24. Disconnected Impervious Surface (DIS)

Description

Disconnected Impervious Surface (DIS) is the practice of directing stormwater runoff from built-upon areas to properly sized, sloped and vegetated pervious surfaces. Both roofs and paved areas can be disconnected with slightly differing designs. DIS is low cost and has been proven to reduce the volume and flows associated with stormwater runoff.

Siting & Use

Yes	High SHWT
Yes	Tight soils
No	Very steep sites
No	Highly impervious sites
Yes	Pathogen removal
Yes	Temperature control

Design Objective

DIS directs stormwater from impervious surfaces to a vegetated area for treatment via infiltration and filtration. The loading ratio shall be at a minimum of 7:1 for (rooftop area : vegetated area) or 10:1 for (pavement area : vegetated area).

Stormwater Credits

Runoff Reduction	Varies from 30% to 100% reduction of the runoff volume from the design storm based on the soil type and size of vegetated receiving area. See Section 24.2.
TSS removal	30% to 85% reduction of the annual Total Suspended Solids (TSS) mass load based on the soil type and size of vegetated receiving area. See Section 24.2.
Nutrient removal	30% reduction of the annual Total Nitrogen (TN) mass load. 35% reduction of the annual Total Phosphorus (TP) mass load.
BUA Status	For the purpose of high/low density calculations, the footprint of the roof or paved area shall be considered impervious and the footprint of the vegetated receiving area shall be considered pervious.

The photo shows a disconnected downspout on a residential lawn in Durham, NC (Carmen, NCSU)

Major Design Elements:

Throughout the table below and the chapter, three different imperatives are used with the following intended meanings:

- **"Shall"** is used for items that are required to receive straightforward approval of the design as well as the regulatory credits summarized on page 24-1.
- **"Should"** is used for items that are recommended for good design practice and optimum performance.
- **"May"** is used for items that are options to consider in the context of the specific DIS application.

Design professionals desiring to deviate from this chapter shall provide technical justification that their design is equally or more protective of water quality (vague, anecdotal or isolated evidence is not acceptable). Review staff shall consider deviations from the required items in this chapter on a case-by-case basis. Alternative designs may receive lower regulatory credits.

1.	For disconnected roofs, a maximum of 300 square feet of roof shall drain to each disconnected downspout unless a device (like a level spreader) is provided to spread the flow evenly across the entire width of the vegetated receiving area. If there is a spreading device, then the drainage area may be increased to 500 square feet. The receiving vegetated area shall be a rectangle of either 6 by 12 feet or 12 by 24 feet (width of vegetated area by length of run in direction of flow). The entire rectangle shall not include any impervious surface to ensure that water released from the roof does not run onto another impervious surface.
2.	For disconnected pavement, the receiving vegetated area shall be either 10 or 15 feet long. The maximum width of pavement run that may discharge to the vegetated area is 100 feet and the maximum slope of the pavement shall be 7 percent.
3.	The vegetated area shall have a maximum slope of 7 percent with land graded to promote sheet flow, except in A soils where the maximum slope is 15 percent.
4.	If the vegetated area is established on fill soils that are less permeable than the in-situ soils, then the soil type for crediting purposes shall be based on the fill soils. However, if the fill soils are more permeable than the in-situ soils, then the soil type for crediting shall reflect the in-situ soil type.
5.	The vegetated receiving area shall not contain any impervious surface.
6.	The vegetated cover shall be established dense lawn with no clumping species.
7.	All sites built within the past fifty years shall be tilled to eight inches prior to vegetation establishment.
8.	Recommended: A minimum separation of five feet should be provided between the disconnected downspout and the foundation.

24.1. Description and Purpose

A disconnected impervious surface (DIS) is a built-upon area (usually a roof or a paved surface) that discharges runoff to a vegetated area that is sized and graded to reduce runoff and pollutants. Much of the development across the state has been designed as ***connected impervious surface***; that is, draining to pipes and ditches that rapidly convey stormwater without runoff reduction or treatment. Using DIS can help restore the hydrology of streams and reduce pollutant loadings.

