Natural Resource Assessment, LID Site Design Checklist, and LID Computations Worksheet

1.1.1 Natural Resource Assessment

Provide a Qualitative Narrative describing the existing conditions of selected natural resources. Include any quantification that may support this assessment.

Components of the Resource Assessment Narrative:

1. Stream Channels: describe the current conditions including size estimates of width and depth, current stability of channel banks and bed, entrenchment, bed materials, and bank vegetation cover conditions;
2. Wetlands: describe locations, size, type and relationship to other hydrologic features;
3. Current drainage features of the site interior (i.e. slopes, watershed size, etc.);
4. Ponds: describe existing condition of the embankment, riser, and outfall area;
5. Buffers: describe type and condition of vegetation within required buffer width; and
6. Significant Soils: provide soil survey and soil reports from http://websoilsurvey.nrcs.usda.gov. Include extent of each soil type, typical depth to bedrock, typical depth to water table, and any know limitations (slopes, infiltration rates, linear extensibility, etc.).

Provide a Natural Resource Assessment Map:

- Identifies water bodies, floodplains, riparian buffers, wetlands, woodlands, natural drainage ways, steep slopes, and other sensitive natural features.
- Do not count any area twice, for example an area that is both a floodplain and wetland may only be considered once.

Sensitive Resource	Mapped (Yes or N/A)	Total Area (acres)	Protected/Undisturbed (Acres)
Floodplains			
Wetlands			
Riparian Buffer			
Woodlands			
Steep slopes (>15%)			
Other:			
Total Areas (acres)			

1.1.2 Low Impact Development Site Design Checklist

Prior to developing any structural stormwater practices on a site, significant reductions in stormwater quantity and quality impacts can be made through Environmental Site Design. Below is a checklist of site design and planning practices that can be used to minimize stormwater impacts. Please check the practices that you are applying to your development, and note the extent to which each selected practices was implemented.

Site Design Standard Technique 1: Conserve Open Space

Preserve the natural cover on as much of the site as possible. The preservation of undisturbed areas or the vegetative restoration of disturbed areas to offset the site's pollutant load. Natural vegetation helps maintain and preserve predevelopment hydrology on a site, thereby reducing the reliance on large-scale stormwater ponds. Natural cover on highly permeable soils increases filtration and infiltration.

Achieved	Percent of Site Area	Practice
		Stormwater facilities located outside of streams, wetlands and buffers
		Riparian Buffer Width maintained along the entire stream. (35 feet for intermittent streams, and 50 feet for perennial streams)
		Maximize contiguous areas to avoid habitat fragmentation
		Legally protect areas by permanent conservation easement prescribing allowable uses and activities and preventing future development
		Open Space accepts and treats stormwater runoff from the development site per the BMP Clearinghouse Specifications. ***Runoff Reduction Volume:***
		Open Space adjacent to a wetland, mature forest or otherwise enhances the riparian buffer.

Site Design Standard Technique 2: Minimize Land Disturbance

Minimize direct stormwater impacts to streams, wetlands and other natural features to the maximum extent practicable. This can be accomplished by siting stormwater facilities outside of streams and wetlands, maintaining natural drainages, and preserving riparian buffers.

Achieved	Percent of Site Area	Practice
		Utilize clustered development designs that preserve a significant portion of the site in a natural state.
		Utilize "fingerprint" clearing, limit the clearing and grading of forests and native vegetation to the minimum area needed for the construction of the lots, necessary access, and fire protection.
		The plan includes detail on construction methods and sequencing to minimize compaction of natural and future stormwater areas.
		Prevent compaction of key soils, protect steep slopes (>15%) and maintain drainage features.
		Minimize total site area cleared and graded at any one time

Site Design Standard Technique 3: Reduce Impervious Cover

Minimize the overall impervious cover. Roadways, sidewalks, driveways and parking areas are the greatest sources of site imperviousness. Impervious areas alter runoff and recharge values which affect site hydrology.

