PART 1B – Nationwide Review of Best Management Practices for Stormwater Management (Construction Phase)

Florida Board of Professional Engineers

Approved Course No. 0010329

4 PDH Hours

A test is provided to assess your comprehension of the course material – 24 questions have been chosen from each of the above sections. You will need to answer at least 17 out of 24 questions correctly (>70%) in order to pass the overall course. You can review the course material and re-take the test if needed.

You are required to review each section of the course in its entirety. Because this course information is part of your Professional Licensure requirements it is important that your knowledge of the course contents and your ability to pass the test is based on your individual efforts.

Course Description:

Uncontrolled stormwater runoff from construction sites can significantly impact rivers, lakes, and estuaries. Sediment in waterbodies from construction sites can reduce the amount of sunlight reaching aquatic plants, clog fish gills, smother aquatic habitat and spawning areas, and impede navigation.

This course is part of a 4 course, 2-PART Series of a compilation of nationwide Best Management Practices (BMPs) published by the U.S. Environmental Protection Agency (EPA). The course includes BMP fact sheets describing practices that engineers involved with stormwater management may want to consider and the fact sheets generally provide applicability, implementation, and effectiveness information. Overall this series offers a total of 16 PDH credit hours (Parts 1A, 1B, and 2A, 2B)

Part 1 is further separated into 2 courses (Part 1A and 1B) and covers **Stormwater BMPs related to the Construction Phase** of projects and will cover areas of interest including:

- Construction Site Planning and Management
- Erosion Control
- Runoff Control
- Sediment Control
- Good Housekeeping/Materials Management

Part 2 is further separated into 2 courses (Part 2A and 2B)Part 2 is covers **Stormwater BMPs related to the Post-Construction Phase** of projects and will cover areas of interest including:

- Innovative BMPs for Site Plans
- Infiltration
- Filtration
- Retention/Detention

How to reach Us …

If you have any questions regarding this course or any of the content contained herein you are encouraged to contact us at Easy-PDH.com. Our normal business hours are Monday through Friday, 10:00 AM to 4:00 PM; any inquiries will be answered within 2 days or less. Contact us by:

EMAIL: bajohnstonpe@aol.com
Phone: 813-398-9380

Refer to Course No. 0010329

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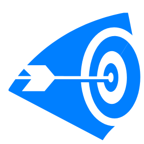
How the Course Works…

What do you want To do?	LOOK For This!
 Search for Test Questions and the relevant review section	 Q1 Search the PDF for: Q1 for Question 1, Q2 for Question 2, Q3 for Question 3, Etc… (Look for the icon on the left to keep you ON Target!)

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24 QUESTIONS

Q1:	**The drainage area for brush barriers should be no greater than one-quarter acre per:**

(A)	50 feet of barrier length
(B)	100 feet of barrier length
(C)	200 feet of barrier length
(D)	250 feet of barrier length

Q2:	**A compost filter berm consists of compost or a compost product and the factors that determine the quality of compost include:**

(A)	Maturity
(B)	Stability
(C)	Absence of pathogens
(D)	All of the Above

Q3:	**In the cost comparison of compost filter berms vs. silt fences, compost filter berms have a distinct advantage:**

(A)	Compost filter berms are spreadable on-site to help achieve final stabilization
(B)	Compost filter berms are recyclable
(C)	Compost filter berms can be relocated and re-used
(D)	NA, there is not distinct advantage of compost filter berms over silt fences

Q4:	**A compost filter sock is typically a mesh tube filled with composted material. Quality guidelines say that the compost used in these filter socks can have a maximum moisture content of:**

(A)	30 percent
(B)	40 percent
(C)	50 percent
(D)	60 percent

Q5:	**According to an Ohio State University study, compost filter socks have WHAT percentage higher flow-through rate than silt fences:**

(A)	30 percent
(B)	40 percent
(C)	50 percent
(D)	60 percent

Q6:	On a construction site, which type of construction track-out control removes mud or soil from vehicle tires through bouncing or shaking action:

(A)	Vibrating gravel pad
(B)	Exit grids
(C)	Rumble strips
(D)	B and C

Q7:	Wheel washing racks, when properly installed, can remove WHAT percentage of sediment from vehicle tires:

(A)	35
(B)	50
(C)	75
(D)	90

Q8:	The Montana Department of Transportation recommends for a 3 to 1 sloped area, the average spacing intervals for 8-inch-diameter fiber rolls is to be:

(A)	10 feet
(B)	20 feet
(C)	30 feet
(D)	40 feet

Q9:	A gravel or stone filter berm is a temporary ridge made up of loose gravel or stone and one design consideration is that the material should contain less than WHAT percentage of fines:

(A)	5 percent
(B)	7 percent
(C)	9 percent
(D)	12 percent

Q10:	Sediment basins in large drainage areas can capture sediment from stormwater before it leaves a construction site. If an earthen enbankment is utilized, the area being drained should be no larger than:

(A)	100 acres
(B)	75 acres
(C)	50 acres
(D)	25 acres

Q11:	Sediment basins are very effective with sediment removal rates up to WHAT:

(A)	50 percent
(B)	60 percent
(C)	70 percent
(D)	80 percent

Q12:	Construction sites typically use sediment filters to remove pollutants (mainly particulates) from stormwater discharges and can effectively remove WHAT low end percentage of total suspended solids, heavy metals and organics:

(A)	20 percent
(B)	30 percent
(C)	40 percent
(D)	50 percent

Q13:	Many municipalities require sediment traps to have a minimum volume of:

(A)	1800 cubic feet per acre of drainage area
(B)	1800 cubic yards per acre of drainage area
(C)	1800 cubic feet per 10000 square feet of drainage area
(D)	1800 cubic yards per 10000 square feet of drainage area

Q14:	In order to make silt fences effectively work, the principal design aspects are:

(A)	Proper placement
(B)	Adequate amounts
(C)	Appropriate materials
(D)	All of the Above

Q15:	A reasonable rule-of -thumb for the proper amount of silt fence required is:

(A)	100 feet per 1000 square feet of disturbed area
(B)	100 feet per 5000 square feet of disturbed area
(C)	100 feet per 10,000 square feet of disturbed area
(D)	100 feet per 15,000 square feet of disturbed area

Q16:	It is critical that silt fence fabric is properly attached to the posts to combine the strength of the fabric and support posts. The silt fence should be able to support how many inches of sediment and water:

(A)	20 inches
(B)	24 inches
(C)	30 inches
(D)	36 inches

Q17:	Proper Storm drain inlet protection controls prevent soil and debris from entering storm drain inlets. Drainage areas to a single control should be no greater than:

(A)	0.25 acres per inlet
(B)	0.50 acres per inlet
(C)	0.75 acres per inlet
(D)	1.00 acres per inlet

Q18:	The cost of implementing storm drain inlet protection controls varies but it is estimated that maintenance costs are WHAT percentage of the construction costs:

(A)	40 percent
(B)	50 percent
(C)	60 percent
(D)	70 percent

Q19:	In what application is the use of straw or hay bales an alternate to silt fence:

(A)	Perimeter controls
(B)	Check dams
(C)	Slope protection
(D)	Storm drain inlet protection

Q20:	Staked hay bales can cost up to an upper range of WHAT per linear foot:

(A)	7 dollars
(B)	10 dollars
(C)	12 dollars
(D)	15 dollars

Q21:	Turbidity is a measure of WHAT in water (affecting clarity):

(A)	Clays
(B)	Silts
(C)	Inorganic and Organic materials
(D)	All of the Above

Q22:	Vegetated buffers are applicable in most areas able to support vegetation and are most effective where:

(A)	On floodplains
(B)	Near wetlands
(C)	Along stream banks
(D)	All of the Above

Q23:	The spill prevention, control and countermeasure (SPCC) rule (40 CFR 112) covers every site with a total aboveground oil storage capacity greater than:

(A)	460 gallons
(B)	720 gallons
(C)	1320 gallons
(D)	1480 gallons

Q24:	Which discharges are allowed from construction sites only with respect to vehicle and equipment operation and maintenance:

(A)	Soaps and detergents
(B)	Fuels, oils or other pollutants
(C)	Solvents
(D)	None of the Above

End of Test Questions

Stormwater Best Management Practice

Brush Barrier

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Brush barriers are coarse sediment and flow velocity control structures constructed of material such as small tree branches, root mats, stone or other debris left over from site clearing and grubbing. A filter cloth cover on a brush barrier can stabilize the structure and improve its efficiency.

Applicability

Brush barriers filter sediment in small drainage areas with a primary flow regime that is sheet flow. They also provide temporary on-site storage for sites that have large amounts of vegetation from clearing and grubbing activities.

Q1

Siting and Design Considerations

The drainage area for brush barriers should be no greater than one-quarter acre per 100 feet of barrier length (DOWL, 2015). In addition, the drainage slope leading down to a brush barrier should be no greater than 2:1. The barrier mound should be at least 2 feet high and 2 feet wide at its base and only installed parallel to slope contours. The material used to create the barrier may consist of site vegetation, composted mulch or wood-based mulch with a diameter smaller than 6 inches (WDE, 2014). Construction staff should not use material larger than 6 inches, as it may be too bulky and create voids where sediment and stormwater could flow through the barrier. They should bury the edge of the filter fabric that covers the barrier in a trench 4 inches deep and 4 inches wide on the uphill side of the barrier. This secures the fabric and blocks sediment while allowing stormwater to pass through the permeable filter fabric. Construction staff should extend the filter fabric just over the peak of the brush mound and fasten it on the downslope edge of the fabric using stakes, sandbags or another equally effective method (WDE, 2014).

A brush barrier at the perimeter of a construction site.
Credit: Hamilton County Soil & Water Conservation District

Limitations

Brush barriers are not appropriate for high-velocity areas, concentrated-flow areas or areas with significant slopes (WDE, 2014). Additionally, brush barriers have limited durability because their constituent materials decompose. A useful brush barrier involves a large amount of material; therefore, alternative sediment controls may be more appropriate for sites with little material available from clearing. Brush barriers provide temporary storage for large amounts of material cleared from a site, but construction staff should remove this material from the site after construction activities have ceased and the area is stable.

Maintenance Considerations

Construction staff should inspect brush barriers after each significant rainfall event to ensure their continued effectiveness. If channels form through voids or around the barrier, construction staff should rebuild the barrier to eliminate the channels. They should also remove accumulated sediment from the uphill side of the barrier when sediment height reaches between one-third and one-half the height of the barrier.

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Effectiveness

Brush barriers effectively reduce off-site sediment transport, and the use of a fabric cover greatly increases their effectiveness. Construction staff should cover brush barriers with a filter fabric to hold the material in place and increase efficiency.

Cost Considerations

The cost of creating brush barriers can vary greatly depending on the equipment used, vegetation type (heavy or light), personnel, amount of filter fabric needed (if used) and number of hours needed to construct the barrier. If the right site conditions exist, they can be a low-cost erosion and sediment control practice.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

DOWL. (2015). *Erosion and sediment control best management practices manual*. Montana Department of Transportation.

Washington State Department of Ecology (WDE). (2014). *2012 stormwater management manual for western Washington as amended in December 2014* (Vol. II) (Publication Number 14-10-055).

Stormwater Best Management Practice

Compost Filter Berms

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

A compost filter berm consists of compost or a compost product placed perpendicular to sheet flow to control erosion in disturbed areas and retain sediment. It can replace a traditional erosion and sediment control practice such as a silt fence. It provides a three-dimensional filter that retains sediment and other pollutants (e.g., suspended solids, metals, oil and grease) while allowing the cleaned water to flow through the berm. Composts in filter berms come from a variety of feedstocks, including yard trimmings, food residuals, separated municipal solid waste, biosolids and manure.