There are two types of DIS discussed in this chapter: downspout disconnection and pavement disconnection. Design elements that apply to both are:

- The vegetated receiving area shall not include any impervious surface.
- The vegetated receiving area shall have a maximum slope of 7% for B, C and D soils and 15% for A soils with land graded to promote diffuse flow in all directions. Vegetative cover shall be established dense lawn with no clumping species.
- All sites built within the past fifty years shall be tilled down to eight inches prior to vegetation establishment.
- Recommended: There should be a minimum 5-foot distance between building foundation and vegetated area receiving runoff.

For ***downspout disconnection***, the roof's downspout is directed to a vegetated area that is either 6 by 12 feet or 12 by 24 feet depending on the space available and credit sought. The maximum roof surface area directed to any downspout disconnection is 300 square feet. The red hatched areas around the perimeter of the built-upon areas on the lot show the recommended five-foot setback from building foundations.

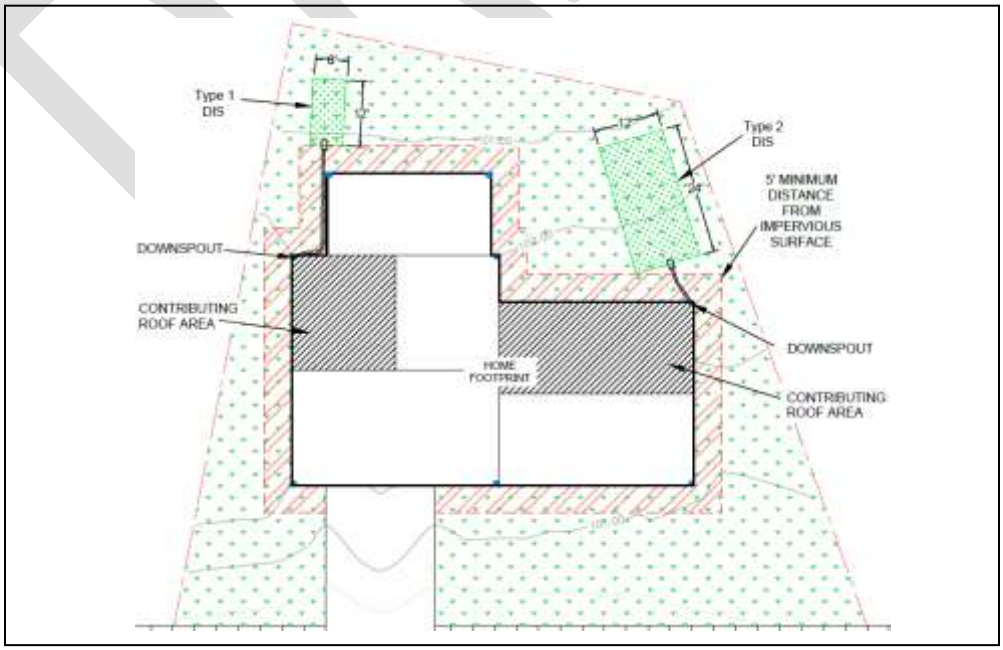

Figure 24-1. Schematic Plan View of a Disconnected Roof (Anderson, NCSU-BAE)

For ***disconnected paved areas***, the vegetated area is either 10 or 15 feet in length depending on the amount of space available and credit sought. A gravel verge or other transition shall be provided between the edge of the paved surface and the vegetated area. The maximum run of the flow on the pavement is 100 feet and the maximum slope of the pavement is 7 percent.