Achieved	Percent of Site Area	Practice
		Utilize the minimum required width for streets and roads.
		Utilize street layouts that reduce total street length by increasing the number of homes per unit length
		Minimize cul-de-sac diameters, use doughnut cul-de-sacs, or use alternative turnarounds
		Minimize excess parking space construction, utilize structured or shared parking
		Reduce home setbacks and frontages
		Where permitted, minimize sidewalk construction by utilizing sidewalks on one side only, utilizing “skinny” sidewalks, or substituting sidewalks with pervious trails through common area.
		Substitute pervious surfaces for impervious wherever possible in accordance with the BMP Clearinghouse Specifications. ***Runoff Reduction Volume:***

Site Design Standard Technique 4: Disconnection

“Disconnect” impervious areas. “Disconnecting” means having impervious cover drain to pervious cover (i.e. downspouts draining to the yard, not the driveway). This decreases both the runoff volume and Time of Concentration. Disconnected parking lots, for example, can provide sheet flow into bioretention areas or engineered infiltration swales.

Achieved	Percent of Site Area	Practice
		Utilize disconnection techniques in accordance with the BMP Clearinghouse Specifications (flow path <40 feet and < 5% slope). ***Runoff Reduction Volume:***
		Utilize Gravel Diaphragm per the BMP Clearinghouse Specification 2 to maintain parking lot sheet flow into a pervious area
		Utilize Level Spreaders per the BMP Clearinghouse Specification 2 to disperse concentrated runoff into sheet flow entering a pervious area
		Utilize Curb Cuts that disperses flow with a reduced Froude number of at most 1/3Fr.

Site Design Standard Technique 5: Vegetated Stormwater Conveyance Systems

Increase the Time of Concentration. Replicating the pre-development Time of Concentration is a key aspect in maintaining pre-development flow regime, and minimizing downstream impacts.

Achieved	Percent of Site Area	Practice
		Maintain predevelopment flow paths by increasing flow length, dispersing and redirecting flows. ***Increased Tc:***
		Where permitted, avoid the use of curb and gutter. Utilize Grass Channels per the BMP Clearinghouse Specification 3. ***Runoff Reduction Volume:***
		Utilize permanent Check Dams to detain and prolong the Time of Concentration. ***Increased Tc:***
		Flatten grades for stormwater conveyance to the minimum sufficient to allow positive drainage. ***Increased Tc:***
		Utilize Dry Swales with engineered soils per the BMP Clearinghouse Specifications. ***Runoff Reduction Volume:***

Site Design Standard Technique 6: Soil Restoration Techniques

Utilize soil restoration/enhancement techniques to improve soil properties. Amend soils that are compacted or poorly drained to improve infiltration and vegetation establishment.

Achieved	Percent of Site Area	Practice
		Minimize compaction of the landscape. In areas where soils will become compacted due to construction equipment, specify soil amendments as per BMP Clearinghouse Specification 4. ***Curve Number Adjustment:***
		Delineate soils on site for the preservation of infiltration capacity. Mark these areas in the field and restrict heavy equipment access.
		Utilized engineered soils for SWMFs and IMPs located on unsuitable native soils

Site Design Standard Technique 7: Creation of Transition Zones

Create transition zones to buffer managed turf from existing vegetated areas. Reduce hydrologic impacts by creating added surface roughness as well as providing for additional filtering and volume storage.

Achieved	Percent of Site Area	Practice
		Maximize overland sheet flow with use of gravel diaphragm, vegetated filter strips, level spreaders and other dispersion techniques. ***Increased Tc:***
		Reconnect vegetated areas by establishing meadows, stream buffers or a minimum of 1,000 square feet of contiguous mulched planting beds. ***Curve Number Adjustment:***
		Clearly delineate the transition zone and provide a management plan for long-term maintenance.

1.1.3 LID Performance Worksheet

Definitions

Detention – The collection of runoff in a ponding area, depression, or storage chamber followed by its gradual release through an outlet into a receiving water body. Detention reduces peak runoff rate to its pre-development peak rate, but is not an effective way to reduce the runoff volume.