The berms can be vegetated or unvegetated. Vegetated filter berms normally remain in place and provide long-term stormwater filtration as a post-construction stormwater control. Construction staff often break down unvegetated berms once construction is complete and spread the compost around the site as a soil amendment or mulch.

Applicability

Construction staff generally use compost filter berms along the perimeter of a construction site with relatively small drainage areas, or at intervals along a slope, to capture and treat stormwater sheet flow. Construction staff can use compost filter berms on steeper slopes with faster flows if they place the berms closer together or use them in combination with other erosion and sediment control practices, such as compost blankets or compost filter socks, to slow stormwater flow velocities. Compost filter berms can also be particularly useful in areas where ground penetration is not desirable.

Q2

Compost Quality Considerations

Compost is the product of controlled biological decomposition of organic material that has undergone sanitization through heat generation and stabilization to the point that it benefits plant growth. The metabolic processes of microorganisms decompose organic material. These microbes require oxygen, moisture and

Compost filter berms placed perpendicular to the slope along the side of a highway.
Credit: Anthony D'Angelo for USEPA, 2012

food to grow and multiply. Maintaining these three factors at optimal levels greatly accelerates the natural process of decomposition. Many organic materials, such as leaves, food scraps, manure and biosolids, can produce compost.

Compost quality is an important consideration when designing a compost filter berm. Use of sanitized, mature, biologically stable compost ensures that the compost filter berm performs according to design, has no identifiable feedstock constituents or offensive odors, and minimizes soluble nutrient loss.

Factors that determine the quality of compost are:

- **Maturity:** Maturity indicates how well the compost will support plant growth. One maturity test compares the percentage of seeds that germinate in compost compared to a potting soil mix. The difference in germination rates marks the maturity of the compost.
- **Stability:** Stability indicates microbial activity in the compost and can directly correlate to carbon dioxide production from the compost due to microbe respiration during the decay process. A stable

compost has no offensive odors, does not resemble the original material and has low rates of carbon dioxide off-gassing.

- **Absence of pathogens:** The pathogen count indicates how sanitary the compost is. In 40 CFR Part 503, EPA has defined processes for composting that reduce the number of pathogenic organisms to nondetectable levels and ensure the resulting compost is sufficiently heat-treated and sanitary.

The compost in filter berms should meet all local, state and federal quality requirements and meet the guidelines outlined in Table 1. All compost should comply with 40 CFR Part 503, which establishes safe standards for pathogen reduction and presence of heavy metals.

Table 1. Quality guidelines for compost in filter berms.

Parameters	Units of Measure	Acceptable Range
pH	N/A	5.0–8.5
Soluble salt concentration (electrical conductivity)	dS/m (millimhos/cm)	Maximum 5 dS/m
Moisture content	Percent, wet weight basis	30–60%
Organic matter content	Percent, dry weight basis	25–100%
Particle size	Percentage passing a selected mesh size, dry weight basis	2 inches, 100% passing; 3/8 inches, 50% passing
Biological stability/maturity (carbon dioxide evolution rate)	mg CO_2-C per gram of organic matter per day	Less than 8 mg
Physical contaminants (human-made inert products; e.g., glass, metal, plastic)	Percent, dry weight basis	Less than 1%

Source: AASHTO 2017, USDA 2011

The U.S. Composting Council (USCC) certifies compost products under its Seal of Testing Assurance Program. Compost producers with Seal of Testing Assurance-certified products provide a standard product label that customers can use to compare compost products. The USCC website (updated daily) contains current Seal of Testing Assurance Program participants.

Construction staff should choose a biologically stable, mature compost that meets the particle size distribution specifications in Table 1 above. This ensures that the nutrients in the composted material are in organic form, less soluble and less likely to migrate into receiving waters.

The American Association of State Highway Transportation Officials (AASHTO) and many individual state departments of transportation have issued specifications for filter berms (AASHTO, 2017; USCC, 2001). These specifications describe the quality and particle size distribution of compost for filter berms, as well as the size and shape of the berm for different scenarios. Although these specifications still serve as common references, research on these parameters continues to evolve. Therefore, before designing the filter berm, design engineers should contact the environmental agency of the state where they will install the filter berm to obtain any applicable specifications or compost-testing recommendations.

Siting and Design Considerations

Filter berm design dimensions should reflect site-specific conditions. The height and width of the berm will vary depending on the precipitation, rainfall erosivity index and slope length of the site (MDE, NRCS, & MASCD, 2011). AASHTO has published compost filter berm dimensions for various rainfall scenarios in R 51-13. The Oregon Department of Transportation (ODOT) has also published example filter berm dimensions based on the site grade and slope length. The ODOT specification states that, where possible, compost berms should be at least 5 feet away from the toes of slopes to allow for energy dissipation and reduce the chance of undermining or washout (ODOT, 2017).

Compost filter berms placed perpendicular to slopes control stormwater velocity and provide filtration.

Credit: Anthony D'Angelo for USEPA, 2012

Sites in high-rainfall areas or with severe grades or long slopes should use larger berms or a series of berms. Design engineers should base sizing and spacing on local rainfall conditions and follow design criteria. Combining filter berms with compost blankets can increase the effectiveness of both practices and promote vegetation growth. Design engineers should not place compost in areas where it can easily transport into waterways (UDFCD, 2010).

Case Study

In a study performed by the Snohomish County, Washington, Department of Planning and Development Services (Caine, 2001), compost filter berms reduced turbidity by 67 percent compared to no reduction from silt fences.

Studies examining the use of erosion and sediment control practices utilizing compost in bioretention systems, compost blankets and as soil amendments have shown both reductions in organic nutrients and releases of nutrients (N and P) in leachate and infiltrate. The potential for nutrient discharges from erosion and sediment control practices that utilize compost should be considered to determine whether compost use is appropriate especially in cases where there are receiving waterbodies that are sensitive to or are currently impaired by nutrients. Site conditions, compost type and composition, compost berm placement and management of the compost system also will affect potential nutrient loadings or reductions and pollutant loadings to receiving waters. The use of this practice should be considered when weighing the overall efficacy of the system in terms initial nutrient loadings, mid-life nutrient trapping capacity and the potential for end-of-life nutrient discharges where nutrients are of concern.

Installation

The installation of compost berms can be by hand; by using a backhoe, bulldozer or grading blade; or by using specialized equipment such as a pneumatic blower or side discharge spreader with a berm attachment. Construction staff can install compost filter berms on frozen or rocky ground. They may vegetate compost filter berms by hand, by incorporating seed into the compost before installation or by hydraulic seeding after berm construction.

Limitations

Construction staff can install compost filter berms on any type of soil surface; however, construction staff should ensure that the berm contacts the ground surface. To accomplish this, it may be necessary to remove some heavy vegetation. Filter berms are not suitable for areas where large amounts of concentrated flow is likely, such as streams, ditches or waterways, unless the drainage area is small and the peak flow rate is low. The initial cost can be higher than the cost for other sediment control practices, and maintenance can be difficult (WES, 2008).

Maintenance Considerations

Construction staff should inspect compost filter berms regularly, as well as after each rainfall event, to ensure that they are intact and that silt has not filled the area behind the berm. Construction staff should remove accumulated sediments behind the berm when they reach approximately one-third the height of the berm, and replace any areas that have eroded. If the berm has experienced significant washout, a filter berm alone may not be appropriate for the area. Depending on the site-specific conditions, construction staff could remedy the problem by increasing the size of the filter berm or adding another erosion control practice in the area, such as an additional compost filter berm, a compost filter sock or a compost blanket. Construction staff should inspect the berm for parallel channel formation, which indicates that the berm acts as a flow barrier and needs repositioning (WES, 2008).

Effectiveness

In general, filter berms provide an effective physical barrier in sheet flow conditions; in addition, the use of compost in the filter berm provides the following additional benefits:

- The compost retains a large volume of water, which helps prevent or reduce rill erosion as well as establish vegetation on the berm. The mix of particle sizes in the compost filter material retains at least as much sediment (especially clays and silts) as traditional perimeter controls, such as silt fences or hay bale barriers, while allowing a larger volume of clear water to pass through the berm (Caine, 2001).
- In addition to retaining sediment, compost can retain pollutants—such as heavy metals, nitrogen, phosphorus, oil and grease, fuel, herbicides, pesticides, and other potentially hazardous substances—due to the better chemical adsorption and physical filtration capacity of the compost media (Faucette & Tyler, 2006; Faucette et al., 2008; Faucette et al., 2009).
- Microorganisms in the compost matrix can naturally decompose nutrients and hydrocarbons that the compost filter adsorbs or traps (Faucette et al., 2008).

Q3

Cost Considerations

The cost to install a compost filter berm depends on the availability of the required quality of compost in an area. Based on current markets, bulk compost costs anywhere from $15 to $35 per cubic yard. For a typical compost filter berm with a bottom width of 3 feet and height of 1.5 feet (AASHTO, 2017), the cost would be $1.25 to $2.90 per linear foot plus labor costs for installation (RSMeans, 2019). By comparison, silt fences (a common stormwater control substitution) cost around $2 to $3 per linear foot to install (RSMeans, 2019). The Oregon Department of Environmental Quality also reports that compost filter berms cost approximately 30 percent less to install than silt fences (Juries, 2004). These costs do not include the cost to remove and dispose of the silt fence or the cost to disperse the compost berm once construction activities are complete. Compost berms have the distinct advantage of being spreadable on-site to help achieve final stabilization.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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Disclaimer

This fact sheet is intended to be used for informational purposes only. These examples and references are not intended to be comprehensive and do not preclude the use of other technically sound practices. State or local requirements may apply.

Stormwater Best Management Practice

Compost Filter Socks

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Erosion Control

Description

A compost filter sock is a type of contained compost filter berm. The filter sock is typically a mesh tube filled with composted material that is placed perpendicular to the direction of sheet flow to control erosion and retain sediment in disturbed areas. A compost filter sock has an oval or round cross-section and provides a three-dimensional filter to retain sediment and other pollutants (e.g., suspended solids, nutrients, metals and motor oil) and allow clean water to flow through (Faucette et al., 2009). The filter sock can replace a traditional erosion and sediment control practice, such as a silt fence or straw bale barrier, and is often more effective. The composts in filter socks come from a variety of feedstocks, including yard trimmings, food residuals, separated municipal solid waste, biosolids and manure.

Construction staff generally place compost filter socks along the perimeter of a site or at intervals along a slope to capture and treat sheet flow. They can also serve as storm drain inlet protection on pavement. They are flexible, and construction staff can fill them in place or fill and move them into position, making compost filter socks especially useful on steep or rocky slopes where installation of other erosion and sediment control practices is not feasible. Compost filter socks have more surface area contact with the underlying soil than typical sediment control devices, so stormwater is less likely to create rills under them and/or create channels carrying unfiltered sediment. The greater contact area and weight of compost filter socks also allows water to pond upgradient and suspended sediments to settle out.

Compost filter socks can be vegetated or unvegetated. Vegetated filter socks can remain in place to provide long-term stormwater filtration as a post-construction stormwater control measure. The vegetation grows into the slope, further anchoring the filter sock. Construction staff often cut open unvegetated filter socks upon project completion, and they spread the compost around the site as soil amendment or mulch. They then dispose of the mesh sock unless it is biodegradable.

Compost filter socks installed in a vegetated channel leading to a sediment basin.
Credit: Anthony D'Angelo for USEPA, 2015

Applicability

Compost filter socks apply to construction sites or other disturbed areas where stormwater discharge occurs as sheet flow. Compost filter socks can apply to steeper slopes with faster flows if they have closer spacing, lie beside and/or on top of each other, have larger diameters, or work in combination with other stormwater controls such as compost blankets.

It is also important to account for regional considerations such as ambient temperature and moisture conditions. Freezing temperatures and prolonged dry periods can impact the compost's effectiveness and life span (USACE, 2008).