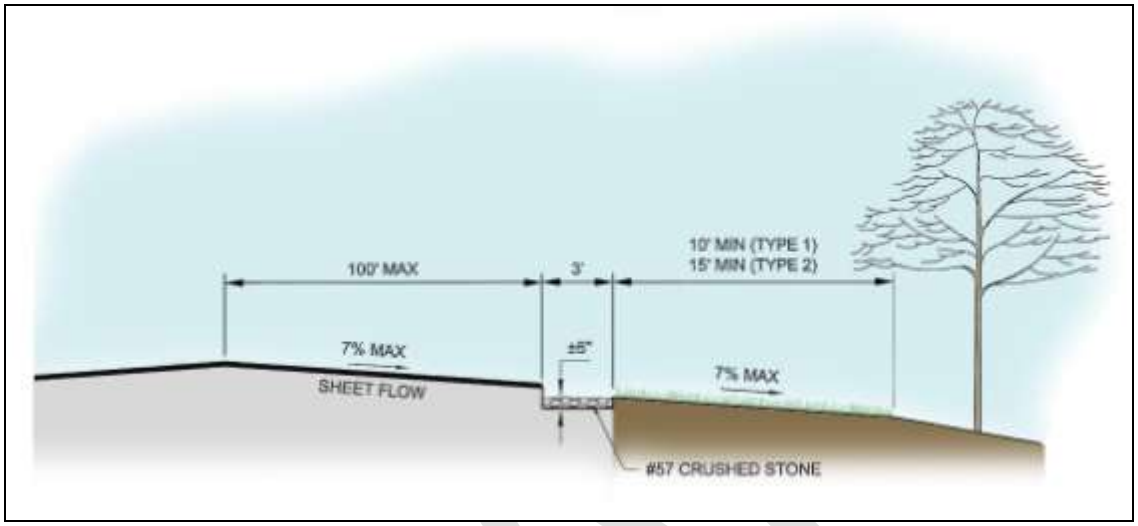

Figure 24-2. Schematic Cross Section of a Disconnected Paved Area (Freeman, Withers & Ravenel)

24.2. Regulatory Credit

DIS shall meet the minimum elements to receive credit for volume and nutrient reduction. The credits listed below are based on the Hydrologic Soil Group. As an alternative to the NRCS soil survey for determining soil type, on-site infiltration tests may be conducted to prove higher infiltration rates than shown by the soils report and subsequent higher volume reduction credit.

It is possible that soil amendments will improve the performance of DIS. In NCSU's downspout disconnection study being conducted in Durham, NC, soils were amended in the fall of 2013 and the monitor period is January – September 2014. This study will provide information on soil amendment's possible effect on DIS performance and the associated possible increase in volume reduction credit of sites with amended soils.

Specific credits for disconnected roofs and pavement are below.

DIS shall receive the following credits if designed, constructed and maintained in accordance with this chapter. These credits are based on research conducted by NCSU's Department of Biological and Agricultural Engineering. Please note that Type 3

DIS receives credit for 85% TSS removal reduction but its use is limited to sites with less than 24% built-upon area overall.

Table 24-1. Sizing and Credit for DIS

	Type 1 DIS		Type 2 DIS		Type 3 DIS
Disconnected Roof: Vegetated Area Size	**6' x 12'**		**12' x 24'**		**12' x 24' & site BUA < 24%**
Disconnected Paved Area: Vegetated Area Size	**10' length**		**15' length**		**15' length & BUA < 24%**
Hydrologic soil group	A/B	C/D	A/B	C/D	A/B only
Runoff reduction credit	45%	30%	65%	50%	100%
TSS reduction credit	45%	30%	65%	50%	85%
TN reduction credit	30%	30%	30%	30%	30%
TP reduction credit	35%	35%	35%	35%	35%

If the vegetated area is established on fill soils that are less permeable than the in-situ soils, then the soil type for crediting purposes shall be based on the fill soils. However, if the fill soils are more permeable than the in-situ soils, then the soil type for crediting shall reflect the in-situ soil type.

24.3. Siting and Feasibility

There are many concerns when determining if and how DIS can be used at a specific site. These are listed in Table 24-3 below.

