Designing Level Spreaders to Treat Stormwater Runoff

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What are Level Spreaders & Why Use Them?

Level spreaders are structures that are designed to uniformly distribute concentrated flow over a large area. Level spreaders come in many forms, depending on the peak rate of inflow, the duration of use, the type of pollutant, and the site conditions. All designs follow the same principle:

1. Concentrated flow enters the spreader through a pipe, ditch or swale.
2. The flow is retarded, energy is dissipated.
3. The flow is distributed throughout a long linear shallow trench or behind a low berm.
4. Water then flows over the berm/ ditch, theoretically, uniformly along the entire length.

The use of level spreaders is expected to grow as riparian buffer rules become widespread throughout North Carolina. Riparian buffers are stream-side vegetated zones. Buffer requirements state that a minimum of 50’ of vegetation must be preserved alongside streams from the top of stream bank. There are many rules regarding riparian buffers employed across much of central and eastern North Carolina. Another important component of riparian buffer rules currently adopted in the Neuse and Tar-Pamlico River Basins is the elimination of concentrated flow of stormwater runoff through a riparian buffer. The rule specifically states:

“Concentrated runoff from new ditches or manmade conveyances shall be converted to diffuse flow before the runoff enters the riparian buffer.” {Tar-Pamlico Rules (15A NCAC 2B .0259 (5) (a))}

The most efficient way of creating diffuse flow is by employing level spreaders. The pollution removal effectiveness of riparian buffers and vegetated filter strips has been demonstrated rather extensively. Assuming appropriate widths and hydrology, these vegetated strips of land remove high percentages of sediment, total nitrogen, and total phosphorus, if flow through buffers and strips is not concentrated in channels. Level spreaders help reduce concentrated flow thereby increasing the effectiveness of buffers and strips.

Types of Level Spreaders & How They are Constructed

All designs follow the same premise: spread concentrated flow out and “release” the flow simultaneously across the same elevation. Figure 1 is a small schematic illustrating the function of level spreaders. Five types of level spreaders are discussed below.

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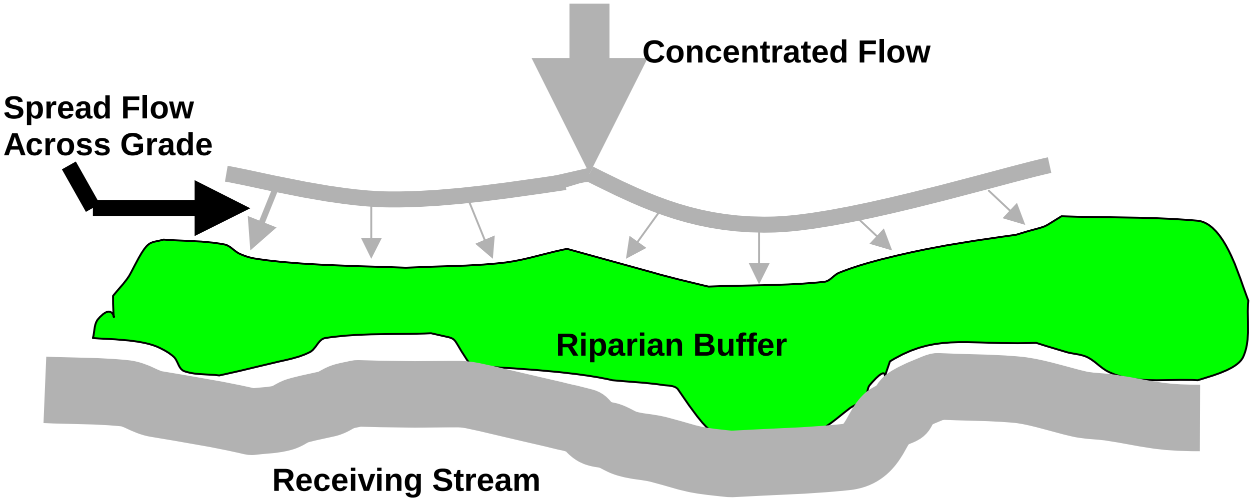
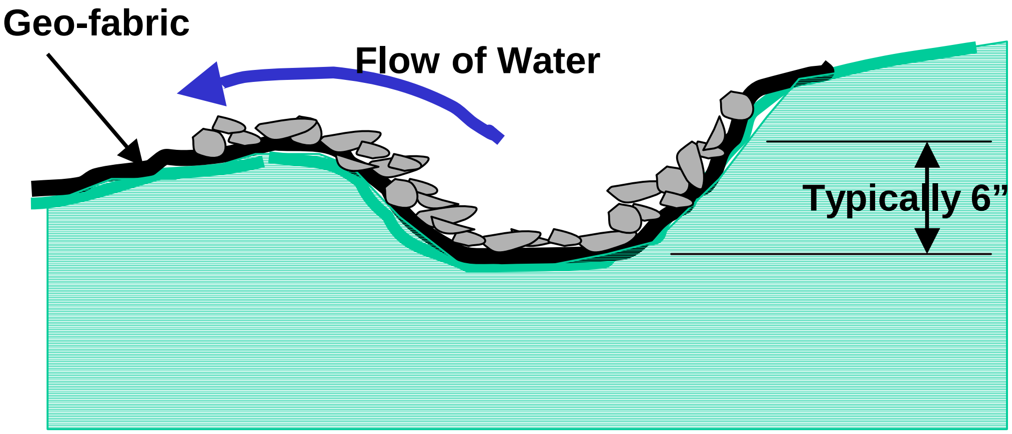
Figure 1. Purpose and Function of Level Spreader



1. <u>Rock lined Channel</u>

One of the simpler designs, rock-lined channels operate under the assumption that the lower (downslope) lip of the channel is the same elevation. The channel must be dug along an elevation contour, which helps make the downstream lip "level." Rock-lined channel depths and widths tend to be small (6-12") and are flow dependent. The channel does not serve as a detention device. Standard ABC stone (crusher run) can be used. Geofabric can be used to underlay the channel and protect the downslope lip, as shown in Figure 2. A disadvantage of this type of channel is that it is very hard to get the lip truly level and keep it that way. The crusher run can prevent uniform flow.