Retention – The collection of runoff in a ponding area or receptacle where water is released through infiltration, evaporation, and transpiration. Retention reduces the volume of runoff from a site and can also be effective in reducing the peak runoff rate if the retention volume is sufficiently large.

Connected Impervious Surface - Hard surfaces such as rooftops, pavement/concrete and compacted gravel that is directly conveyed within a pipe or channel.

Disconnected Impervious Surface – Where hard surfaces such as rooftops, pavement/concrete and compacted gravel disperses stormwater into pervious areas in accordance with BMP Clearinghouse Specifications.

Curve Number (CN) Adjustment – The modification of the post development CN by reducing impervious areas, disconnecting impervious runoff and preserving open space. Consequently, this will lessen the amount of storage that would otherwise be required to maintain the predevelopment runoff volume.

Time of Concentration (Tc) – The time for runoff to travel from the hydraulically most distant point in a catchment to the watershed outlet or study point.

Instructions

Before beginning the LID Performance Worksheet, first evaluate your site design using the Natural Resource Assessment (11.1.1) and Environmental Site Design Checklist (11.1.2). The use of environmental site design techniques is a critical component in ensuring that the pre-development hydrology on a site can be maintained.

The following worksheet follows the process detailed in *LID Hydrologic Analysis* (see references).

Protected and Undisturbed areas should be excluded from the storage volume calculations. Ideally, each subarea shall compute storage volumes separately. Retention volume may be provided in one subarea to compensate for an uncontrolled subarea. The uncontrolled subarea must discharge stormwater as sheet flow into an undisturbed area of vegetation that is uniform and mature enough to inhibit erosion.

Note: Development projects that are unable to provide sufficient runoff reduction practices to maintain the predevelopment runoff volume should revisit the application of the environmental site design techniques to the site. The thorough use of ESD techniques will reduce post-development curve numbers, and can result in decreased stormwater detention and retention volume requirements.

Computing Pre and Post-Development Composite Curve Numbers for LID Approach

$$CN_C = \frac{CN_1 A_1 + CN_2 A_2 ... + CN_j A_j}{A_1 + A_2 ... + A_j}$$

CN_C=Composite Curve Number
Aj=Area of each Land Cover
CNj=Curve Number for each Land Cover

a. Forested Runoff Curve Number. The predevelopment condition is required to be woods in good condition (LID Hydrological Analysis, pg. 37). Calculate the composite curve number for the site, using woods in good condition.

HSG	**CN (woods good condition)**	**Area$_j$**	**% of Site**	**Area$_j$ X CN$_{j,pre}$**
A	30			
B	55			
C	70			
D	77			
	SUM			

$$CN_{C,woods} = \frac{\sum (CN_{j,woods} * A_j)}{\sum A_j}$$

b. For comparison purposes, calculate a composite curve number for the ***developed site***, using the **conventional TR-55 approach**.

Land Cover and Soil	**CN**	**Area**	**% of Site**	**Area x CN**
Protected/Undisturbed				

Disturbed Area = Total Site Area – Undisturbed Area

<u>Composite CN of Disturbed Area:</u>

Land Cover and Soil	**CN**	**Area**	**% of Disturbed Area**	**Area x CN**
Connected – impervious	*98*			
disconnected - impervious	*98*			
Sum				

$CN_{C,post}$ = _________

c. Calculate a composite **custom LID curve number**. This approach factors in the use of higher permeability soils for infiltration and the use of "disconnection".

$$CN_{LID} = CN_p + \left(\frac{P_{imp}}{100}\right) \times \left(98 - CN_p\right) \times \left(1 - 0.5R\right)$$

where:

R = ratio of disconnected impervious area to total impervious area;
CN_{LID} = LID curve number;
CN_p = composite pervious CN post development pervious surface only;
P_{imp} = percent of impervious site area.