Table 24-3. Siting and Feasibility Considerations for DIS

Installation Size	The size of disconnected roof areas is limited to a maximum of 300 square feet per downspout. Paved areas are limited to a 100-foot run of pavement; however, there is no limit to the length of pavement that may be disconnected. This will allow most standard roadway cross-sections to be disconnected provided that there is an adequate width of vegetated area in the right-of-way.
Buffers and setbacks	The vegetated receiving area may be allowed within Zone 2 of protected riparian buffers or the setbacks required under Phase II, WS, Coastal Counties, HQW, ORW or other stormwater programs.

Proximity to building foundations & utilities	As a precaution, at least five feet of setback from building foundations should be allowed for downspout disconnection. The limit of 300 square feet for each downspout makes it unlikely that foundations or underground utilities will be adversely affected by DIS.
Proximity to water supply wells	No setback from water supply wells is required for DIS.
Status of the site as high or low density	DIS can be used on either high or low density sites. On high density sites, DIS can reduce required BMP volumes. However, DIS may be impractical on highly built-out sites that do not have vegetated areas available to receive stormwater runoff. On low density sites, as much impervious surface as possible should be handled as DIS.
Soil type	DIS may be used on any soil type, although the credit will vary.
Site slopes	In B, C and D soils, the vegetated areas associated with DIS shall have a slope of seven percent or less. In A soils, the slope may not exceed 15 percent. It may not be cost-effective to meet the requirement for gently sloping vegetated surface on a steep site.
Seasonal high water table	There are no seasonal high water table requirements associated with DIS.
Stormwater hotspots	DIS shall not be used to treat stormwater hotspots – areas where concentrations of pollutants such as oils and grease, heavy metals and toxic chemicals are likely to be significantly higher than in typical stormwater runoff.
Redevelopment sites	Care should be taken when implementing DIS at redevelopment sites. Stormwater shall not be infiltrated into contaminated soils because this can cause dispersion of toxic substances. If contaminated soils are present or suspected, the state recommends that the designer consult with an appropriately licensed NC professional.
Maintenance access	Because its performance depends on maintenance, DIS should be accessible by mowing equipment

24.4. Design

The design standards for DIS are based on providing a minimum loading ratio of 7:1 for (rooftop area : vegetated area) or 10:1 for (pavement area : vegetated area). Lower loading ratios receive higher credits as explained above. These loading ratios ensure a significant level of infiltration for stormwater and significant pollutant reductions.

24.4.1. Design Step 1: Ensure Acceptable Conditions for Construction

Before pursuing a DIS beyond the conceptual stage, the designer shall verify site feasibility and meet with the owner to explain the installation, construction and maintenance requirements of the proposed DIS. These costs are likely lower than other BMPs, but it is important to integrate maintenance requirements into the owner's planning for site operations.

24.4.2. Design Step 2: Design the Drainage and Outlet System

For disconnected roofs, the gutter system shall be designed so that no more than 300 square feet of roof flows to each downspout if the downspout releases at a single point as shown in Figure 24-3. If the flow is distributed evenly across the vegetated area via a spreading device such as a level spreader, then up to 500 square feet of rooftop may flow to the downspout. Most designs require the use of a converter joint as shown below.

Figure 24-3. Disconnected downspouts on the left and a converter joint on the right (Carmen, NCSU)

Figure 24-4 shows two potential problems with downspout disconnection. In Figure 24-4a, the converter joint was omitted and instead the four-inch corrugated plastic pipe was split. This weakens the structure and the pipe will most likely continue to split over time. In Figure 24-4b, the downspout releases onto a sidewalk instead of vegetated area. Additionally the sidewalk is graded to collect water.

Figure 24-4. Poorly designed and installed downspout disconnections (Carmen, NCSU)

There are many possible outlet configurations for a disconnected downspout. Figure 24-5 shows a variety of possibilities. All outlet configurations should be designed with maintenance in mind. As mentioned above, outlet configurations that are equipped with a durable means of spreading the flow evenly across the vegetated filter strip shall be able to serve a larger rooftop area.