Figure 2. Cross-section of Rock-lined channel with geo-fabric underlay.



2. <u>Treated Lumber</u>

Another simple design is laying treated lumber end-on-end to create a downslope lip, as shown in Figure 3. Each piece of wood can be easily set to grade. Sometimes the boards are installed in a trench and serve as the downstream lip so that water can flow out of the level spreader more uniformly. The boards are often supported by rebar driven into the ground. This effectively marries options 1 and 2. While 2X6 pretreated lumber has been most frequently used, other board sizes can work. Joints between boards can be constructed by wrapping cloth around both ends of the board. Maintenance on this option is very important as tree roots can cause some boards to heave. This option may be the most aesthetically pleasing and could potentially have a life of 5-10 years.

Figure 3. Installing a Pretreated Lumber Level Spreader

3. <u>Concrete Troughs & ½ Pipe</u>

A more expensive option is to pour a concrete trough. Standard depths of the trough will range from 4" to 12." The troughs will be comparably wide. A similar option is to have the troughs be one-half sections of pipe. Neither option is particularly aesthetically pleasing, but both are structurally sound.

There are two prime advantages to using a concrete level spreader. The concrete trough is easy to maintain. If there is a sediment or debris accumulation, the extra material can be easily shoveled out. Also, this design is the most permanent. While other level spreader designs may be able to effectively function for a period of 5-10 years, concrete level spreaders could conceivably have lives as long as 20 years. Accordingly, long term maintenance should be very low if installed properly.

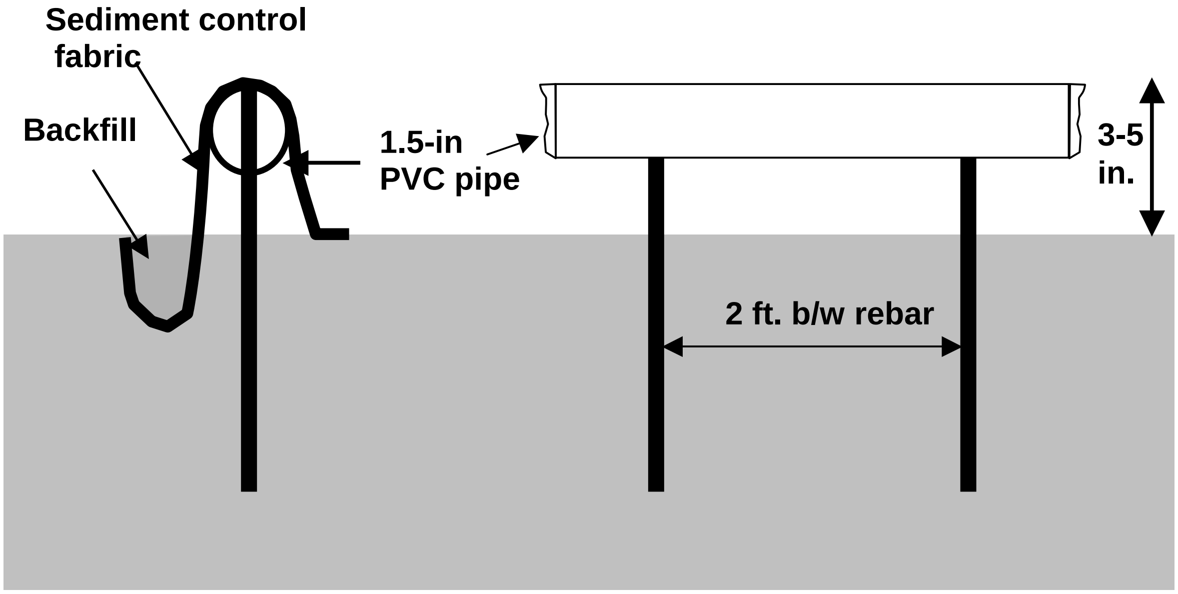
4. <u>PVC-Silt Fence</u>

One option that has proven particularly effective for removing TSS and reducing turbidity in runoff from construction areas is a level spreader constructed like a low silt fence – except in a sturdier fashion. An advantage of this spreader is that it allows water to seep through the silt fence in addition to having runoff flow over the top. A cross section of this level spreader is shown in Figure 4.

Rebar is driven into the ground on two feet intervals and capped with a 1.5" PVC pipe. This pipe is easily made level. Over the pipe sediment control fabric, silt fence material, is draped over the top of the pipe. This fabric can be backfilled, or trenched into the ground on the upstream side.

If desired, it is possible to put washed, 57 or 47, stone on either side of the fabric. No trench is dug with this type of level spreader. The PVC-Silt Fence type of level spreader may be best used for shorter term purposes, such as during and immediately after construction projects. This type of level spreader has yet to be tested for long term usage; so, there is a concern as to the longevity of silt fence material when exposed to direct sunlight. It should be placed away from potential foot traffic, as it can easily be made unlevel by stepping on it.

Figure 4. Level Spreader Cross-Section and Profile using rebar, silt fence, and PVC.



Helpful Construction Tips

There are several common mistakes during construction that need to be averted.

1. Level Spreaders must be LEVEL. By allowing small variations in height on the downstream lip of gravel-lined trench, height in lumber boards, concrete channel or PVC cap, small rivulets will quickly reform. Experience suggests that variations of more than 0.25 inches will in time cause water to quickly reconcentrate and potentially erode downstream of the level spreader. It is imperative that the site selected for level spreader installment be nearly level before construction. A change in ground elevation of more than 4” across the entire length of the level spreader can begin to make “level” construction difficult.