Calculate CN_p: Use the composite CN of the pervious surfaces only from table in step "b." above

Calculate R
R = Disconnected Impervious / Total Impervious Area
R = ______

$CN_{C,post}$ = ______ *(from step "b." above)*
CN_{LID} = _______

Reduction in CN achieved with site design = ______ *($CN_{C,post}$ - CN_{LID})*

d. Calculate the **pre-development** Time of Concentration (Tc) using TR-55 for each discrete drainage area discharging from the site. Utilize the environmental site design techniques described in section 11.1.2, such as flattening grades, lengthening flow paths, etc to maintain the Tc as much as possible. Then, calculate the **post-development** Time of Concentration (Tc_{LID}) for the same drainages.

	Drainage A	*Drainage B*	*Drainage C*	*Drainage D*	*Drainage E*	*Drainage F*
Tc_{pre}						
Tc_{LID}						

NOTE: For the LID approach to function effectively, the Tc_{LID} must be greater than or equal to Tc_{PRE}. If not, STOP here and incorporate additional practices to the maximum extent practical to maintain Tc. See LID Manuals for details.

e. Calculate the 1-year peak flow rate under a forested condition and with LID. SCS Curve Number Method or equivalent shall be used.

$q_{\text{1-year forest}}$ = _______ cfs

$q_{\text{1-year LID}}$ = _______ cfs

Step 1: Determine the Retention Volume Required to Maintain Pre-development Runoff Volume

a. The **Design Rainfall** for your site will be the 1-year, 24 hour storm. This is the assumed rainfall at which runoff would have initiated on the site, if it were vegetated with "woods in good condition".

Culpeper County 1-Year, 24 hour Rainfall (NOAA Atlas 14) = <u>2.75</u> inches

b. Calculate watershed storage to **<u>Maintain Predevelopment Runoff Volume using Retention Storage</u>.**

Forested $CN_{C,woods}$	=	___
Post Development CN_{LID}	=	___
Forested Runoff Depth, Q_{woods}	=	___ inch
LID Runoff Depth, Q_{LID}	=	___ inch

Watershed Storage = $Q_{LID} - Q_{woods}$ = ___ inch

$$VR = \left(\frac{WatershedStorage}{12}\right) \times DA \times \left(\frac{43560}{Acres}\right) = \_\_\_\_ ft^3$$

VR = Volume of Retention Storage

Watershed Storage = Volume of Runoff Storage Required (inches)

DA = Disturbed Drainage Area (Acres)

Step 2: Determine Storage Volume for Water Quality Protection

a. The Predevelopment Retention Storage Volume (Step 1.b) should meet or exceed the current **Water Quality Standard,** which is the Treatment Volume, Tv of the total site area as determined by RRM.

Volume of Retention Storage = ______ **cu. ft.** **(From Step 1.b)** **Treatment Volume, Tv = (1/12)*Rv*DA =** _____ **cu. ft.** **(Virginia Runoff Reduction Spreadsheet)**	Enter Higher Value **Required Retention Storage Volume** ____________ **cu. ft.**

b. **Estimate the BMP surface area required** to retain the Retention Storage Volume (Step 2.a.). VR / depth of storage = BMP Surface Area

Estimated BMP Surface Area = __________________ Sq. Ft.

Provided BMP Surface Area = ____________________ Sq. Ft.

Step 3: Determine the Storage Volume for Maintaining Peak Runoff Rate Using 100% Retention

Using the Charts starting on page 14 of this document (2 inch and 3 inch Type II 24 hour storms), determine the **storage volume** required to **maintain peak Runoff Rate using 100% RETENTION storage.**

Pre-Development $CN_{C,pre}$ = ____

Post-Development CN_{LID} = ____

Watershed Storage = ____ inch

$$VR_{100} = \left(\frac{WatershedStorage}{12}\right) \times \left(DA \times 43560\right) = \_\_\_\_\_ ft^3$$

VR_{100} = Retention Volume for Peak Flow Control (cubic feet)

Watershed Storage = Volume of Runoff Storage (inches)

DA = Disturbed Drainage Areas (Acres)

Step 4: Evaluate Need for Additional Detention Storage

Compare the volumes required for volume control and peak rate control:

VR_{100} =__________ ft³ vs. **VR=__________ ft³**

(Step 3) *(Step 2a)*

If **VR > VR_{100}** then:

Design IMPs or SWMFs that provides runoff reduction equivalent to the VR storage volume.