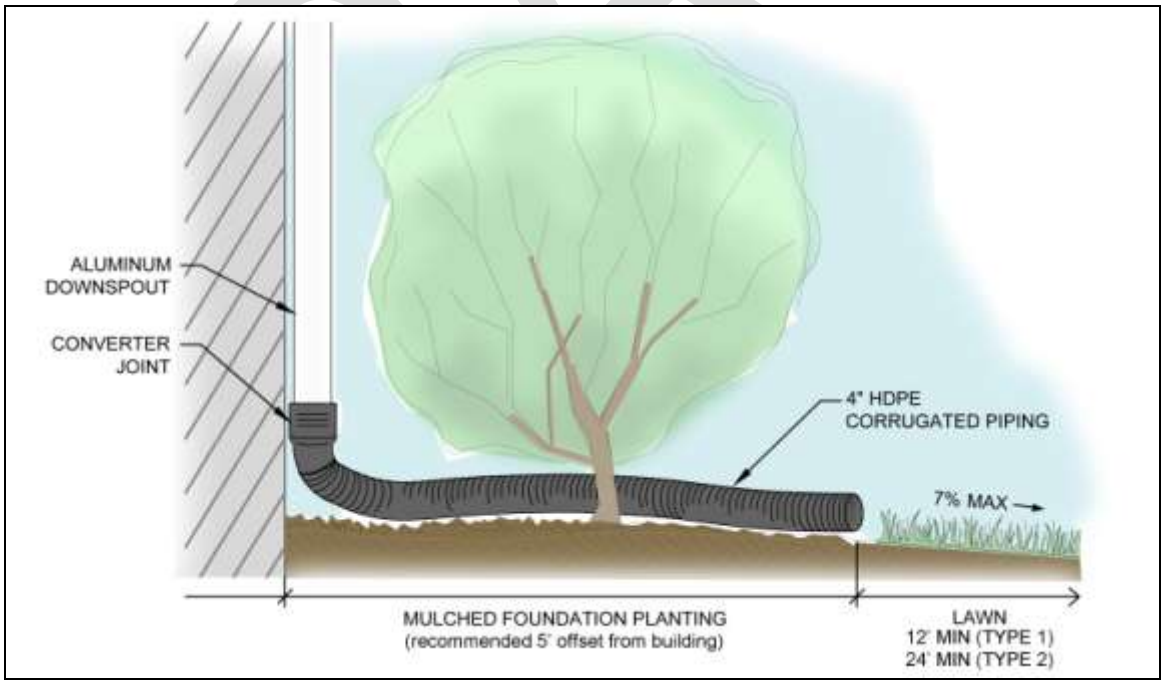

Figure 24-5a. Outlet configuration with a foundation planting (Carmen, NCSU)