2. The downslope side of the level spreader should be clear of debris. Often after construction, debris such as earth, wood, and other organic matter will accumulate immediately downstream of the level spreader. This effectively blocks water as it tries to flow out of the level spreader, forcing it to quickly re-concentrate.

3. Avoid constructing upstream of disturbed area. If a level spreader is installed above a disturbed area without a good vegetative stand, such as grass or trees, or other ground cover such as mulch or construction matting, erosion rills will quickly form. Even sheet flow can initially cause significant downstream erosion on disturbed areas.

4. Do not construct level spreaders in newly deposited fill dirt. Virgin earth is much more resistant to erosion than fill. Even with what appears to be a good young stand

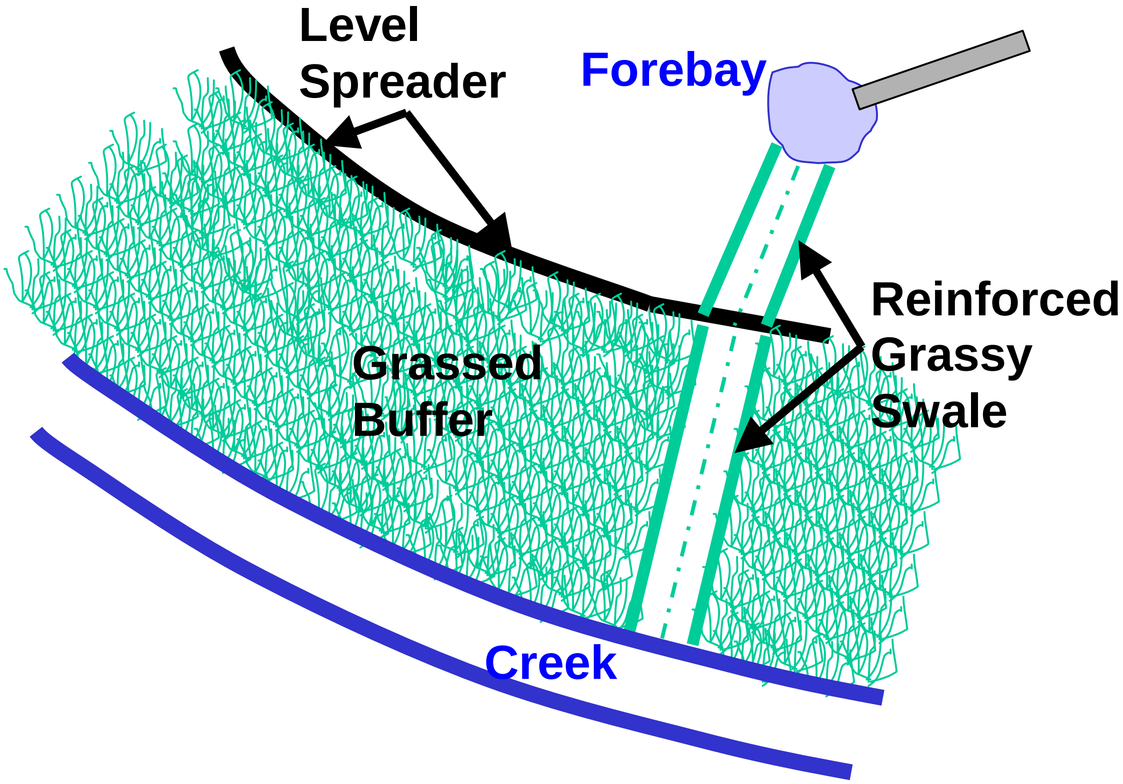
of grass over fill dirt, erosion is likely to occur. Site level spreaders away from newly deposited earth.

5. Except for the PVC-Silt Fence and concrete trough forms of level spreaders, do not use spreaders to remove sediment. They are not made for removing sand and larger size sediment. Significant sediment deposition in the spreader can render it ineffective.

Level Spreader System Configuration

Level spreaders are part of a treatment system. This level spreader system consists of three main parts:. 1. Preliminary treatment, 2. Principal treatment, and 3. Emergency treatment. Wet ponds, stormwater wetlands, and sand filters each have the same treatment path as level spreaders. A schematic of the level spreader system configuration is shown in Figure 5.

Figure 5. Level Spreader System consists of pre-treatment (forebay), principal treatemnt (level spreader with grassed buffer), and emergency treatment (reinforced grassy swale downslope of spreader).



1. *Preliminary treatment*. A forebay is commonly used in other practices to drop out heavy sediment before it enters the main body of the BMP. A stilling area such as a forebay is particularly useful because flows entering the level spreader should not approach with high energy. There are several procedures for sizing a stilling basin/forebay. They are included in NC DENR documents such as the *Erosion and*

Sediment Control Planning and Design Manual and the *Stormwater Best Management Practices Manual*.

One simple way of sizing a forebay for a level spreader is to calculate the size a wet pond would need to be to treat the amount of runoff that would enter the level spreader. This is typically 1-2% of the watershed area. Were the wet pond to be constructed, the forebay would account for 5-10% of the pond surface area. Using these guidelines, the surface area of the level spreader forebay (or series of forebays) would be between 1/2000 to 1/500 the size of the watershed area. Forebay depth would be relatively shallow (up to 2 feet). The forebay will fill with sediment periodically and it will need to be cleaned out to continue to function.

2. *Principal treatment*. Principal treatment tends to be the distinguishing feature of best management practices. For sand filters it is the bed of sand through which water must infiltrate; whereas, for stormwater wetlands, the principal treatment is the constructed wetland. The level spreader's principal treatment is the level spreader and the buffer immediately downslope. The sizing of this principal treatment mechanism is the focus of the second half of this document.