Compost Quality Considerations

Compost quality is an important consideration when designing a compost filter sock. Use of sanitized, mature, biologically stable compost ensures that the compost filter sock performs according to design, has no identifiable feedstock constituents or offensive odors, and minimizes soluble nutrient loss.

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Maturity: Maturity indicates how well the compost will support plant growth. One maturity test compares the percentage of seeds that germinate in compost compared to a potting soil mix. The difference in germination rates marks the maturity of the compost.

Stability: Stability indicates microbial activity in the compost and can directly correlate to carbon dioxide production from the compost due to microbe respiration during the decay process. A stable compost has no offensive odors, does not resemble the original material and has low rates of carbon dioxide off-gassing.

Absence of pathogens: The pathogen count indicates how sanitary the compost is. In 40 CFR, Part 503, EPA has defined processes for composting that reduce the number of pathogenic organisms to nondetectable levels and ensure the resulting compost is sufficiently heat-treated and sanitary.

The compost in filter socks should meet all local, state and federal quality requirements and meet the guidelines outlined in Table 1. All compost should comply with 40 CFR, Part 503, which establishes safe standards for pathogen reduction and presence of heavy metals.

Table 1. Quality guidelines for compost used in filter socks.

Parameters	Units of Measure	Acceptable Range
pH	N/A	5.0–8.5
Soluble salt concentration (electrical conductivity)	dS/m (millimhos/cm)	Maximum 5 dS/m
Moisture content	Percent, wet weight basis	30–60%
Organic matter content	Percent, dry weight basis	25–100%
Particle size	Percentage passing a selected mesh size, dry weight basis	2 inches, 100% passing; 3/8 inches, 50% passing
Biological stability/maturity (carbon dioxide evolution rate)	mg CO_2-C per gram of organic matter per day	Less than 8 mg
Physical contaminants (human-made inerts)	Percent, dry weight basis	Less than 1%

Source: AASHTO 2017, USDA 2011

The U.S. Composting Council (USCC) certifies compost products under its Seal of Testing Assurance Program. Compost producers whose products the Seal of Testing Assurance Program has certified provide customers with a standard product label that allows comparison among compost products. The USCC website contains information on the current Seal of Testing Assurance Program requirements and testing methods.

Construction staff should choose a mature, biologically stable compost that meets the particle size specifications in Table 1 above. This ensures that the nutrients in the composted material are in organic form, less soluble and less likely to migrate into receiving waters.

The American Association of State Highway Transportation Officials (AASHTO) and many individual state departments of transportation have issued specifications for filter socks (AASHTO, 2017; USCC, 2001). These specifications describe the quality and particle size distribution of compost for compost filter socks for highway construction projects. Research on these parameters continues to evolve; therefore, design engineers should contact the department of transportation or state environmental agency where they will install the filter sock to obtain any applicable specifications or compost-testing recommendations. Compost filter socks can apply to many types of construction projects and various landscaping projects as well. Construction staff may modify these parameters depending on local site conditions or needs, as appropriate.

Siting and Design Considerations

Filter sock assembly involves tying a knot in one end of the mesh sock, filling the sock with the composted material (usually using a pneumatic blower), then knotting the other end once the sock reaches the desired length. A filter sock is normally the width of the slope to ensure that stormwater does not break through at the intersection of socks placed end to end. Where this is not possible, construction staff place the socks end to end along a slope and interlock the ends.

The diameter of the filter sock varies depending on the purpose of the filter sock, as well as the steepness and length of the slope. Construction staff usually place compost filter socks along a contour perpendicular to sheet flow. In areas of concentrated flow, compost filter socks often serve as check dams. Local rainfall and appropriate storm scenarios should determine the sizing and spacing of filter socks. Specifications manuals can provide detailed information regarding diameter, length, specific location and spacing recommendations for filter socks (e.g., USDA 2011 and ASSHTO 2017).

Studies examining the use of erosion and sediment control practices utilizing compost in bioretention systems, compost blankets and as soil amendments have shown both reductions in organic nutrients and releases of nutrients (N and P) in leachate and infiltrate. The potential for nutrient discharges from erosion and sediment control practices that utilize compost should be considered to determine whether compost use is appropriate especially in cases where there are receiving waterbodies that are sensitive to or are currently impaired by nutrients. Site conditions, compost type and composition, compost berm placement and management of the compost system also will affect potential nutrient loadings or reductions and pollutant loadings to receiving waters. The use of this practice should be considered weighing the overall efficacy of the system in terms initial nutrient loadings, mid-life nutrient trapping capacity and the potential for end-of-life nutrient discharges where nutrients are of concern.

Installation

The advantage of compost filter socks over similar stormwater controls is that they do not require trenching; therefore, installing them does not disturb the soil. However, construction staff should trim or remove vegetation and debris to ensure full contact with the ground surface. Once staff have filled the filter sock and placed it, they should anchor it to the slope. The preferred anchoring method is to drive stakes at regular intervals through the center of the sock at least 8 inches into the ground (USDA, 2011); alternatively, construction staff can place stakes on the downstream side of the sock. They should direct the ends of the filter sock upslope to prevent stormwater from running around them. Incorporating seed into the compost before placement in the filter sock can vegetate the filter sock. Since it is not necessary to trench compost filter socks into the ground, construction staff can install them on frozen ground or even cement.

Limitations

Construction staff can install compost filter socks on any type of soil surface; however, they should cut down or remove heavy vegetation to ensure that the compost contacts the ground surface. Stormwater and sediment control devices, including filter socks, are not appropriate for use in streams.

Maintenance Considerations

Construction staff should inspect compost filter socks regularly, including after each rainfall event, to ensure proper function. Excessive upstream ponding or overtopping indicates that the current configuration is not adequate. In these cases, construction staff should place an additional filter sock further up the slope or use an additional erosion control, such as a compost blanket, in conjunction with the filter sock. Staff should remove accumulated sediment when it reaches one half the height of the filter sock or as the current EPA Construction General Permit or equivalent state and local permits mandate. If the compost filter sock is a temporary application, at the end of the project, construction staff can spread the compost material in areas that do not receive concentrated flow (USDA, 2011).

Effectiveness

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A number of studies have shown that compost filter socks are at least as effective as traditional erosion controls at removing settleable solids, total suspended solids and a variety of other pollutants from stormwater. An Ohio State University study found that compost filter socks have a 50 percent higher flow-through rate than silt fences without a reduction in sediment removal efficiencies (Keener et al., 2007). A U.S. Department of Agriculture study found that compost filter socks reduced clay and silt particulates (the major contributors to suspended solids and turbidity) by 65 percent, outperforming straw bales and mulch berms. The same study saw a reduction in bacteria of 75 percent, reduction in heavy metals of 37 to 71 percent and reduction in petroleum hydrocarbons of 43 to 84 percent (Faucette et al., 2009). In a similar study, compost filter socks reduced phosphorus concentrations by about 60 percent, compared to removal rates of around 20 percent by silt fences (Faucette et al., 2008).

Cost Considerations

The cost to install a compost filter sock depends on the availability of the required quality of compost in an area. The cost for a biodegradable compost filter sock generally ranges from $5 to $10 per linear foot, with the cost mostly dependent on the cost of the compost (RSMeans, 2019). Although costs for fully biodegradable netting can be more than non-biodegradable netting, the labor cost savings from not having to remove the control measure—as well as the subsequent benefit to soil condition and vegetation establishment—may justify this cost. However, there is still the cost to remove and dispose of sediment that accumulates to at least one-third the distance between the top of the fiber roll and the ground surface.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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Stormwater Best Management Practice

Construction Track-Out Controls

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Q6

Description

Construction track-out controls minimize the amount of sediment leaving or being tracked out from the construction site as dirt, mud or other sediment attached to vehicles. Stabilization measures, vehicle wash stations and sediment collection devices are all common track-out controls.

A construction entrance stabilized with gravel over filter cloth reduces the amount of sediment transported off site.
Photo Credit: PG Environmental for USEPA

Installing a pad of gravel over filter cloth where construction traffic leaves a site can help stabilize sediment at a construction entrance/exit. As a vehicle drives over the pad, the pad removes mud and sediment from the wheels and reduces soil transport off the site. The filter cloth separates the gravel from the soil below. It also reduces rutting by vehicle tires.

In addition to using a gravel pad, construction staff can install a vehicle washing station at the site entrance/exit. Using washing stations routinely can remove a lot of sediment from vehicles before they leave the site. Construction staff should divert wash water from vehicle washing stations into a sediment trap that will handle sediment from vehicles properly and keep it on-site.

Several other types of track-out controls, such as shaker racks (also called exit grids, rumble strips or cattle guards) and other similar proprietary devices, can help knock mud and dirt off vehicle tires. Shaker racks work by removing mud or soil from vehicle tires through bouncing or shaking action as the vehicle drives over the rack.

Applicability

Construction staff should install track-out controls anywhere construction traffic leaves or enters a construction site. Track-out controls can also provide benefits from a public relations point of view, as the site entrance/exit is often the most noticeable part of a construction site and can show community members that controls are in place to minimize sediment being tracked onto nearby streets and neighboring areas. Minimizing sediment on roads can improve both the appearance and the public perception of the construction project as well as limit the occurrence of complaints about the site. Additionally, a stabilized construction entrance/exit is generally a requirement of any construction permit, though design engineers should contact local authorities for specific requirements and design specifications.

Siting and Design Considerations

Before considering track-out controls, design engineers should consider the locations of construction site entrances/exits. Where possible, they should place site entrances/exits in well-drained areas, away from streams or wetlands, and in a place where construction staff can easily conduct regular maintenance. If including wash areas, design engineers should account for adjacent, downstream areas on-site that can collect and treat wash water (e.g., using a sediment basin or similar temporary treatment practice).

Design engineers should follow local design and installation details for all construction entrances/exits. Some common design practices include the following (Caltrans, 2017; MPCA, 2019):

- Stabilize all entrances/exits to a site before land disturbance begins.
- Make sure the stabilized site entrances/exits are long and wide enough to allow the largest construction vehicle to fit with room to spare. If many vehicles will use an entrance/exit in any one day, make the site entrance/exit wide enough for two vehicles to pass at the same time with room on either side.
- If a site entrance/exit leads to a paved road, make the end of the entrance/exit flared so that long vehicles do not leave the stabilized area when they turn onto or off the road.
- Grade the exit pad so that sediment-laden stormwater does not flow onto streets or into storm drains.
- Install non-woven geotextile on graded soil to support the exit pad and spread rock evenly over the geotextile.
- Make sure the stone and gravel used to stabilize the construction site entrance/exit is large enough that vehicles do not carry it off-site.
- Avoid using sharp-edged stones, which can puncture tires.
- Install stone or gravel at a depth of at least 6 inches for the entire length and width of the stabilized construction entrance/exit. If the design uses shaker racks, make sure they are wide enough to fit the widest vehicles and long enough to allow enough shaking time. Make sure there is enough storage beneath the rack—at least 4 inches is typical.
- If a construction site entrance/exit crosses a stream, swale or other depression, provide a bridge or culvert to prevent erosion from unprotected banks.

Operational practices can also help limit sediment track-out. To limit overloading track-out controls, construction staff should avoid vehicle traffic on exposed, muddy areas of the site where possible. They should also limit traffic onto and off the site by parking vehicles on the street if possible.

Limitations

Although stabilizing a construction entrance/exit reduces the amount of sediment leaving a site, vehicle tires might still deposit some soil onto paved surfaces. To further reduce the chance of these sediments polluting stormwater, construction staff should sweep the paved area adjacent to the stabilized site entrance/exit as needed. Times of wet weather will likely call for increased sweeping and maintenance. For sites that use wash stations, a reliable water source might not be initially available and trucks might have to bring water to the site at an additional cost. Using a recapture and treatment system can help reduce the cost of water imports.