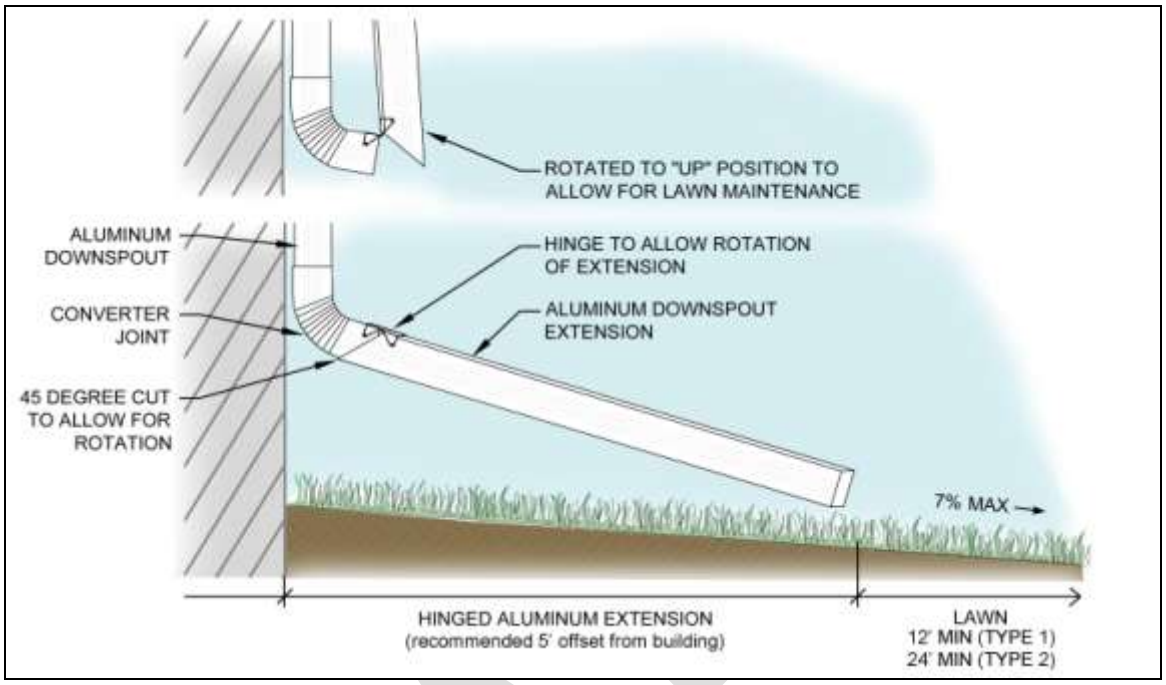

Figure 24-5b. Hinged outlet configuration (Carmen, NCSU)

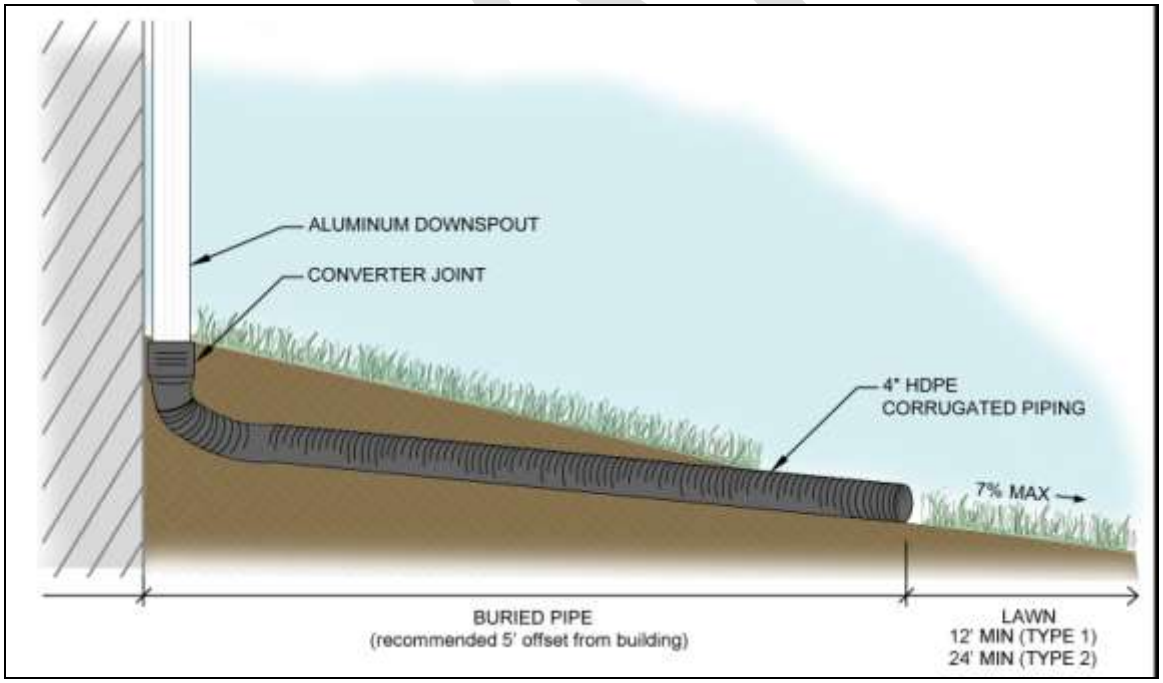

Figure 24-5c. Buried pipe outlet configuration (Carmen, NCSU)

For disconnected pavement, a stone verge or concrete edge restraint should be used between contributing pavement and receiving vegetated area.