No additional detention is required to control peak flow rate.

If **VR < VR_{100}** then a HYBRID DESIGN IS REQUIRED:

Follow Steps 5, and 6 to calculate additional detention storage volume required to meet peak flow rate. If additional detention storage within a runoff reduction practice is not practicable for the site, extended detention and wet ponds can be used to detain the additional volume.

OR if providing Runoff Reduction storage of the VR is unachievable due to site constraints then an Exception Request is required for Partial LID. *Follow Steps 5, and 7 to calculate additional detention required to meet peak runoff rate.*

Step 5: Determine the Storage Volume for Maintaining Peak Runoff Rate using 100% Detention

Using TR-55 storage volume for detention basins method determine storage volume required to **maintain peak runoff rate using 100% DETENTION storage.**

LID Runoff Depth, Q_{LID} = _____ inch

$q_{1\text{-year forest}}$ = ____ cfs

$q_{1\text{-year LID}}$ = ____ cfs

Watershed Storage =

$$\left(0.682 - 1.43\left(\frac{qforest}{qLID}\right) + 1.64\left(\frac{qforest}{qLID}\right)^2 - 0.804\left(\frac{qforest}{qLID}\right)^3\right] x\ QLID = \text{\_\_\_\_\_ inch}$$

$$V_{D100} = \left(\frac{WatershedStorage}{12}\right) \times \left(DA \times 43560\right) = \text{\_\_\_\_\_} ft^3$$

V_{D100} = Detention Volume for Peak Flow Control (cubic feet)

Watershed Storage = Volume of Runoff Storage (inches)

DA = Disturbed Drainage Area (acre)

Step 6: Hybrid Design for Full LID Design

$$X = \frac{50}{V_{R100} - V_{D100}}\left[-V_{D100} + \left(V^2{}_{D100} + 4\left(V_{R100} - V_{D100}\right)VR\right)^{0.5}\right]$$

X = Area ratio of retention storage to total storage

Detention Storage, H = $VR \times \left(\frac{100}{X}\right) - VR = \text{\_\_\_\_\_} ft^3$

Retention Storage Required = VR = _________ft^3

With a Hybrid Design, IMPs and SWMFs must be provided that can meet the Additional Detention Storage (calculated above) **AND** Retention Storage (VR).

Step 7: Hybrid Design for Partial LID Design

Retention Storage Provided = VR' = _________ft³

VR' = Available Retention storage volume (cubic feet) (determined by the designer by analyzing the site constraints)

Partial LID Design: $\frac{VR'}{VR} x\, 100 > 50\%$

$$X' = \frac{50}{V_{R100} - V_{D100}}\left[-V_{D100} + \left(V^2{}_{D100} + 4\left(V_{R100} - V_{D100}\right)VR'\right)^{0.5}\right]$$

X' = Ratio of available Retention storage to Total storage

$$H' = VR' \times \left(\frac{100}{X'}\right) - VR' = \_\_\_\_\_ ft^3$$

H' = Detention Storage Volume required to maintain peak flow.

<u>Summary of Quantitative LID Results</u>

Yes / No - Site design and impervious cover reduction practices were used to the maximum extent practicable to minimize runoff volume.

Yes / No - The design results in a post-development Tc equal to the pre-development Tc.

Yes / No - The entire **Retention Storage Volume** will be retained and infiltrated.

Yes / No / NA - If the entire **Retention Storage Volume** is not retained and infiltrated, the plans show that every practicable effort was made to implement runoff volume reduction efforts, and all potential green space areas were made hydrologically functional for retention.