3. *Emergency treatment*. It is not realistic to expect the level spreader to handle all flows all the time. There is a limit to the amount of flow a level spreader can reasonably transport. Once this limit is reached it will be necessary to bypass the excess flow. This can be done using environmentally sensitive means such as grass swales constructed with turf reinforcement mats. Swale design is found in N.C. DENR's *Stormwater Best Management Practice Manual*.

   The overflow or bypass swale is essential. If all flow from large runoff events were forced through the level spreader, then new swales or ditches may be eroded by the concentrated and excess water after it flows over the level spreader. Once these channels have formed downslope of the level spreader, it will be easier for dispersed flow to reconcentrate even if the runoff event is relatively small. At that point the level spreader would lose its design goal: keep overland flow dispersed.

Maximum Flows

The maximum allowable flow, which the level spreader effectively distributes, is a function of 1. the ability to still inflow before it flows over a level spreader and 2. the length of the level spreader. If the "stilling" basin in front of a level spreader is a small stormwater pond and the level spreader is several hundred feet long then the maximum flow allowed to spill over a level spreader is considerably high. However, normal usage of level spreaders to disperse parking lot or road runoff does not require a drastic energy dissipator and excessive lengths.

Design storms

Like any other stormwater quality BMP, level spreaders should be constructed to treat the water quality storm. This is often the first flush event, which ranges from 0.5" to 1.5" of rain depending on land use and geographic location. A standard 1.0" storm is most often considered to be the first flush event. For a level spreader to "adequately treat" an event, it must be able to disperse a concentrated flow so that no erosion occurs downslope. In other words a level spreader would fail if any storm event less than a water quality rainfall (first flush) event creates erosion. It is imperative that other, larger storms be bypassed without creating additional erosion. This will be discussed later.

The length of the level spreader is determined by peak flow. To determine peak flow from small watersheds, the rational method is typically used. The rational method is described by the following equation:

$$\mathbf{Q_p = C \bullet I \bullet A}$$

Where Q_p is peak flow (in cfs),
C is the Rational Runoff Coefficient (the higher the number the more runoff – as shown in Table 1),
I is rainfall intensity measured in terms of inches/hour;
A is watershed size in acres.

Assuming a 1.0” event is the design storm, a suggested rainfall intensity (I) is 1”/hour. This describes a 1.0” storm with a one-hour duration that rains at a constant rate. There are other methods that could be used to calculate the peak flow entering the level spreader. An example of the method described is shown below:

Table 1. Selection of Rational Coefficients per Land Use. (taken from Malcom, 1997, and Lindeburg, 1999)

Land Use	**Runoff Coefficient (C)**	**Peak Flow per Acre (First Flush=1.0”)**
Street, Driveway, Sidewalk, Rooftop	0.95	0.95 cfs
Parking Lot	0.90	0.9 cfs
Commercial	0.85	0.85 cfs
Apartments, Schools, Churches	0.60	0.6 cfs
Light Industrial	0.50-0.80	0.5-0.8 cfs
Heavy Industrial	0.60-0.90	0.6-0.9 cfs
Single Family Residential	0.30-0.50	0.3-0.5 cfs
Playground, Lawn w/dense soil & steep slope	0.25-0.35	0.25-0.35 cfs
Park, Cemetery	0.25	0.25 cfs
Lawn on Clay Soil, moderate to flat slope	0.13-0.22	0.13-0.22 cfs
Lawn on Sandy Soil	0.10-0.20	0.1-0.2 cfs
Wooded	0.10-0.20	0.1-0.2 cfs

Example 1:
Given: 6 acre Watershed comprised of apartments.
Find: Peak flow (Q_p) entering the level spreader system

1. From Table 1, the rational coefficient is 0.6 (C=0.6)
2. Assume a first flush event of 1.0” with an intensity of 1”/hour (I=1.0)
3. Multiply C • I • A (with area = 6 acres)
   $Q_p = 0.6 \bullet 1.0 \bullet 6$
4. Peak Flow to be managed by level spreader is 3.6 cfs
   $Q_p = 3.6$ cfs

Flow Bypass

Most municipalities require stormwater devices such as a level spreader to adequately pass a 10-year storm event. Once the first flush flow has been diverted to the level spreader, higher runoff rates will bypass the level spreader to avoid overloading the device. A typical bypass is a grassed swale often employing turf reinforcement matting. This swale should be designed to carry the 10-year (or other specified) storm event. There may be particularly sensitive areas where precipitation events with less frequent return intervals, or greater rainfall amounts, need to be carried. An example would be a 25-year storm. The 10-year peak flow event is calculated similarly to the first flush flow. The only difference being a change in rainfall intensity. A typical 10-year rainfall intensity for Raleigh, NC, is 6 in/hour. A flow splitter will need to be constructed to allow the level spreader to only treat flows resulting from the first flush event. The splitter will bypass portions of heavier runoff events.

Design to Avoid Downstream Erosion

In determining allowable flows over a level spreader, downstream conditions are considered. In particular, what is the soil covering: grass, mulch, or something else in between such as a thicket. The length of level spreader is determined by what’s on the downstream side.