24.4.3. Design Step 3: Design Vegetated Receiving Area

Disconnected downspouts and pavement shall be directed to appropriately sized vegetated areas based on Table 24-1 above. In B, C and D soils, the vegetated receiving area shall have a uniform slope that does not exceed 7 percent. In A soils, the vegetated receiving area slope may be increased up to 15 percent. The vegetated area may be graded to achieve this slope, but shall have additional positive grade at the end of the receiving area for possible runoff to be directed offsite and not cause ponding.

If appropriate vegetation is not already established on site, then seed blend application is recommended. Seed blends should be selected based on shade/sun exposure of vegetated area and regional climate within North Carolina. A non-clumping species should be selected. Sod should not be grown in a clay base or otherwise should be washed.

Forested areas are not recommended as vegetated receiving areas because uneven micro-topography often causes channelization, which reduces surface area exposed to stormwater.

24.5. Construction

For an existing home, downspouts can be disconnected easily with minimum effort and expense if there is already an appropriately sized, sloped and vegetated area on the lot. For a new construction project, a preconstruction meeting is highly recommended to ensure contractors understand the locations and function of the DIS. Contractors will need to understand the need to construct the site drainage system according to the plans. Also, contractors shall grade and till the vegetated receiving areas as one of the last steps in the site construction process. A preconstruction meeting is also an opportunity to discuss other unique construction considerations for DIS.

24.5.1 Construction Step 1: Ensure Acceptable Conditions for Construction

Do not construct vegetated receiving areas until:

- Impervious areas that will drain to the vegetated receiving areas are completed.
- Areas of the site adjacent to the vegetated receiving area are stabilized with vegetation, mulch, straw, seed, sod, fiber blankets or other appropriate cover.
- The forecast calls for for a window of dry weather to prevent smearing and compaction if grading the vegetated receiving area is necessary subgrade.
- The forecast calls for extremely hot or cold temperatures, which can hinder establishment of vegetation.

24.5.2 Construction Step 2: Install the Downspout System (If Applicable)

The downspout system shall be installed per the plans. In the field, verify that the downspout system has been installed correctly and that the drainage areas do not exceed the allowable design standards.

24.5.3 Construction Step 3: Grade, Prepare and Plant the Vegetated Receiving Area

It is important to ensure that the vegetated receiving areas are uniformly graded with no gullies, low spots or lateral slopes. Soils should be tilled to a depth of 8 inches unless this is an existing site that was built more than 50 years ago.

When the sod is brought to the site, inspect it to be certain that it does not have a clay base or has been washed. A one-time fertilizer application and regular watering should be conducted to establish the vegetation in a DIS.

For a downspout disconnection system, the vegetated receiving area shall be kept off-line until vegetation has been established. For disconnected pavement, soils should be stabilized with temporary means such as straw or matting until the permanent vegetative cover has taken root.

24.5.4 Construction Step 4: As-Built Inspection

After installation, an appropriately licensed NC design professional shall perform a final as-built inspection and certification that includes:

- Ensuring that the DIS is installed per the plans and specifications.
- Checking that the vegetated receiving areas are sized correctly and that the vegetated receiving areas are stabilized with vegetation.
- Checking that the impervious surfaces are free from sediment and debris.

Any deficiencies found during the as-built inspection shall be promptly addressed and corrected.