Maintenance Considerations

Construction staff maintain track-out controls in compliance with applicable permits and local regulations, generally until they have fully stabilized the rest of the construction site. Below are some steps they can follow:

- Add stone and gravel periodically to each stabilized construction site entrance/exit.
- Remove mud and dirt clods to keep the stabilized pad relatively clean.
- Immediately sweep up or vacuum soil and dirt clods tracked off-site for proper disposal.
- Make sure not to hose or sweep tracked-out sediment into any stormwater conveyance or storm drain inlet, or directly into any creek, stream or other waterway.
- Periodically remove sediment from wash rack sediment traps to make sure they keep working.

Effectiveness

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The effectiveness of track-out controls is highly variable and depends on their design, use and maintenance. Sediment removal rates can range from less than 30 percent up to 60 percent for gravel pads and shaker racks. Wheel washing racks, when properly installed, can remove 75 percent or more of sediment (MPCA, 2019).

In some cases, such as areas with high clay content or persistent rain, stabilizing the site entrances/exits might not be very effective without routine use of a wash rack. Track-out controls are only effective when site rules require vehicles to use them and physical constrictions force traffic through the controls. This can be problematic for sites with multiple entrances/exits and high vehicle traffic.

Cost Considerations[1]

Track-out control costs will vary greatly depending on the controls' type and design specifications, as well as site conditions (MPCA, 2019). According to Minnesota Department of Transportation project bids awarded in 2019, the average cost for a stabilized rock construction entrance was $3,100 (MnDOT, 2019, bid item 2573501/00025). This cost includes maintenance of the track-out control throughout the project. The Construction BMP Online Handbook cites an average annual cost for installation and maintenance of $2,900 (range of $1,500–$5,900) for a stabilized rock entrance. With an added wash rack and sediment trap at the entrance, the average cost increases to $4,400 (range of $1,500–$7,300) per entrance (CASQA, 2009).

[1]Prices updated to 2020 dollars. Inflation rates obtained from the Bureau of Labor Statistics CPI Inflation Calculator Web site, https://data.bls.gov/cgi-bin/cpicalc.pl. Reference dates for the calculation are October 2011 and September 2019.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Fiber Rolls

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Fiber rolls (also called fiber logs or straw wattles) are tube-shaped erosion control devices filled with straw, flax, rice, coconut fiber material or composted material. Manufacturers wrap each roll with either UV-degradable polypropylene netting for longevity or 100 percent biodegradable materials like burlap, jute or coir (MDOT, 2015). Fiber rolls reduce the erosive potential of stormwater on long or steep slopes by helping to slow, filter and spread overland flows. This helps minimize rill and gully development, prevent erosion, and reduce sediment loads to receiving waters by filtering stormwater and capturing sediment. Fiber rolls also complement other permanent stormwater control measures used for source control and revegetation such as straw mulch, erosion control blankets, hydraulic mulches or bounded fiber matrices for slope stabilization.

Applicability

Design engineers and construction staff have used fiber rolls to control erosion in a variety of areas—along highways and at construction sites, golf courses, ski areas, vineyards and reclaimed mines. They typically use fiber rolls when stabilizing and revegetating slopes. They can also place fiber rolls along the shorelines of lakes and ponds to provide immediate protection by dissipating the erosive force of small waves and help enable permanent vegetation establishment. Construction staff should not use fiber rolls in channels, particularly channels that are experiencing erosion from concentrated flows, or in reaches with large debris loads.

Fiber rolls can be suitable for the following applications (City of Seattle, 2017):

- Along the toe, top, face and at-grade breaks of exposed and erodible slopes to shorten slope length and spread stormwater as sheet flow.
- At the end of a downward slope where it transitions to a flatter slope.
- Along the perimeter of a project (can be an alternative to silt fence).
- At downslopes of exposed soil areas or slopes needing stabilization until construction staff establishes permanent vegetation in the area.
- Around temporary stockpiles.

Fiber rolls also have several benefits that design engineers should consider when specifying erosion control practices. As an alternative to silt fence, fiber rolls have some distinct advantages, including the following (CWS, 2008):

- Installation is easier, particularly in shallow soils, rocky material or frozen ground or near sidewalks and tree roots.
- They are more adaptable to slope applications and contour installations than other erosion and sediment control practices.
- They blend in with the landscape and are less obtrusive than other erosion and sediment control practices such as silt fence.
- They do not obstruct hydraulic mulch and seed applications.
- They store moisture for vegetation immediately adjacent to them or seed mixes within the rolls.
- Construction staff can remove them or leave them in place after the site establishes vegetation. Straw and biodegradable netting will break down into the soil, adding organic material to the soil.

Siting and Design Considerations

Construction staff can use prefabricated fiber rolls or roll them on-site. In either case, fiber rolls consist of rolled tubes of erosion control blanket or fiber material wrapped in netting. When rolling the tubes on-site, each tube should be at least 8 inches in diameter, and bound at each end and every 4 feet along the length of the roll with jute-type twine (MDOT, 2015).

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Fiber rolls can control erosion when installed perpendicular to the slope and spaced appropriately.

Credit: Anthony D'Angelo for USEPA, 2015

Projects on a Slope

Construction staff should install fiber rolls along the contour of a slope, perpendicular to the direction of flow. They should turn the ends of each roll upslope to prevent stormwater from flowing around the roll (MDOT, 2015). Construction staff should install fiber rolls in trenches at least 2 inches deep. In fact, some localities recommend depths greater than 2 inches: the City of Seattle recommends a trench depth of 5 to 7 inches for steep, soft or loamy soils and 3 to 5 inches for shallow slope, hard or rocky soils (City of Seattle, 2017). Spacing between rows of fiber rolls for slope installations also depends on slope and soil type. According to the Montana Department of Transportation (MDOT), soft, loamy soils require more closely spaced rows than hard, rocky soils. The MDOT recommends the following average spacing intervals for 8-inch-diameter fiber rolls (MDOT, 2015):

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- 1:1 slopes = 10 feet apart
- 2:1 slopes = 20 feet apart
- 3:1 slopes = 30 feet apart
- 4:1 slopes or flatter = 40 feet apart

Construction staff should stake fiber rolls securely into the ground using wood stakes (at least ¾ inch thick) or metal stakes. Metal stakes may be easier to drive into hard or compacted ground. Construction staff should drive stakes through the middle of the fiber roll and deep enough into the ground to anchor the roll in place. The stakes should extend at least 12 inches below the ground surface (MDOT, 2015). The City of Seattle recommends a 24-inch stake for use on soft, loamy soils while an 18-inch stake for use on hard, rocky soils; in either case, 2 to 3 inches of the stake should protrude (City of Seattle, 2017). Construction staff should stake fiber rolls every 4 feet (MDOT, 2015), though municipalities sometimes permit wider spacing if construction staff also place the roll in a deep enough trench.

Projects Without Slopes

Construction staff can also use fiber rolls at projects with minimal slopes. Typically, construction staff install fiber rolls along sidewalks, on the bare lot side, to keep sediment from washing onto sidewalks and streets and into gutters and storm drains. For installations along sidewalks and behind street curbs, it might not be necessary to stake the fiber rolls, but it is still necessary to dig trenches. Fiber rolls placed around a storm drain or inlet should be 1 to 1½ feet back from it.

Limitations

There are several limits to the installation and overall performance of fiber rolls (CWS, 2008):

- Fiber rolls are not effective unless trenched and in contact with soil.
- Fiber rolls can be difficult to move once saturated.
- If construction staff do not properly stake and entrench fiber rolls, high flows can transport them.
- Fiber rolls on steep slopes and sandy soils will require frequent maintenance to make sure they stay in contact with soil and gullies or riling do not develop.
- Fiber rolls have a very limited sediment capture zone, so they may need frequent maintenance.
- Construction staff should not use fiber rolls on slopes subject to creep, slumping or landslide.

Maintenance Considerations

The maintenance requirements of fiber rolls are minimal, but construction staff should regularly inspect installed fiber rolls while the site is active or when stormwater flow is occurring to ensure that the rolls remain firmly anchored in place and equipment traffic does not crush or damage them. During periods of inactivity and dry weather, construction staff may space out inspections by as much as 2 weeks (CWS, 2008). When sediment accumulation reaches one-third of the height of the roll on the upslope side, construction staff should remove the sediment. They should repair or replace split, torn, unraveled or slumping fiber rolls.

Following project completion, construction staff can leave fiber rolls in place as a soil amendment to help promote moisture retention and organic matter accumulation. If construction staff remove fiber rolls, they should collect and dispose of accumulated sediment and fill any holes, trenches or depressions to grade. If necessary, they should re-seed or re-plant exposed soil to aid in permanent stabilization (MDOT, 2015).

Effectiveness

The sediment removal performance of fiber rolls is generally good but is highly variable depending upon factors like media type, stormwater flow rate and sediment composition. The Minnesota Department of Transportation commissioned a laboratory study that found that, under controlled conditions, median sediment removal rates varied between 72 percent for wood fiber rolls and 92 percent for compost rolls (Wilson, 2019). Although field conditions are generally more variable, proper use should ensure similar removal rates.

A restoration project in the Flint Creek watershed demonstrated the effectiveness of fiber rolls as a shoreline protection device to reduce shoreline erosion. The project used fiber roll installation, along with other bioengineering techniques, along the shorelines of creeks to reduce the effects of wave action. Project staff installed native plants in the fiber rolls. As a result, the growth of vegetative cover increased and helped to stabilize the slopes along the banks of the creek. Ultimately, the water quality of Flint Creek improved (U.S. EPA, 2001).

Cost Considerations

Material and installation costs of fiber rolls depend on a number of factors, including fiber media type, netting type and roll size. The cost for a fully biodegradable straw roll in polymeric netting can range from $8 to $10 per linear foot (RSMeans, 2019). Although fully biodegradable netting can cost more than non-biodegradable netting, the labor cost savings from not having to remove the control measure—as well as the subsequent benefit to soil condition and vegetation establishment—may justify this cost. However, there is still the cost to remove and dispose of sediment that accumulates to at least one-third the distance between the top of the fiber roll and the ground surface.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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Stormwater Best Management Practice

Filter Berms

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

A gravel or stone filter berm is a temporary ridge made up of loose gravel, stone or crushed rock that filters sediments from sheet flow.

Applicability

Gravel or stone filter berms are most suitable for areas with a shallow slope (10 percent or less) and where stormwater primarily travels as sheet flow. Construction staff can place filter berms at the toe of a slope, at construction site perimeters, at inlet/outlet structures and around potential pollution sources. Staff should not place berms in areas of concentrated flows (DOWL, 2015). Filter berms can divert and filter flows from areas of open traffic (SPU, 2017), and they can be particularly useful in areas where municipalities prohibit earth-disturbing activities or find them undesirable, such as archaeological or historical sites, sites containing historical artifacts, or areas with soil or water contamination (MDE, NRCS, & MASCD, 2011).

Siting and Design Considerations

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Design engineers should consult local design criteria and specifications for design requirements and can consider the following general guidelines when building a filter berm (DOWL, 2015; MDE, NRCS, & MASCD, 2011; SPU, 2017; WES, 2008):

- Use washed, well-graded gravel or crushed rock—with sizes ranging from 3/4 inches to 3 inches in diameter—containing less than 5 percent fines.
- Space berms according to the steepness of the slope. Space them closer together as the slope increases.
- The berm should receive flow no greater than 1 cubic foot per second per 8 linear feet of berm.
- Remove and dispose of sediment buildup and replace the filter material as capacity decreases. Regular inspection should indicate how often construction staff need to remove sediment.

A gravel filter berm covered with filter fabric.
Credit: Anthony D'Angelo for USEPA, 2015

- Filter berms should be at least 2 feet wide at the top, with side slopes of 3:1 or flatter.
- For best sediment removal performance, embed the berm at least 4 inches into the ground (unless ground contamination concerns exist).
- Install filter berms parallel to contours of the site to intercept and slow sheet flow.