Allowable Velocities

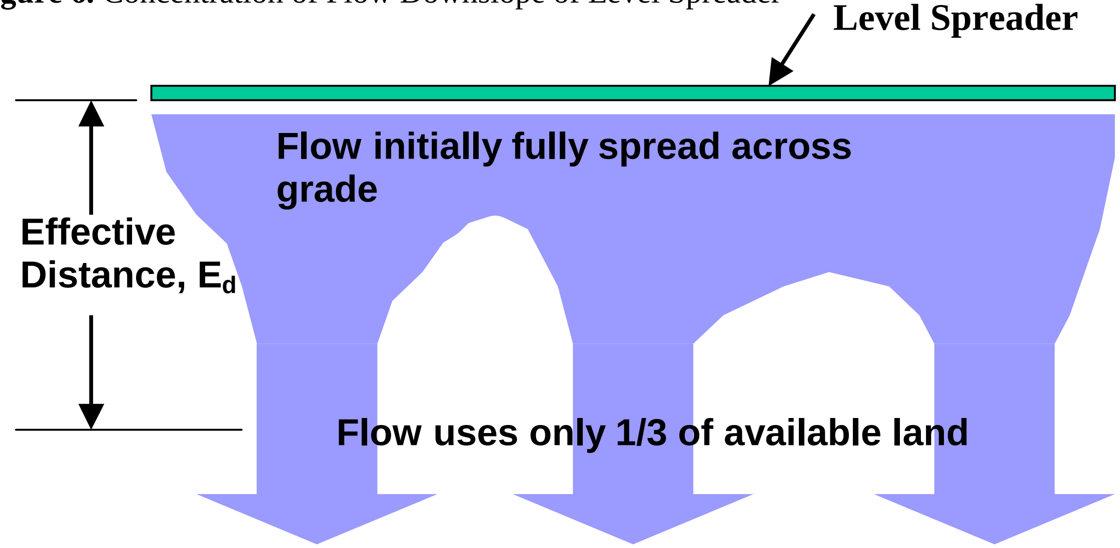
Different ground coverings have different allowable velocities, which is the maximum velocity of water before it causes erosion. The maximum allowable velocities for downstream soil covers are shown in Table 2. Please note that tree and shrub riparian buffer is assumed to have a mulch groundcover.

Table 2. Allowable velocities for downstream covers for channeled flows.

Ground Cover	Allowable Velocity
Grass	4 feet per second (fps)
Gravel	5 fps
Mulch	1-2 fps

The level spreader length needs to be designed so that velocities are not exceeded. It is important to include in the design the following fact*: water will recollect as it flows down* *slope*. Studies have shown that water that has been distributed across the grade may recollect in as little as 10-12 feet. Recollection is inevitable. How much recollection is allowable until flow can no longer be considered sheet flow? It is suggested that once water is using only 33% of available land (as shown in Figure 6), sheet flow becomes concentrated flow. The distance down slope of the level spreader where only 33% of available land is used can be described as the level spreader's Effective Distance, or $\mathbf{E_d}$. Flow beyond the level spreader's effective distance would be considered to be concentrated, not dispersed.

Figure 6. Concentration of Flow Downslope of Level Spreader



Level spreaders must be designed, therefore, to ensure non-erosive velocities not only at the time water passes over the level spreader (when flow is theoretically completely dispersed), but at the time water has reached the effective distance. The more limiting parameter is the latter. Level spreaders must be designed so that non-erosive velocities are not exceeded once the flow has traveled the effective distance down slope.

Velocities allowed as water flows over the level spreader must be 33% of the erosive velocity experienced at the effective distance down slope. So, if a mulch ground covering is able to withstand velocities as high as 2 feet per second (fps) the design velocity over the level spreader needs to be 0.67 fps, or 1/3 of the erosive velocity.

Calculating Level Spreader Length

The designer's main goal with level spreader design is to ensure an appropriate length of a level spreader – a length that does not allow for erosive velocities down slope. Allowable velocities over a level spreader are summarized in Table 3.

Table 3. Maximum Velocities of Flow Across Level Spreader

Down Slope Ground Cover	**Velocity at Level Spreader**	**"Equivalent" Water Height over Level Spreader, X**
Grass	1.33 fps	0.058 ft
Gravel	1.5 fps	0.074 ft
Thicket (Shrubs, Grass)	1.33 fps	0.058 ft
Mulch (Trees/ Shrubs)	0.67 fps	0.015 ft

Using Allowable Velocities to Establish Level Spreader Length

With an allowable velocity determined based upon down slope ground cover, it is now possible to calculate the necessary level spreader length. The calculation is based on two equations: 1. the Weir Equation and 2. the Continuity Equation. They are described below.

Weir Equation:
It is assumed that the level spreader functions as a long weir. Flow over a weir is described by the following equation and graphically shown in Figure 7.

$$\mathbf{Q = C_w \bullet L \bullet H^{3/2}}$$

Where Q = Flow
L = Length of Level Spreader
C_w = Weir Coefficient (set to 3)
H = Driving Head (shown in Figure 7)

Flow over the level spreader is a function of its length and the height of water up slope. Increasing the length reduces the height of water, as they are directly related. This is important because the height and length of water flow dictates the velocity of flow over the level spreader. This relationship is shown in the second equation, the continuity equation.

Continuity Equation:

$$\mathbf{Q = V \bullet A}$$

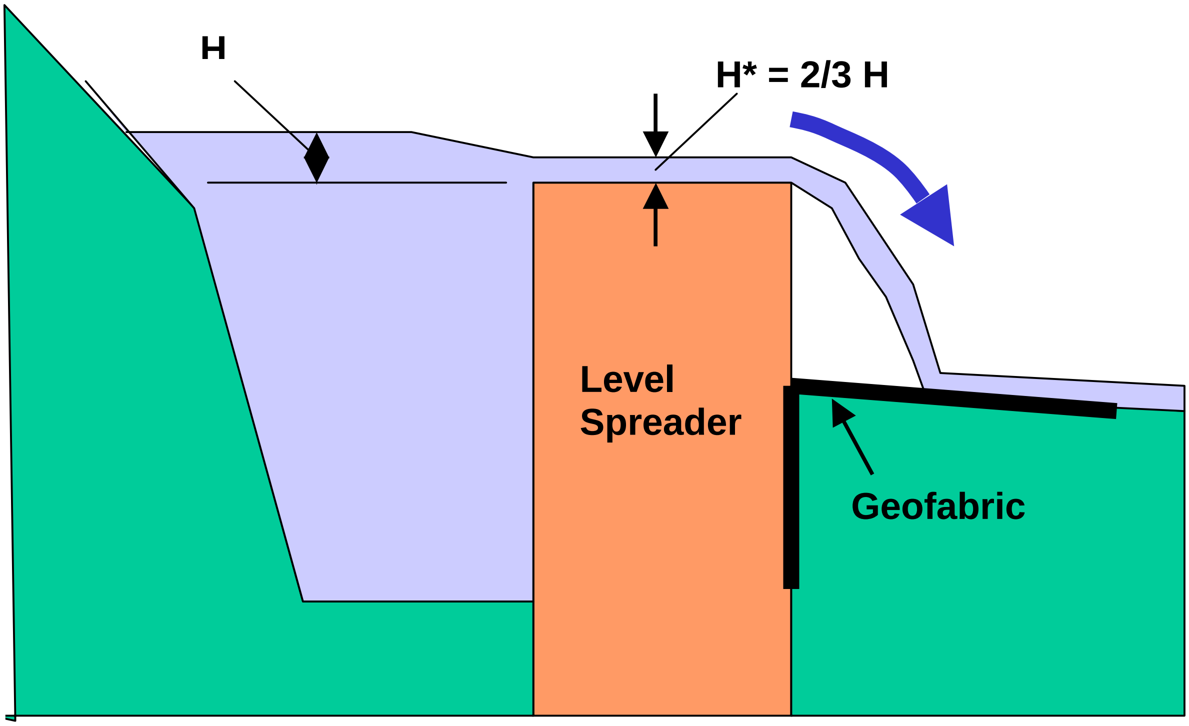
Where, Q = Flow
V = Velocity
A = Cross-Sectional Area of Flow = (L • 2/3 H)

The allowable velocity is determined by down slope cover (grass, gravel, mulch). This then dictates the cross-sectional area, L • 2/3H. Combining the two equations lead to the following relationship:

$$\mathbf{V = 1.5 \bullet C_w \bullet H^{1/2}}$$

In this way the height of water flow over the weir is determined for the three down slope cover conditions (grass: 0.09'; gravel: 0.11'; mulch: 0.02'). By inserting this height back into either the weir equation or continuity equation, it is possible to calculate the length of level spreader needed to distribute a given flow. An example is shown below and a more complete list in Table 4 shows required level spreader lengths as a function of flow and down slope cover.

Figure 7. Weir Equation Inputs Shown during Storm



Example 2: Determine length of level spreader with mulch down slope and an incoming flow of 1 cfs.

Use Continuity Equation, Q = V •A = V • 2/3 H • L.
As listed above, Q= 1 cfs, Cw is set to 3, allowable velocity for mulch down slope (from Table 3) is 0.67 fps and H = 0.02'. Inserting these known parameters into the continuity equation gives:

1 cfs = 0.67 fps • 0.02 ft • 2/3 • L

L = 1 cfs ÷ (0.67 fps • 0.02 ft • 2/3)
L = 112 ft

Simple Level Spreader Length Equation:

By combining the equations discussed above a simple equation can be used to calculate the required length of the level spreader.

$$\mathbf{L = Q \div (X \bullet V)}$$

Where X = "Equivalent" Water Height over Level Spreader (from Table 3, page 9)
V = 1.33 for grass and thicket, 0.67 for mulch, and 1.5 for gravel

Table 4. Level Spreader Lengths as a function of flow and cover down slope

Flow (cfs)	**Down slope Cover**	**Length of Level Spreader (feet)**
1	Grass	13
2	Grass	26
3	Grass	39
5	Grass	65
10	Grass	130
1	Gravel	9
2	Gravel	18
3	Gravel	27
5	Gravel	45
10	Gravel	90
1	Thicket (Shrubs/Grass)	13
2	Thicket (Shrubs/Grass)	26
3	Thicket (Shrubs/Grass)	39
5	Thicket (Shrubs/Grass)	65
10	Thicket (Shrubs/Grass)	130
1	Mulch (Trees/Shrubs)	100
2	Mulch (Trees/Shrubs)	200
3	Mulch (Trees/Shrubs)	300
5	Mulch (Trees/Shrubs)	N/A
10	Mulch (Trees/Shrubs)	N/A

Effective Distance

Level Spreaders have a "zone" of influence downstream. As described above, water eventually congregates into new mini-channels that quickly flow through the riparian buffer, bypassing the desired function. How quickly water re-congregates is dependent upon two factors, the ground cover over which water is flowing and how steep the slope is below the level spreader. Water will recollect more quickly when flowing through a wooded buffer than when flowing over a grassed buffer. Water will typically regroup faster if it flows over steep slopes than over gentle slopes. Effective distances based upon observed flow recollection are shown below in Table 5.

Table 5. Effective Distance of Level Spreaders

Ground Cover	Slope from Level Spreader to Top of Stream Bank	Effective Distance (feet)
Trees/ Shrubs	0-6%	50’
Trees/ Shrubs	6-15%	25’
Trees/ Shrubs	>15%	17’
Thicket	0-8%	50’
Thicket	8-25%	25’
Thicket	>25%	17’
Grass	0-8%	50’
Grass	8-25%	25’
Grass	>25%	17’

Putting Level Spreaders in Series

The outcome of effective distance is that level spreaders may need to be placed in series, particularly on steeped sloped sites. If a level spreader were installed in a tree/shrub area 50’ from a stream bank with a standard slope of 15%, three level spreaders in series would be needed to maintain a degree of sheet flow throughout the riparian buffer. For a quick calculation of the number of level spreaders in series needed throughout a riparian buffer use the following equation:

$$\mathbf{N_s = W \div E_d}$$

Where: N_p = Number of Level Spreaders in Series
W = Width of Riparian Buffer through which flow is spread
E_d = Effective Distance Flow is Sheet Flow (from Table 5)