24.6. Cost

The cost of designing, constructing and maintaining DIS is very low – in fact, negligible in many cases. In fact, using DIS whenever possible can reduce or eliminate costs associated with traditional conveyance systems, such as, curbs, gutters, and storm drains. In addition, since DIS can be used to reduce runoff and pollutant loadings, it can reduce or eliminate the need for other stormwater BMPs and open-up land normally designated for stormwater management. Long-term maintenance of DIS is only slightly greater than maintaining a typical grassed area. It will be important to inspect the vegetated receiving area quarterly and address any erosion problems or other issues immediately.

If using DIS as a retrofit on existing developed sites, some basic supplies will be needed including enough 4-inch HDPE corrugated pipe to route downspout to lawn, a converter joint, screws and a splash block (the splash block is recommended, not required). Based on Lowe's Home Improvement prices, disconnecting a downspout can be done for less than $37. Then each additional downspout can be disconnected for less than $16 (these prices do not include the cost of splash blocks).

24.7. Maintenance

DIS requires maintenance to provide long-term stormwater benefits. Regular inspection will determine whether the impervious surface and the vegetated receiving area are draining and functioning as intended.

24.7.1 Directions for Maintenance Staff

Communication with maintenance staff is important in maintaining DIS. Maintenance staff shall:

- Not regrade the vegetated receiving areas or cover them with impervious surfaces such as a shed or patio.
- Not stockpile soil, sand, mulch or other materials on the vegetated receiving area.
- Immediately repair any areas that are eroding or where vegetation has died.
- Immediately remove sediment and debris from contributing impervious surfaces.

24.7.2 Required Operation and Maintenance Provisions

After DIS is constructed, it shall be inspected **once a quarter.** The inspector shall check each component and address any deficiencies in accordance with Table 24-4 below. The person responsible for maintaining the DIS shall keep a signed and notarized Operation and Maintenance Agreement and inspection records. These records shall be available upon request.

At all times, the roof area shall be maintained to reduce the debris and sediment load to the system. Excess debris can clog the system and lead to bypass of the design storm and reduced infiltration and pollutant removal.

To ensure proper operation as designed, a licensed Professional Engineer, Landscape Architect or other qualified professional shall inspect the system annually. The system components will be repaired or replaced whenever they fail to function properly.

Table 24-4
Inspection Process and Required Remedies for DIS

BMP element:	Potential problem:	How to remediate the problem:
The contributing impervious area	Excess debris or sediment is present on the rooftop or impervious surface	Remove the debris or sediment as soon as possible.
The gutter system (if applicable)	Gutters are clogged or water is backing up out of the gutter system.	Unclog and remove the debris. May need to install gutter screens to prevent future clogging.
	Rooftop runoff is not flowing into the gutter system	Correct the positioning or installation of the gutters. Replace if necessary to capture the roof runoff.

Roadways & parking lots (if applicable)	Runoff flows to the pervious area as concentrated flow	Remove any sediment or obstructions at the pavement-vegetate area interface.
	The aggregate transition area or concrete edge restraint is cracked, settled, undercut, eroded or otherwise damaged.	Repair or replace the transition area or concrete edge restraint.
The pervious area	Areas of bare soil and/or erosive gullies have formed	Regrade the soil if necessary to remove the gully and re-seed and water until it is established. Provide lime and a one-time fertilizer application.
	Trees or shrubs have begun to grow	Remove them.
	Vegetation is too short or too long.	Maintain vegetation at a height of approximately three to four inches.

24.8. References

Carmen, N.B., Hunt, W.F., and Anderson, A.R. (2013). "Evaluating Residential Disconnected Downspouts as Stormwater Control Measures". 6th International Low Impact Development Conference. August 19-22, 2013. St. Paul, MN. (Extended Abstract)

Lowe's Home Improvement. (2013) "Shop at Lowes.com: Search Results." *Home: Search*. Lowe's Home Improvement, 2013. <http://www.lowes.com/Search=hacksaw>. (Aug. 1, 2013).