Limitations

Construction staff should install filter berms only in gently sloping areas (less than 10 percent). Berms have a limited life span due to sediment clogging. The addition of filter fabric on the upstream side of the berm can extend the life of the berm media (WES, 2008). Filter berms are also susceptible to undermining and washouts (DOWL, 2015).

Maintenance Considerations

Construction staff should inspect filter berms before significant rainfall events to ensure sediment has not built up and that the berms have not been damaged and are still operational. After rainfall events, staff should

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also inspect filter berms for sediment buildup, undermining and washout and rebuild the berms as necessary. Construction staff should remove sediment when buildup equals one-third of the berm's height and replace rock or gravel after filter capacity reduces by one-half (WES, 2008). It is important to make repairs at the first sign of deterioration to keep the berm functioning properly.

Effectiveness

The effectiveness of a filter berm depends on rock size, slope, soil, rainfall amount and proper sizing. Construction staff do not have to stake filter berms into the ground, and the berms require no trenching, though trenching will increase the berm's effectiveness.

Cost Considerations

Construction materials for filter berms can be more expensive than materials for other practices, mainly due to the need for washed gravel or rock (WES, 2008). In addition, labor costs associated with installation and regular maintenance can be high. Costs are lower in areas of less traffic, gentler slopes and low rainfall.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Sediment Basins and Rock Dams

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Sediment basins in large drainage areas can capture sediment from stormwater before it leaves a construction site. A sediment basin allows a pool to form in an excavated or natural depression, where sediment can settle.

The embankment of a sediment basin can either be compacted soil or a rock dam. When using an earthen embankment, the sediment basin dewaters the pool through a single riser and drainage hole that leads to a suitable outlet on the downstream side of the embankment. Rock dams use rock and gravel as an embankment instead of compacted soil. They gradually release water from the settling pool through the spaces between the rocks. A sediment basin slows the release of stormwater leaving a construction site and reduces the amount of sediment it carries.

Methods for constructing a sediment basin are excavation or erecting an embankment across a low area or drainage swale. A basin can be temporary or permanent. Engineers design some sediment basins to drain completely during dry periods. They construct others so that a shallow pool of water remains between storm events.

Applicability

Sediment basins apply to drainage areas where smaller erosion controls, such as sediment traps, will not adequately prevent off-site transport of sediment. They typically apply to drainage areas of 5 to 100 acres. Drainage areas of less than 5 acres, which generally do not produce enough stormwater to maintain a permanent pool, should use sediment traps. It is possible to convert temporary sediment basins into permanent stormwater management ponds, but they must meet all regulatory requirements for wet ponds.

The choice to construct a sediment basin with an earthen embankment or a rock dam depends on the materials available, the location of the basin, and the

A sediment basin with earthen embankments stabilized with erosion matting and hydroseed.
Credit: Anthony D'Angelo for USEPA, 2015

desired capacity for holding stormwater and settling sediment. Rock dams are suitable where earthen embankments would be difficult to construct and where rocks for the dams are readily available. They are also desirable if the area will use the top of the dam structure as an overflow outlet. Rock dams are best for drainage areas of less than 50 acres. Earthen damming structures are appropriate where dam failure will not result in substantial damage or loss of property or life.

Siting and Design Considerations

A sediment basin should be at the lowest point of the site and in an area that maintenance crews can easily access to remove accumulated sediment. Erosion and sediment control permits often require installation of sediment basins before grading or earth disturbance begins, which is a best practice to minimize sediment transport off-site.

Jurisdictional requirements typically specify hydrologic calculations to determine the size of a sediment basin. A typical guideline is to design a sediment basin to store 3,600 cubic feet of water for every acre that drains to the basin (MDE, 2011; WSDOT, 2019). Storage volume consists of two parts: dry storage (volume of storage below the riser height) and wet storage (volume of storage above the riser). Side slopes should be no steeper than 2 feet horizontally for every 1 foot of elevation change inside the structure and 3 feet horizontally for every 1 foot of elevation change on the outlet side.

A large sediment basin with partially stabilized embankments.
Credit: Anthony D'Angelo for USEPA, 2015

National Pollutant Discharge Elimination System regulations require that for regulated construction sites (disturbing 1 or more acres of earth), unless infeasible, discharges of stormwater from a sediment basin or impoundment must utilize outlet structures that withdraw water from the surface of the water (40 C.F.R. § 450.21[f], 2014).

For sediment basins that will also be permanent stormwater management structures, a qualified professional engineer experienced in designing dams should create the designs.

Sediment Basins with Earthen Embankments

For sediment basins with earthen embankments, the principal spillway is a riser structure. The riser is ideally at the deepest point of the basin, and its height is typically 1 foot below the level of the earthen dam. Most jurisdictions require design engineers to size the riser to handle flow from a specific size of storm. The riser discharges to a barrel, which transports dewatered stormwater through the embankment to discharge from the basin. A properly designed barrel adequately handles flow from the riser and has a watertight connection to the riser.

When using a sediment basin with an earthen embankment, a perforated dewatering pipe or skimmer device that floats on the water surface is advisable to dewater the basin. The dewatering device should have a watertight connection to the base of the riser. If using a perforated dewatering pipe, a water-permeable cover over the pipe prevents trash and debris from entering and clogging the spillway. Design engineers should use erosion and sediment control manuals to determine the size, spacing and total area of the dewatering holes in the pipe. A qualified engineer or other appropriate professional should consider local hydrologic, hydraulic, topographic and sediment conditions when calculating perforations.

Sediment Basins with Rock Dams

Suitable material for a rock dam is well-graded, erosion-resistant stone of mixed size, with a minimum stone size of 12 inches (MPCA, 2019; NCDEQ, 2013). Covering the basin side of the rock dam with fine gravel from top to bottom for at least 1 foot is advisable to slow the drainage rate through the dam and give sediments time to settle.

For erosion protection, construction staff should place a rock apron downstream of the rock dam starting at the toe of the dam. The apron should have a flat slope and at a minimum, a length equal to the height of the rock dam. Construction staff should lay filter fabric under the entire rock dam structure, including the outlet protection, to prevent soil movement.

Limitations

Q10

The area draining to a single sediment basin should be no more than 100 acres for a basin with an earthen embankment and 50 acres for a sediment basin using a rock dam. Construction staff should not install sediment basins in a permanent or intermittent stream. Sediment basins are also not suitable for locations where failure of the earthen or rock dam will result in loss of life; cause damage to homes, buildings, or utilities; or prevent the use of public roads.

Most jurisdictions have height maximums for sediment basin embankments. Exceeding these height limitations may trigger more stringent regulatory requirements applicable to dams.

A common cause of structural failure for sediment basins is water piping, a process where water seeps through granular soil and slowly erodes the embankment. Construction staff can reduce the risk of water piping by ensuring that connections between the riser and barrel are tight, they have adequately anchored the riser, they have properly compacted the soil, and they have properly installed anti-seep devices (WSDOT, 2019). For rock dams, using filter fabric at the foundation of the rock structure and along the rock apron for outlet protection reduces the risk of water piping.

Maintenance Considerations

Routine inspection and maintenance of sediment basins is essential for their continued effectiveness. Construction staff should inspect basins after each storm event to ensure proper drainage from the collection pool and to determine the need for structural repairs. They should also inspect dewatering devices and remove any trash and debris they find. Construction staff should immediately repair eroded earthen embankments and immediately replace displaced stones from rock dams. Construction staff should remove sediment accumulation when it exceeds 50 percent of the storage volume.

Effectiveness

The effectiveness of a sediment basin depends primarily on incoming sediment particle size and the ratio of basin surface area to inflow rate (MDE, 2011; MPCA, 2019). Sediment basins are more effective at removing large particles, which settle more quickly than smaller particles such as fine silts and clays. Sediment basins are also more effective when their designs have a large surface area-to-volume ratio. Design engineers can increase sediment removal by adding baffles along the bottom of the basin to slow the flow of water through the basin and trap sediment. Use of a sediment trap as pretreatment before a sediment basin can reduce maintenance requirements for the basin and improve sediment removal rates.

For sites with significant amounts of fine silts and clay soils, adding a treatment chemical—such as a flocculant—can improve performance (MPCA, 2019). If construction staff consider treatment chemicals, they should consult with local permitting authorities to help identify suitable chemicals and ensure the identified chemicals have approval for use.

Q11

Estimates from various state agencies show a sediment removal rate of 60 to 80 percent for properly designed sediment basins (Honolulu, 2018; MDE, 2011; U.S. EPA, 2005).

Cost Considerations

When estimating total costs of a sediment basin, construction staff should consider the costs of excavation, embankment materials, piping and pretreatment methods. Excavation costs for a sediment basin range from $3 to $10 per bulk cubic yard (MPCA, 2019; RSMeans, 2019). Raw material costs for an embankment range from $2 per cubic yard for common soils to $9 per cubic yard for granular soils. After incorporating labor and other costs, construction of an earthen embankment costs $15 to $35 per bulk cubic yard of material (MPCA, 2019; RSMeans, 2019). For large stone and gravel, material costs range from $12 to $25 per cubic yard (RSMeans, 2019), with a wide variability due to regional price differences.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Sediment Filters and Sediment Chambers

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Construction sites typically use sediment filters—a type of sediment-trapping device—to remove pollutants (mainly particulates) from stormwater discharges. Sediment filters have four components: 1) inflow regulation, 2) pretreatment, 3) filter bed and 4) outflow mechanism. Sediment chambers are one component (pretreatment) of a sediment filter system.

Stormwater enters the filter system or practice through the inflow regulator, which then directs it to a pretreatment sedimentation chamber. This chamber is a preliminary settling area for large debris and sediments. Construction staff can maintain the settling area like a wet detention facility or construct it to draw down over a given interval—generally 24 to 48 hours. When water reaches a predetermined level, it flows over a weir into the bed of a filter medium. The medium is typically sand, but it can consist of soil, gravel, peat, compost or a combination of these materials. The filter bed removes small sediments and other pollutants from the stormwater. Finally, treated stormwater exits the sediment filter system via an outflow mechanism. The treated stormwater discharges off-site or to a stormwater conveyance system.

Water flows from a stormwater inlet into the pre-treatment basin of a sediment chamber, then overflows through weirs into four separate gravel sediment filters.
Credit: Taylor Fontaine for USEPA, 2018

Common Term

Pretreatment plays an important role in stormwater treatment. Construction staff install pretreatment structures immediately upgradient to a stormwater control to reduce flow rates and remove sediment and debris before stormwater enters the stormwater control. This helps to improve the stormwater control's pollutant removal efficiency and reduces maintenance requirements.

Applicability

Sediment filters can be a good alternative for small construction sites due to size limitations. Sediment filters are also widely applicable in urban areas with large amounts of highly impervious area. When considering whether to install this device for construction site stormwater management, site developers typically consider the size of the drainage area and sediment type. Generally, the drainage area should be no greater than 10 acres, and design engineers often recommend a size of 5 acres or less.

The type of filter system that site developers select depends on the amount of land available and the desired location. The Austin and Delaware sand filters are examples of sediment filter systems. The Austin sand filter is a surface filter system suitable for areas with space restrictions. If space is at a premium, an underground filter might be the best choice. A Delaware sand filter can effectively remove sediment from stormwater at the perimeter of a site. It consists of two parallel, trench-like chambers that construction staff install at the site perimeter. The first trench (sediment chamber) provides pretreatment sediment settling before the stormwater spills into the second trench (filter medium).

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Siting and Design Considerations

Sediment filter systems can be a good sediment control option for urban areas with close to 100-percent impervious drainage areas or for treatment of stormwater hotspots (VDEQ, 2011). They can be confined or unconfined, online or offline, and aboveground or belowground. Confined sediment filters feature a filter medium that is contained in a structure—often a concrete vault. Unconfined sediment filters do not have a confining structure. For example, construction staff might place sand on the banks of a permanent wet pond detention system to create an unconfined filter. Online systems retain stormwater in its original stream channel or storm drain system. Offline systems divert only a portion of the main stormwater flow to a side-stream treatment location.