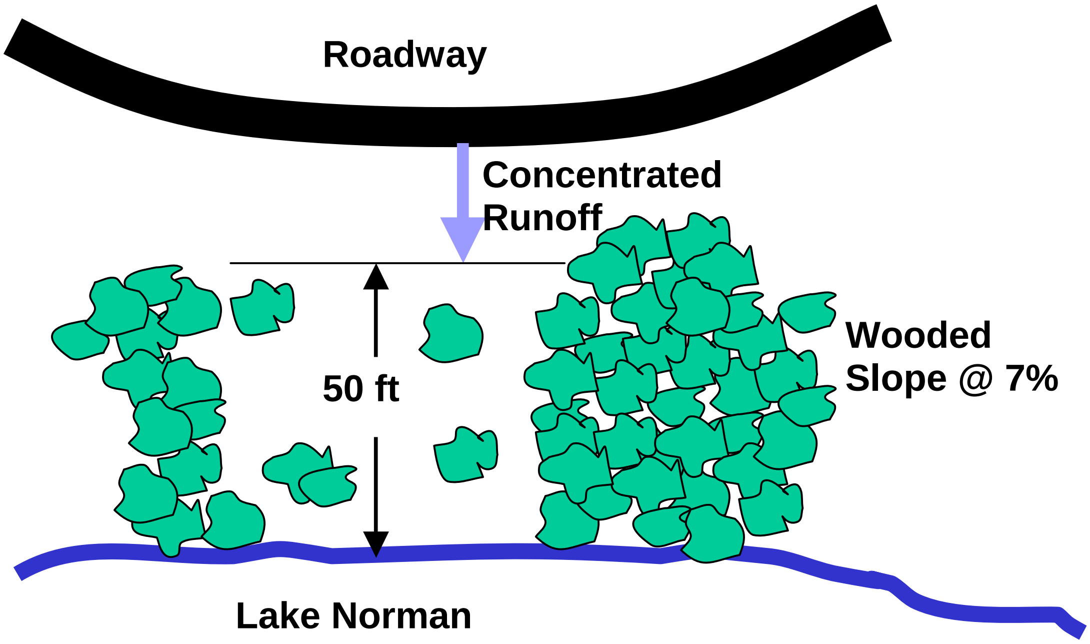
Example Calculation

A complete level spreader design is reviewed below:

Problem Statement:

A road in a residential development on the western shores of Lake Norman will encroach within 75 feet of the lake. A 50’ foot wooded buffer has just been required along the Catawba River in Lincoln County. No concentrated flow is allowed through the buffer. The drainage area (all road runoff) collecting at a point 75’ from the lake is 1.2 acres. The average slope from the roadway to the Lake Norman waterline is 7%. This slope is continuous. The existing condition is shown in Figure 8.

Figure 8. Development Before Level Spreader Installment



A designer wishes to know the required length and number of level spreaders to keep flow in the final 50 feet of the buffer dispersed.

I. Find Design Storm

A 1.0 inch first flush storm is decided upon. A rainfall intensity of 1.0 in/hr is used. Using the Rational Method, the following inputs are needed to calculate peak flow to be dispersed over the level spreader.

1. Drainage Area (known to be 1.2 acres)
2. Runoff Coefficient (0.90 standard for roadway)
3. Rainfall Intensity (1 in/hour)

These parameters are inputs for calculating peak flow using the equation,

$Qp = C \bullet I \bullet A$,

Where Qp = Peak Flow (cfs), C = Runoff Coefficient, I = Rainfall Intensity (inches/hour) , and A = Area (acres).

$Qp = 0.90 \bullet 1 \bullet 1.20$

$\boxed{Qp \approx 1 \text{ cfs}}$

II. Determine Length of Level Spreader

A. Quick Design:

Both flow and downstream cover are known (1 cfs, mulch). From Table 4, the length of level spreader is found to be 100 feet.

B. Long Design:

1. From Table 3, the maximum velocity allowed over the level spreader when the down slope condition is tree/shrub is 0.5 fps.

Inserting this velocity into the following equation calculates the associated height of water up slope of the level spreader:

$V = C_w \bullet H^{½}$

Where, $V = 1$ fps and C_w is 3. H is found as:

$H = (V \div C_w)^2 = (0.5 \div 3)^2 = 0.03$

As shown in Figure 7, the height of water as it flows over the level spreader is 2/3 H. Leaving the following as the height of water directly over the level spreader (H*) during the peak storm event:

$H^* = 2/3\ H = 0.02$

2. Insert H*, Flow, Allowable Velocity into Continuity Equation (or weir equation)

$Q = V \bullet L \bullet H^*$

$L = Q \div (V \bullet H^*)$

$L = 1 \text{ cfs} \div (0.5 \text{ fps} \bullet 0.02 \text{ ft})$

$$\boxed{L = 100 \text{ feet}}$$

III. Determine Number of Level Spreaders

Down slope conditions include mulch covering and an average slope of 7%. A level spreader’s effective distance through the buffer can be determined from Table 5 and is shown to be 25 feet. The riparian buffer width is 50 feet. Using the following equation the number of level spreaders in series is determined:

$N_s = W \div E_d$

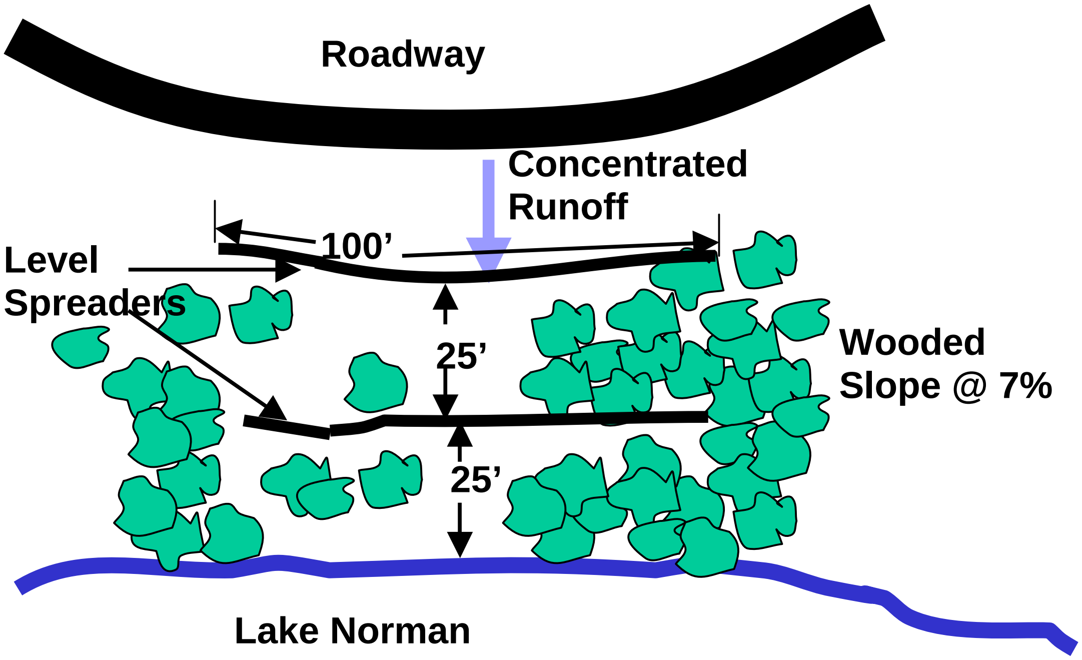
Inserting W= 50 ft and E_d= 25 ft, the Number of Level Spreaders in series needed to keep flow dispersed is shown as,

$N_s = 50' \div 25'$

$$\boxed{N_s = 2}$$

The design is now complete: 2 level spreaders constructed in series that are each 100’ feet long will adequately disperse flow through a 50 feet wide wooded buffer. The buffer is on land with a slope of 7%. The final design is shown in Figure 9.

Figure 9. Level Spreaders in Series to disperse overland flow into Lake Norman.



Other Design Factors

Level spreader design described previously was a hydraulic design. There are other ways of determining level spreader spacing and length. The most closely related to the design presented here is to determine critical shear stress and make sure this stress is not exceeded.

Level spreaders can be designed so that infiltration rates down slope are met. That is, flow can be spread out so that water that flows over a level spreader during a first flush event (such as 1.0” rainfall) is able to infiltrate into the soil down slope.

A third design factor that could be included is riparian buffer effectiveness. Level spreaders should be designed so that they utilize the minimum width of riparian buffer found to have a desired pollutant material. For example, studies may indicate that a grassed buffer on 0-8% slopes is able to remove 90% of TSS within the first 25 feet. If 90% TSS removal is required at a given site, then a level spreader must be sized and spaced so that at least 25’ of buffer down slope is used.

Maintenance & Costs

Level spreaders, like any other Best Management Practice (BMP) do require regular maintenance. This is particularly true of the less structurally sound level spreaders such as PVC-Silt Fence design. Maintenance concerns include cleaning debris that may accumulate immediately up slope of the level spreader. This prevents long-term clogging. Debris accumulation could be significant if the level spreader is constructed down slope of a construction site. As mentioned in the construction tips section, debris can also gather immediately down slope of the level spreader causing localized damming, forcing the level spreader to have concentrated flow.

With the exception of the concrete construction, level spreaders must be occasionally checked to make sure they are still level. Animals, falling limbs, and differential settling can cause the level spreaders to have low areas on the down slope end, rendering level spreaders no longer level. Livestock should be fenced out. Often simple visual inspection is adequate. The frequency of inspection is dependant upon site conditions, including local traffic (by people and other animals) and weather.

Perhaps the best time to inspect is immediately after a large precipitation event. Is there evidence that flow has congregated sooner than expected?

Level spreaders are a preferred BMP because they are simple to construct and relatively inexpensive. A two-person crew can construct a 50 feet long wooden or PVC-silt fence level spreader in a few hours. Per foot material and equipment cost will range from $3-$10 depending upon the type of level spreader, with the exception of concrete trough level spreaders, which are substantially more expensive. A sample cost estimation is shown in Table 6. Note that by comparison, if a sand filter were needed to treat a comparable amount of runoff, construction costs would range from 10-15 times higher than level spreader costs shown below.

Table 6. Calculating a Level Spreader Construction Cost for a 100 feet long channel with wooden 2X6" lower "lip"

Activity	**Unit Cost (if labor – per hour @ $30/hour for 2 person crew)**	**Total Cost**
Site Selection & Clearing Location/ Path	1 hour - $30	$30
Trench Excavation	2 hours - $60	$60
Equipment Rental	$65/hour	$130
2X6 Purchase	$2/ linear foot	$200
Geo-Fabric Purchase	$1/ linear foot	$100
Geo-Fabric, Wood Installation	3 hours - $90	$90
TOTAL		**$600**

References

Lindeberg, M. R. 1999. *Civil Engineering Reference Manual*. Belmont, CA: Professional Publications, Inc. p 22-10.

Malcom, H. R. 1997. *Elements of Stormwater Design*, Raleigh, NC; North Carolina State University - Industrial Extension Service, 85 pp.

N.C. DENR. 1988. *Erosion and Sediment Control Planning and Design Manual*. Raleigh, NC: North Carolina Department of Environment and Natural Resources.

N.C. DENR. 1997. *Stormwater Best Management Practices Manual*. Raleigh, NC: North Carolina Department of Environment and Environmental Resources – Division of Water Quality. 85 pp.