Yes / No/NA- Detention practices were used to store the additional volume required to maintain the predevelopment peak flow rate as determined by Hybrid Design.

Yes / No/NA- Detention Practices discharge the detention storage volume as overland sheet flow at a non-erosive rate. If no, concentrated flows must discharge the 1-year peak flow rate at or below the 1-year predevelopment flow rate in forested condition.

References

1. **Low Impact Development National Manual.** ***Low-Impact Development Design Strategies An Integrated Design Approach.*** EPA 841-B-00-003. Available on the web at http://water.epa.gov/polwaste/green/upload/lidnatl.pdf
2. **Low Impact Development National Hydrology Manual.** ***Low-Impact Development Hydrologic Analysis***. EPA 841-B-00-002**.** Available on the web at http://water.epa.gov/polwaste/green/upload/lid_hydr.pdf

NOTE: The appendices to the hydrology document include a series of charts which are required to calculate LID storage volumes. They are not currently available in the downloadable version, but selected charts from that series are attached to the end of this document.

Selected Charts for Calculating LID Storage Volumes

taken from

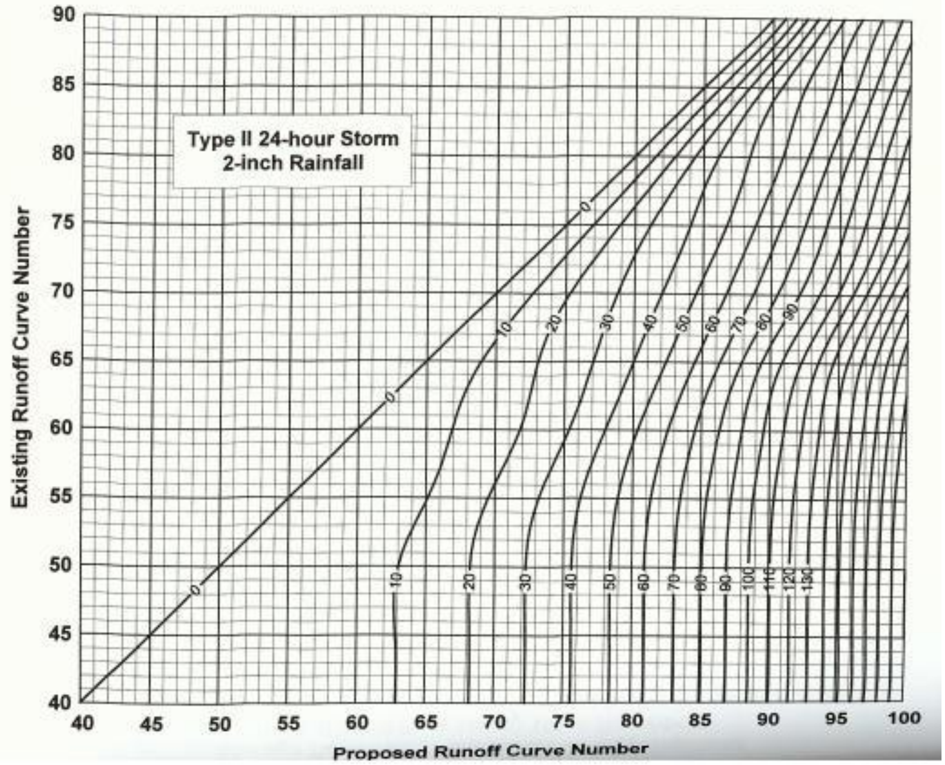
"LID Hydrologic Analysis"

(Low Impact Development National Hydrology Manual)

Prince Georges County, Md. – June 2002

EPA 841-B-00-002

Storage Required to Maintain Pre-Development Peak Runoff Rate Using 100% Retention (hundredths of an inch)



Storage Required to Maintain Pre-Development Peak Runoff Rate Using 100% Retention (hundredths of an inch)