Space and head availability are important siting and design considerations. Head is the vertical distance between the inflow of the system and the outflow point. Because most filtering systems depend on gravity to move water through the system, if enough head is not available (2 to 10 feet depending on the design variant), the system will not be effective. Additional factors to consider include the depth-to-water table and soil infiltration capacity, especially where groundwater contamination is a concern. In all cases, maintain at least 2 feet of space between the bottom of the filter and the seasonal high groundwater table (VDEQ, 2011).

The sediment chamber area and filter bed area are the most important design parameters, as they have the largest effect on sedimentation and filtration, respectively (City of Austin, n.d.). However, as sedimentation and filtration are also a function of stormwater sediment size and type, design engineers should also consult local specifications. In addition, the depth of filter media will vary depending on media type. For sand filters, the sand (0.04-inch diameter or smaller) should be at least 18 inches deep, with at least 4 to 6 inches of gravel for the filter bed. Throughout the life of a sediment filter system, frequent access is necessary to assess the system's effectiveness and perform routine maintenance and emergency repairs. Because most maintenance requires manual rather than mechanical removal of sediments and debris, filter systems should be located to allow easy access.

Lastly, design flow rates should be carefully considered. The filter capacity should adequately ensure that sediments and debris in stormwater do not overwhelm or clog the filter medium and that the filter can handle the desired hydraulic loading (Hirschman, Seipp, & Schueler, 2017).

Limitations

Sediment filters can be costly, do not provide stormwater volume or flood control, and can be prone to clogging in cases of overloading or under-design. In addition, sediment filters may lose effectiveness in cold regions because of freezing conditions.

Maintenance Considerations

Maintenance costs of stormwater sediment filters can be relatively high compared to other sediment-trapping devices. Often, operators should perform routine and long-term maintenance activities by hand rather than mechanically due to the size of the filter. Depending on actual rainfall intensity and sediment loading, sediment chambers may require clearing and filter media may require replacing several times a year. Local guidance documents generally recommend clearing sediment chambers when more than 50 percent of the storage volume is filled and replacing filter media if standing water persists for more than 36 hours. Sometimes, replacing the top 3 to 4 inches of a filter medium may effectively restore proper infiltration rates, though this depends on specific site conditions.

Because filter media can experience high loadings of metals and petroleum hydrocarbons, site operators should analyze them periodically to ensure that those loadings do not reach levels that would classify the media as hazardous waste. This is especially true at sites that use solvents or other potentially hazardous chemicals. Regardless, site operators should appropriately remove, collect and dispose of waste that they remove from the filter.

Effectiveness

Q12

Treatment effectiveness depends on factors like treatment surface area; whether the filter is online or offline, confined or unconfined; and the type of land use in the contributing drainage area. Studies have shown that sediment filters and chambers can remove 40 to 90 percent of total suspended solids, heavy metals and organics (VDEQ, 2011).

Cost Considerations

The installation and maintenance costs of sediment filters and chambers can be high, as they are more permanent than other temporary erosion and sediment control practices (e.g., silt fence and filter socks). Costs also vary widely—reflecting the wide range of design variations—and may include costs associated with basin excavation, inflow and outflow structures, piping, concrete vaults, and filter media. The high costs may be warranted for specific sites because sediment filters and sediment chambers can more effectively control concentrated sources of stormwater sediment and pollutants.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Sediment Traps

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Sediment traps are small, temporary ponding basins that treat stormwater by allowing sediment particles to settle out of the water. Typically lying in a drainageway or other point of discharge from a construction site, they capture stormwater before it flows into the surrounding area (U.S. EPA, 2007). Sediment traps detain sediments in stormwater to protect receiving streams, lakes and drainage systems.

To create a sediment trap, construction staff excavate an area or place an earthen embankment across a low area or drainage swale. An outlet or spillway often features large stones or gravel to slow the release of stormwater into the receiving water body (Washington Department of Ecology, 2019).

A sediment trap in an unstabilized area with sediment-laden stormwater collected inside.
Photo Credit: USEPA/Wikimedia

Q13

Applicability

Sediment traps are common at the outlets of stormwater diversion structures, channels, slope drains, construction site entrance wash racks, or any other stormwater conveyance that releases waters containing sediment and debris. They are only suitable for small drainage areas—generally 5 acres or less, though some states and localities set smaller thresholds.

Siting and Design Considerations

Design engineers can place multiple sediment traps on a construction site to treat stormwater in different areas (U.S. EPA, 2007). When siting the traps, they should consider the site's natural drainage patterns and place the traps to manage areas with the highest erosion potential. They should also take care to give construction staff easy access to the traps, so they can periodically inspect the traps and remove any accumulated sediment. Design engineers should also strive to prevent flow from undisturbed areas from entering the traps so as to maximize treatment of disturbed areas.

Specific design requirements vary by location and site conditions, but some design considerations are common to all applications. Many municipalities require sediment traps to have a minimum volume of 1,800 cubic feet per acre of drainage area. Additionally, most design manuals provide equations to calculate the required volume based on the design flow rates and particle settling velocity. Designs should optimize the surface area of the sediment trap to allow for maximum infiltration and settling. This increases the effectiveness of the trap and decreases the likelihood of backup during and after periods of high flow.

The width of the outlet should correspond to the amount of flow the sediment trap receives. For example, the Tennessee Department of Conservation requires the outlet to be at least 4 feet wide for a 1-acre drainage area (TDEC, 2012).

When excavating the area for a sediment trap, construction staff should make sure the side slopes meet local design requirements but are no steeper than 2:1. The embankment height should be no more than 5 feet from the original ground surface. Construction staff should machine-compact all embankments to ensure stability. To reduce the flow rate of the sediment trap discharge, construction staff should line the outlet with well-graded stone.

If the sediment trap is near a residential area or if trespassing is likely, construction staff should secure the area with a fence.

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Limitations

Sediment traps are not suitable for large drainage areas (generally greater than 5 acres). They also do not last long—their effective life span is usually 24 months or less (NCDEQ, 2013; TDEC, 2012). Although sediment traps are effective in removing eroded soils, their detention periods are too short for removing fine particles like silts and clays.

Maintenance Considerations

Over time, captured sediment will accumulate in a sediment trap and interfere with its ability to effectively treat incoming stormwater. Construction staff should remove sediments when the basin reaches 50 percent capacity. Additionally, they should inspect the sediment trap after each rainfall event for damage from erosion and to ensure that the trap is draining properly.

Effectiveness

Design engineers should construct sediment traps in accordance with design manual specifications to ensure high sediment removal efficiency, generally 50 to 70 percent (Wossink et al., 2005). Still, a trap's performance varies depending on a number of factors including the trap's surface area, rainfall intensity, peak inflow rates, the level of disturbance or erosion in the contributing area, and proper maintenance (NCDEQ, 2013). Traps that provide pools with large length-to-width ratios or incorporate internal baffles—both of which provide greater opportunity for sedimentation—are generally more effective.

Cost Considerations

The cost of constructing a sediment trap includes excavation, grading, compaction and stone. Excavation can be one of the largest costs and generally ranges from $2 to $3 per bulk cubic yard (RSMeans, 2020).

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Silt Fences

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Purpose and Description

The purpose of a silt fence is to retain the soil on disturbed land (Figure 1), such as a construction site, until the activities disturbing the land are sufficiently completed to allow revegetation and permanent soil stabilization to begin. Keeping the soil on a construction site, rather than letting it be washed off into natural water bodies (e.g., streams, rivers, ponds, lakes, estuaries) prevents the degradation of aquatic habitats and siltation of harbor channels. And preventing soil from washing onto roads, which readily transport it to storm sewers, avoids having sewers clogged with sediment. The cost of installing silt fences on a watershed's construction sites is considerably less than the costs associated with losing aquatic species, dredging navigation channels, and cleaning sediment out of municipal storm sewers.

A silt fence is a temporary sediment barrier made of porous fabric. It's held up by wooden or metal posts driven into the ground, so it's inexpensive and relatively easy to remove. The fabric ponds sediment-laden stormwater, causing sediment to be retained by the settling processes. A single 100-foot run of silt fence may hold 50 tons of sediment in place. Most construction sites today do have silt fences. However, many do not work effectively because they are not well designed, installed, or maintained. The focus of this fact sheet is—how to make silt fences work.

Design

Q14

The three principal aspects of silt fence design are: proper placement of fencing, adequate amount of fencing, and appropriate materials.

Proper Placement of Fencing

Placement is important because where a fence starts, runs, and ends is critical to its effectiveness. Improper placement can make the fence a complete waste of money. Construction staff should analyze the construction site's contours to determine the proper placement.

Figure 1. A silt fence at the perimeter of a construction site.
Photo Credit: USEPA/Wikimedia

Staff should segment the site into manageable sediment storage areas for using multiple silt fence runs. The drainage area above any fence should usually not exceed a quarter of an acre. Water flowing over the top of a fence during a normal rainfall indicates the drainage area is too large. An equation for calculating the maximum drainage area length above a silt fence, measured perpendicular to the fence, is given in Fifield (2011). Construction staff should avoid long

Figure 2. Create manageable sediment storage areas.

Figure 3. Water should not flow over the filter fabric during a normal rainfall

runs of silt fence because they concentrate the water in a small area where it will easily overflow the fence. The lowest point of the fence in Figure 4 is indicated by a red arrow. Water is directed to this low point by both long runs of fence on either side of the arrow. Most of the water overflows the fence at this low point and little sediment is trapped for such a long fence.

Figure 4. Avoid long runs of silt fence

Construction staff should use J-hooks as shown in Figures 5 and 6, which have ends turning up the slope to break up long fence runs and provide multiple storage areas that work like mini-retention areas. If the fence doesn't create a ponding condition, it will not work well. The silt fence in Figure 7 doesn't pond water or retain sediment. Stormwater will run around the fence carrying sediment to the street, which will transport the water and its sediment load to the storm sewer inlet.

Figure 5. Use J-hook fences to break up long fence runs

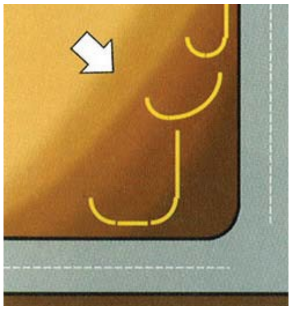

Figure 6. J-hook silt fences provide multiple storage

Figure 7. This silt fence doesn't work

Water flowing around the ends of a silt fence will cause additional erosion and defeat its purpose. Construction staff should ensure that the bottom of each end of the fence is higher than the top of the middle of the fence (Figure 8). This ensures that during an unusually heavy rain, water will flow over the top rather than around either end of the fence. Only fine suspended material will spill over the top, which is not as harmful as having erosion at the ends. When there is a long steep slope, construction staff should install one fence near the head of the slope to reduce the volume and velocity of water flowing down the slope, and another fence 6-10 feet from the toe of the slope to create a sediment storage area near the bottom. A common misconception is that only steep slopes cause a stormwater management concern. However, steep slopes may have a relatively small water collection area. The total drainage area of a gentle slope, if large (Figure 10), can be more important than its slope in determining sediment loss. A silt fence should not be placed in a channel with continuous flow (channels in Figures 8 and 9 don't have a continuous flow), nor across a narrow or steep-sided channel. However, when necessary a silt fence can be placed parallel to the channel to retain sediment before it enters the watercourse.

Figure 8. Proper installation, bottom of both ends are above the top of the middle.

