treatment.

- 1) The Target Runoff reduction (cf, RRv_1) (from the Site Data Sheet, **cell B34**) is reported in **cell B6**.
- 2) The Runoff Reduction Volume Achieved (cf) is the sum of the Runoff Volume Adjustment (RRv_{adjust}) provided by all practices on the specific Practice sheets, plus the Runoff Reduction Volume achieved by *Better Site Planning* and *Better Site Design*, and is calculated in **cell B8** as:

$$RRv_{adjust-total} = RRv_1 - RRv_3 + \sum_i RRv_{adjust\ DA-i}$$

- 3) The % of Runoff Reduction Volume Achieved (cf) is calculated in **cell B10** as:

$$RRv_{\%} = \frac{RRv_{adjust-total}}{RRv_1}$$

- 4) The Runoff reduction volume Achieved (in inches) is calculated in **cell B12** by multiplying the % Runoff Reduction Volume Achieved by the Target Rainfall Event (default is 1.2”).
- 5) The *Runoff Reduction Volume Remaining*(cf) is calculated in **cell B14** as:

$$RRv_{remain} = RRv_1 - RRv_{adjust-total}$$

- 6) The Treatment Volume Achieved (cf) is the sum of the *Treatment Volume Adjustment* (Tv_{adjust}) provided by all practices on the specific Practice sheets plus the Runoff Reduction Volume achieved by *Better Site Planning* and *Better Site Design*, and is calculated in **cell B20** as:

$$Tv_{adjust-total} = RRv_1 - RRv_3 + \sum_i Tv_{adjust\ DA-i}$$

- 7) The Runoff Reduction Volume Remaining (cf) is calculated in **cell B22** as:

$$Tv_{remaining-total} = RRv_1 - Tv_{adjust-total}$$

FLOOD PROTECTION

This sheet assists with calculation of Adjusted Curve Numbers that can be used to calculate peak flows associated with the 2-year storm, 15-year storm, or other storm events.

- 1) Tables in **rows 6-17** summarize the land uses reported on the *Site Data* tab.
- 2) Default depths for the Runoff Reduction Storm, 1-year, 25-year, and 100-year 24-hour storms are provided in **cells B21-B24**. These cells are yellow, meaning that they are constant values that generally should not be modified, and are reported again in the grey formula cells in **row 31**.
- 3) The total site area and the runoff reduction achieved for each drainage area are derived from *Drainage Area* worksheets and reported in **column C** for each drainage area
- 4) Each cover type is associated with a Natural Resource Conservation Service (NRCS) curve number for both the pre-developed and post-developed condition tables (provided in **cells B35 to B39**).
- 5) Following are a series of sections for each drainage area, with data needed to estimate runoff volumes and peak discharge rates.
- 6) The Drainage Area (acres) and Adjustment to the Runoff Reduction Volume by LID Practices (cf) is reported for each drainage area in **column C**.
- 7) In the *predeveloped condition* table (**columns G to J**), enter the area of Conservation Areas and Disturbed Pervious Cover in the green cells. Undisturbed Pervious Cover is calculated as:

$$UPA_{pre} = A_{p-pre} - CA_{pre} - DPA_{pre}$$

Where:

A_{p-pre} = Pervious Area in the pre-developed condition (acres)

CA_{pre} = Area of Conservation Areas in the pre-developed condition (acres)

DPA_{pre} = Disturbed Pervious Area in the pre-developed condition (acres)

- 8) Land use is reported in the *postdeveloped condition* table (**columns L to O**).
- 9) The *weighted curve number* for both the pre-developed and post-developed conditions below these tables in columns J and O, respectively as:

$$CN_{weighted} = \sum (CN_i \times A_i) / SA$$

Where:

$$\begin{aligned} CN_i &= \text{Curve number associated with Land Cover } i \\ A_i &= \text{Area of Land Cover } i \text{ (acres).} \end{aligned}$$

10) The *Potential Abstraction (S)* is then calculated for the pre- and post-developed conditions in **columns K** and **P**, as:

$$S = 1000 / (CN_{weighted} - 10)$$

11) The runoff volume without runoff reduction credits (in inches) is reported below these land use tables in **columns H to J**, and is calculated as:

$$Q = (p - 0.2 \times S)^2 / (p + 0.8 \times S)$$

Where:

$$\begin{aligned} p &= \text{precipitation depth for a given 24-hour storm (in.)} \\ S &= \text{potential abstraction (in.)} \end{aligned}$$

12) The *runoff volume with runoff reduction credits* is then calculated with the following equation:

$$Q_{adjusted} = Q - RRv_{total} / SA \times 3,630$$

13) The *adjusted curve number*, is calculated by using lookup tables to determine the curve number

$$\begin{aligned} CN_{adjusted}, \text{ so } (p - 0.2 \times S_{adjusted}) \times 2 / (p + 0.8 \times S_{adjusted}) &= Q_{adjusted} \\ S_{adjusted} &= 1000 / (CN_{adjusted} - 10) \end{aligned}$$

14) Finally, it is determined if detention is required for each storm event with the following rule:

$$\text{Detention is required if } CN_{adjusted} > CN_{weighted-predeveloped}$$

15) Tables in **columns R to U** determine the peak discharge from each storm event, using the *adjusted curve number* . In these tables, select the “Rainfall Distribution Type” (type II or III) from the pull-down menu, and enter the Time of Concentration in the green cells.

Unit Peak Discharge

$$qu = 10^{[C0+C1 \times \log(Tc)+C2 \times (\log(Tc))^2]}$$

Where:

- qu = unit discharge(cfs/sm-in)
- C0, C1,C2 = constants (interpolated from Tables 2 and 3 below)
- Tc = time of concentration

| <i>Ia / p</i> | 0.10 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| C0 | 2.55323 | 2.46532 | 2.41896 | 2.36409 | 2.29238 | 2.20282 |
| C1 | -0.61512 | -0.62257 | -0.61594 | -0.59857 | -0.57005 | -0.51599 |
| C2 | -0.16403 | -0.11657 | -0.08820 | -0.05621 | -0.02281 | -0.01259 |

| <i>Ia / p</i> | 0.10 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| C0 | 2.47317 | 2.39628 | 2.35477 | 2.30726 | 2.24876 | 2.17772 |
| C1 | -0.51848 | -0.51202 | -0.49735 | -0.46541 | -0.41314 | -0.36803 |
| C2 | -0.17083 | -0.13245 | -0.11985 | -0.11094 | -0.11508 | -0.09525 |

$$Ia/p = 0.2 \times S_{adjusted}$$

$$S_{adjusted} = 1000 / (CN_{adjusted} - 10)$$

Peak Discharge

The peak discharge (in cfs), is calculated as:

$$Q_{peak} = SA \times p \times qu / 640$$

PRINT SUMMARY

This sheet allows the user to print a summary of the relevant information included in the spreadsheet's other sheets.

- 1) Click the "Update Summary" button located on **cell D4**. Data will be filled in for the site and the drainage areas that were utilized in the design.
- 2) Click the "Print" button located on **cell F4** to print the summary.