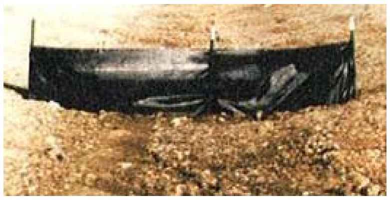

Figure 9. Poor installation, water can flow around the ends causing additional erosion

Figure 10. Gentle slopes may require a silt fence

Paved streets are major conduits of stormwater and silt, and they drain to storm sewer inlets. The best solution is to retain as much sediment as possible before it reaches paved surfaces. Construction staff should install a silt fence at the inlet side of a storm sewer or culvert, rather than at the discharge where there is greater velocity and less storage area. Streets cut in the grade, but not yet paved, are also prime erosion conduits. If the streets are not going to be paved right away, they need a containment barrier such as a silt fence. Finally, as a construction site's dynamics change, construction staff should adjust the silt fence layout to maintain its effectiveness.

Silt fences are a “last line of defense” sediment control practice (U.S. EPA, 2007), and designers and contractors should always consider diverting sediment-laden stormwater to a sediment detention pond or other primary sediment control practice in conjunction with the use of silt fences. If the site can provide a large enough area, this is usually the most effective and economical best management practice for retaining sediments.

Adequate Amount of Fencing

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Silt fences are typically perimeter control practices or the last line of defense for discharge points like storm drains. As such, the amount of silt fence needed at a site depends on the site’s configuration, or more specifically, the configuration of the contributing area that is subject to erosion. Still, it is important to not overload a silt fence. A reasonable rule-of -thumb for the proper amount of silt fence is—at least 100 feet of silt fence per 10,000 square feet of disturbed area. Soil type, slope, slope length, rainfall, and site configuration are all important elements in determining the adequate silt fence protection for a site, and to what extent it fits the 100 feet per 10,000 square feet rule-of-thumb. If the amount of fencing provides the volume of storage needed, then over-flowing the silt fence runs will be minimized. This is the basic test; if fences are over-flowing after a moderate rainfall event, construction staff should probably increase the amount of fencing to avoid undercutting, washouts, and fence failures.

Appropriate Materials

There are different types of porous fabrics available (e.g., woven, non-woven, mono-filament) as well as different types of posts (e.g. wooden or metal) available to support the silt fence. Proper installation methods are more important than the fabric or post type for overall effectiveness. However, a lightweight fabric tends to tear where it is attached to the posts. Posts should hold the fabric up and support the horizontal load of retained water and sediment. Hardwood posts (2 inches by 2 inches) are potentially strong enough to support the loads but are difficult to drive into the ground more than 6-8 inches. To hold 2 feet of sediment and water, construction staff should drive the posts 2 feet into the ground. Steel posts are best because staff can drive them into compacted soil to a depth of 2 feet. Staff should space the support posts 3-4 feet apart where water may run over the top of the fence, 5 feet in most other areas, and 6-7 feet where there isn’t a considerable horizontal load. Improper post depth and spacing is often the cause of sagging fabric and falling posts. A more robust wire or chain link supported silt fence is needed to withstand heavy rain events or sediment loading. However, this may double the cost of a silt fence installation and entails disposing of more material when the fence is removed. Construction staff can usually obviate the need for a wire or chain link reinforced fence by installing silt fencing with five interacting features: (1) proper placement based on the site’s contours, (2) adequate amount of fencing without long runs, (3) heavy porous filter fabric, (4) metal posts with proper depth and spacing, and (5) tight soil compaction on both sides of the silt fence.

Figure 11. Chain link supported silt fence

Silt Fence Installation

Two approaches that construction staff commonly use for installing silt fences are the static slicing method and the trenching method.

Static Slicing Method

The static slicing machine pulls a narrow blade through the ground to create a slit 12 inches deep, and simultaneously inserts the silt fence fabric into this slit behind the blade. The blade is designed to slightly disrupt soil upward next to the slit and to minimize horizontal compaction, thereby creating an optimum condition for compacting the soil vertically on both sides of the fabric. Construction staff compact soil by rolling a tractor wheel along both sides of the slit in the ground 2 to 4 times to achieve nearly the same or greater compaction as the original undisturbed soil. This vertical compaction reduces the air spaces between soil particles, which minimizes infiltration. Without this compaction infiltration can saturate the soil, and water may find a pathway under the fence. When a silt fence is holding back several tons of accumulated water and sediment, it needs to be supported by posts that are driven 2 feet into well compacted soil. To complete installation, construction staff should drive in the posts and attach the fabric to the posts.

Figure 12. Static slicing machine

Figure 13. Tractor wheel compacting the soil

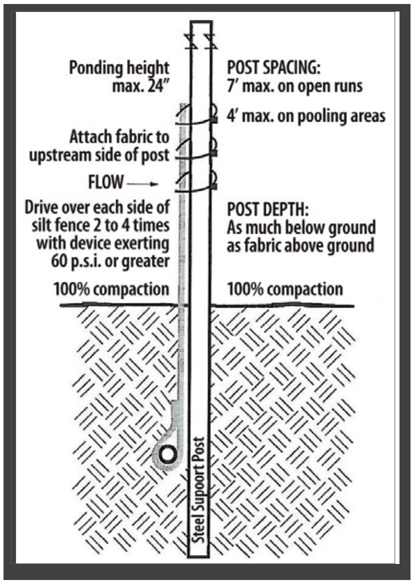

Figure 14. Silt fence installation using the static slicing method

Trenching Method

Trenching machines have been used for over twenty-five years to dig a trench for burying part of the filter fabric underground. Usually the trench is about 6 inches wide with a 6-inch excavation. Its walls are often more curved than vertical, so they don't provide as much support for the posts and fabric. Turning the trencher is necessary to maneuver around obstacles, follow terrain contours or property lines, and install upturns or J-hooks. However, trenchers can't turn without making a wider excavation, and this results in poorer soil compaction, which allows infiltration along the underground portion of the fence. This infiltration leads to water seeking pathways under the fence, which causes subsequent soil erosion and retained sediment washout under the fence. The white line on the fence in Figure 16 and red arrow both mark the previous sediment level before the washout. Post setting and fabric installation often precede compaction, which make effective compaction more difficult to achieve. EPA supported an independent technology evaluation (ASCE 2001), which compared three progressively better variations of the trenching method with the static slicing method. The static slicing method performed better than the two lower performance levels of the trenching method and was as good or better than the trenching method's highest performance level. The best trenching method typically required nearly triple the time and effort to achieve results comparable to the static slicing method.

Figure 15. Trenchers make a wider excavation at turns.

Figure 16. Poor compaction has resulted in infiltration and water flowing under this silt fence causing retained sediment washout.

Q16

Proper Attachment

Regardless of the installation method, it is critical for construction staff to properly attach the fabric to the posts to combine the strength of the fabric and support posts into a unified structure. The silt fence should be able to support 24 inches of sediment and water. For steel posts, construction staff should use three plastic ties per post (50-pound test strength), located in the top 8 inches of the fabric, with each tie hung on a post nipple, placed diagonally to attach as many vertical and horizontal threads as possible. For wooden posts, staff should use several staples per post, with a wood lath to overlay the fabric.

Silt Fence Applications

When staff place silt fences around the perimeter of a stockpile or a construction site, the conventional silt fence design and materials discussed previously may not be sufficient.

Stockpile example. A stockpile of dirt and large rocks is shown in Figures 17 and 18 with a silt fence protecting the downgradient area of its perimeter. By only protecting the downgradient area, the silt fence will allow access of the stockpile from the upgradient side without having to remove it. Rocks that roll down the pile would likely damage a conventional silt fence. The bottom of the porous fabric is held firmly against both the ground and base of precast concrete, highway, barriers by light-colored stones. An alternative installation would for construction staff to rest the concrete barriers directly on the bottom edge of the filter fabric, which would extend under the barriers about 10 inches, so the barriers' weight will press the fabric against the ground to prevent washout. Water passing through the silt fence (red arrow in Figure 18) flows to a storm sewer culvert inlet, which is surrounded by a fabric silt fence (yellow arrows in Figures 17 and 18) that reduces the stormwater's velocity and allows settling before the water is discharged to a creek.

Figure 17. Back of silt fence on part of the stockpile's perimeter.

Figure 18. Front of silt fence on part of stockpile's perimeter.

Bridge abutment example. While constructing a bridge over a river between two lakes, construction staff needed an excavation on the riverbank to pour footings for the bridge abutment. Design engineers created the silt fence along the excavation's perimeter, composed of concrete highway barriers with orange filter fabric, to prevent stormwater from washing excavated soil into the river and to fend off the river during high flows. A portion of the orange filter fabric that has blown away from the concrete barriers shows the need for construction staff to overlap and reinforce the joints where two sections of filter fabric are attached.

Figure 19. Silt fence for bridge abutment excavation.

Highway example. Because of the proximity of a construction site to a highway, a concrete barrier was required by Minnesota's DOT to protect the highway and an underground fiber optic cable next to the highway from construction activities. Construction staff used the concrete barrier to support a silt fence along the perimeter of a large amount of dirt that was stock piled before being used for fill at a different location.

Figure 20. Silt fence protecting a highway and underground fiber optics cable.

Lake shore example. Workers are restoring the lake's shoreline with plant plugs and seeding it with native plant species. Staff are using a plywood,

Figure 21. Silt fence protecting a lake shore.

perimeter, silt fence to trap sediment from a construction site on the right-side of the picture, protect the lake shore from boat-wake erosion, and prevent geese from eating the seeds and young plants. Staff will remove this fencing when 70% vegetative cover is achieved.

Inspection and Maintenance

Construction staff should inspect silt fences routinely and after precipitation events to determine whether they need maintenance because they are full (Figure 22) or damaged by construction equipment. The ASTM silt fence specification (ASTM 2003) recommends that staff remove sediment deposits from behind the fence when they reach half the height of the fence or install a second fence.

Figure 22. A silt fence full of sediment that needs maintenance.

However, there are several problems associated with cleaning out silt fences. Once the fabric is clogged with sediment, it can no longer drain slowly and function as originally designed. The result is normally a low volume sediment basin because the cleaning process doesn't unclog the fabric. The soil is normally very wet behind a silt fence, inhibiting the use of equipment needed to move it. Construction staff typically use a backhoe, but if the sediment is removed, what is to be done with it during construction? Another solution is to leave the sediment in place where it is stable and build a new silt fence above or below it to collect additional sediment as shown in Figure 23. The proper maintenance may be site specific, e.g. small construction sites might not have sufficient space for another silt fence. Construction staff should maintain adequate access to the sediment control devices so inspections and maintenance can be performed.

Figure 23. New silt fence below the old fence

Permanent Soil Stabilization

When construction staff have sufficiently completed the land disturbing activities to allow permanent soil stabilization on the site, they should remove the silt fences and sediment basins. The fabric and damaged posts go to the landfill. Steel posts and some of the wooden posts can be reused. Then, staff spread the sediment over the site to provide fertile soil, and the area can be seeded and mulched to support revegetation.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Figure 1: U.S. EPA/Wikimedia

Figures 2–10, 12-16, 22, 23: Thomas Carpenter, CPESC, Carpenter Erosion Control

Figure 11: Pete Schumann, Fairfax County, Virginia, Department of Public Works and Environmental Services

Figures 17–21: Dwayne Stenlund, CPESC, Minnesota Department of Transportation

Stormwater Best Management Practice

Storm Drain Inlet Protection

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Storm drain inlet protection controls prevent soil and debris from entering storm drain inlets. These controls are usually temporary and allow storm drain inlets on-site to remain operational prior to permanent site stabilization. Inlet protection is often the last opportunity to provide treatment to stormwater prior to discharge. There are several types of inlet protections that construction site operators can use depending on site conditions, inlet configurations and material availability. Inlet protection can be either internal or external. Internal controls consist of a filter insert that construction staff place within a storm drain, and these controls are generally only useful for larger sediment. External controls enable ponding around the storm drain inlet using some type of filter barrier made of stone, gravel or fabric. Construction staff can create the ponded area by either excavating around a drop inlet or by building the filter material up around a drop inlet's perimeter. External controls slow flow velocities and allow for sediment settling and filtration before stormwater enters the inlet.

A variety of controls can protect storm drain inlets, such as the mostly structural controls that this fact sheet discusses or non-structural controls that the Compost Filter Socks and Fiber Rolls fact sheets discuss in greater detail.

Applicability

Inlet protection is applicable to operational inlets for which all or some of the inlet's drainage area is disturbed. Storm drain inlet protection is a secondary control device, meaning that construction staff should always use inlet protection in conjunction with other sediment and erosion control practices.

Internal controls are applicable to areas with high construction traffic or where roadway flooding is a concern (WSDOT, 2019). External controls—which

Storm drains and curb inlets should be protected with filter fabric and filter socks, which trap sediment and allow water to flow through.

Photo Credit: PG Environmental for USEPA

require more space for stormwater ponding but are generally more effective as sediment control practices—are applicable to a wide range of inlet configurations. Excavated drop inlet protection and block and gravel inlet protection are applicable to areas of high flow, where drain overflow is likely. Fabric (e.g., silt fence or geotextile) barriers are applicable to smaller, flatter drainage areas, but construction staff should be aware that some locations caution against this practice due to its high failure rate (e.g., TDEC, 2012).

Q17

Siting and Design Considerations

Construction staff should install temporary inlet protection controls before any soil disturbance occurs in the drainage area. Generally, drainage areas to each control should be no greater than 1 acre per inlet. In all cases, the overtopping depth of an inlet protection control should not be greater than any surrounding low point in the drainage area so that stormwater does not bypass the inlet. In some cases, controls may require an emergency overflow (City of Seattle, 2017).

Given the wide variety of inlet protection types, design engineers and construction staff should always consult local, state and manufacturer specifications for siting, installation and maintenance requirements. Considerations for common inlet protection controls are below (City of Seattle, 2017; DC, 2017; Lake, 2016; TDEC, 2012; WSDOT, 2019):

- ***Excavated drop inlet protection*** – This consists of a small area that construction staff can excavate or leave below grade around an inlet to create a settling pool. Small holes (also called weep holes) with gravel and/or filter fabric protection slowly release stormwater into the inlet. Recommended depths vary by location but are generally between 1 and 2 feet depending on site configurations. Most jurisdictions also provide recommendations for minimum storage volume as a function of drainage area. For example, the New York State Department of Environmental Conservation recommends a minimum of 35 cubic yards per acre disturbed (Lake, 2016).
- ***Fabric drop inlet protection*** – This consists of a barrier of porous fabric around an inlet that creates a shield against sediment while allowing water to flow into the inlet. This barrier slows stormwater while catching soil and other debris. If water levels are high enough, water should be able to overflow into the inlet leaving settled sediment behind. Most jurisdictions specify a maximum fabric height of 1.5 feet unless adequate reinforcement is in place.
- ***Block and gravel inlet protection*** – Standard concrete blocks and gravel form a barrier to sediments that permits stormwater to flow through select sideways blocks. Similar to fabric drop inlet protection, block and gravel controls should be high enough to pond stormwater and enable settling of sediments, but not so high as to prohibit overtopping during times of high flows. Designs typically require wire mesh between the blocks and gravel to prevent gravel from entering the inlet.
- ***Sod inlet protection*** – For permanent inlet protection after construction staff have stabilized the surrounding area, staff can install sod. This permanent measure is an aesthetically pleasing way to slow stormwater near drop inlet entrances and to remove sediments and other pollutants from stormwater. Only use sod inlet protection after staff have stabilized the entire drainage area.

Limitations

Stormwater inlet protection is not appropriate as a primary sediment control. Construction staff should always use it with other controls, such as an upstream buffer strip or storm drain diversion (Lake, 2016). In general, stormwater inlet protection is only practical for areas receiving relatively clean stormwater that does not contain large amounts of sediment, as the controls often clog quickly. If sediment and other debris clog the water intake, inlet protection controls can cause stormwater to bypass the inlet and erode unprotected areas.

Maintenance Considerations

Storm drain inlet protection controls require regular maintenance to prevent clogging and ensure effective operation. Regular maintenance activities include:

- Checking all controls after each storm event.
- Removing accumulated sediment from settling areas when the capacity decreases by half.
- Removing sediment from the settling area or unclogging weep holes if the control does not drain within 48 hours.
- Immediately replacing tears in fabric controls or internal filtering controls. This may require replacing the entire control depending on the amount of damage.
- Periodically removing additional debris from the shallow pools.

Effectiveness

Inlet protection controls alone have limited effectiveness, as stormwater would quickly overwhelm them if used as a primary control. However, inlet protection can provide a moderate level of pollutant removal in conjunction with other controls. Given the wide variability in designs of external controls, performance data for external controls is limited. In a review of 11 internal inlet protection controls, Clary et al. (2011) found inlet inserts to reduce total suspended solids concentrations from a median influent concentration of 52 mg/L to a median effluent concentration of 33 mg/L. Removals for other parameters, including metals and nutrients, were variable but mostly positive.

Q18

Cost Considerations[1]

The cost of implementing storm drain inlet protection controls varies depending on many factors including the control type, availability and proximity of materials, prevailing wage rates, and regional cost trends. It is therefore difficult to develop cost estimates that apply nationwide. The New York State Department of Environmental Conservation used average bid prices from 2013 to estimate a cost of $210 for each filter fabric inlet control and $1,100 for each excavated or block and gravel inlet control; they also suggest maintenance costs to be about 60 percent of construction costs (Lake, 2016).

[1]Prices updated to 2020 dollars. Inflation rates obtained from the Bureau of Labor Statistics CPI Inflation Calculator Web site https://data.bls.gov/cgi-bin/cpicalc.pl. Reference dates for the calculation are October 2011 and September 2019."

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Disclaimer

This fact sheet is intended to be used for informational purposes only. These examples and references are not intended to be comprehensive and do not preclude the use of other technically sound practices. State or local requirements may apply.

Stormwater Best Management Practice

Straw or Hay Bales

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Construction sites have historically used straw or hay bales for erosion and sediment control as check dams, inlet protection, outlet protection and perimeter control. Many applications of straw bales for erosion and sediment control are ineffective due to the composition of straw bales, inappropriate placement, inadequate installation, lack of maintenance or a combination of all these factors (Fifeld, 1999). In addition, straw bales are maintenance-intensive and can be expensive. Because many applications of straw and hay bales have been ineffective, EPA recommends carefully considering other stormwater control measures first. This fact sheet provides more information and alternatives to straw and hay bales.

Q19

Limitations

Limitations to straw and hay bales include the following:

- ***Channel flow***: Straw bales cannot reduce erosion in channel conveyances. Installing a straw bale structure across a channel may actually increase stormwater velocities by reducing the channel's cross-sectional area. This can result in increased erosion around the bales and widening of the channel's cross section (City of Portland, 2008).
- ***Heavy rain***: Straw bales do not work well in areas with heavy rain or on sites with large drainage areas or steep slopes. Straw bales can be impermeable and cannot withstand high flows. Construction staff should take care during placement and installation to avoid failure from undercutting, overtopping and end-running. Construction staff should not install straw bale structures across ditches or concentrated-flow areas because the structures can exacerbate erosion and flooding.
- ***Deployment and use***: Construction staff should not use straw bales on streets or sidewalks because they cannot properly stake the bales into concrete or asphalt, and the straw bales will wash away in higher flows. Straw bales are also difficult to transport and to carry around onsite, particularly when attempting to dispose of waterlogged straw bales. Often, the bindings break and the straw can wash into and clog storm drains (City of Portland, 2008).
- ***Resilience***: Straw bales will rot and fall apart over time (approximately 3 months), particularly in areas of high rainfall; therefore, they require intensive maintenance. Straw bales will float, and construction staff should properly stake them even in low-flow conditions. As previously stated, in high-flow conditions, water will flow around a straw bale barrier or undercut spaces between the bales.

Alternatives

The following is a list of typical applications for straw and hay bales and some alternative practices that are more effective.

Common Uses of Straw or Hay Bales	Alternatives to Straw or Hay Bales
Perimeter controls	■ Silt fence ■ Brush barrier
Check dams	■ Rock check dams ■ Fiber rolls ■ Compost filter berm ■ Filter berm
Slope protection	■ Geotextiles ■ Compost blankets ■ Erosion control blanket
Storm drain inlet protection	■ Filter fabric, gravel bags and other designs ■ Compost filter socks ■ Fiber rolls
Concrete washout structures	■ Prefabricated concrete washout containers

Considerations

If using straw bales (considering the limitations listed above), each bale should be at least 14 inches wide, 18 inches high and 30 inches long, with a minimum mass of 50 pounds (Broz et al., 2017). The straw bale should consist entirely of vegetation except for the binding material. Steel wire, nylon or polypropylene string should bind the bales. Bales should not have jute or cotton binding. Baling wire should be at least 14 gauges in diameter, while nylon or polypropylene string should

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have an approximately 12-gauge diameter with a breaking strength of 80 pounds of force.

Proper installation of straw bales is critical, as improper installation can make them ineffective. Construction staff should intrench straw bales approximately 4 to 6 inches into a pervious ground surface. They should use wood stakes to hold the bales in place. The stake material should be commercial-quality lumber that is free from decay, splits or cracks longer than the thickness of the stake or other defects that would render it structurally unsuitable. Steel bar reinforcement should be equal to a #4 designation or greater. Any exposed bar reinforcement should have end protection. Upstream slopes should be shallow, with an upstream flow path of less than 100 feet from the bale, as steep slopes will cause flow to overtop the straw bales.

Maintenance Considerations

Straw bales degrade making the replacement of rotting bales a regular maintenance activity. Replacement intervals are typically every 3 months, depending on local conditions. Maintenance will include repairing any erosion from washouts around the bales. Construction staff may also have to clean out sediment that settles in ponded areas around correctly installed bales when the sediment accumulation reaches one-third of the bale height. Construction staff will also have to remove straw bales when they burst open or are no longer necessary.

Effectiveness

Straw bale barriers are generally not as effective as similar alternative practices due to the limitations discussed above. These barriers often fill to capacity after small storms and can wash away if staked incorrectly. Straw bale structures cannot accommodate large storms and tend to fail during large storm events.

Cost Considerations

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Staked hay bales cost around $5 to $10 per linear foot to install depending on location, site layout and material availability. By comparison, silt fences cost around $2 to $3 per linear foot to install, last longer, and are often a more effective means of erosion and sediment control (RSMeans, 2019). Similarly, brush barriers can be a low-cost alternative to site perimeter control when material comes from the clearing of the site.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Treatment Chemicals for Particulate Removal from Construction Stormwater

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Q21

Description

Turbidity is a measure of suspended material in water that affects water's clarity. It is an optical property of water that indicates the presence of any material that reduces light transmission, such as colloids, clays, silts, and a variety of organic or inorganic particles. Turbidity in waterbodies may increase due to natural causes, such as river turbulence or algal blooms, but it may result from human disturbances, such as construction and development, urban stormwater, or combined sewer overflows. In stormwater discharges from construction sites, high turbidity often indicates sediment export that can damage downstream ecosystems. Although water quality standards vary by state, jurisdiction and receiving water classification, a commonly implemented criterion limits turbidity to no more than 5 Nephelometric Turbidity Units (NTUs) above the background turbidity of the receiving water (McLaughlin & Zimmerman, 2009).

At some construction sites, traditional stormwater control measures may not be able to adequately control sediment export. This can be due to a number of factors, including the high proportion of fine particles in on-site soils or challenging site conditions, such as steep slopes or highly erodible soils. In such cases, the use of treatment chemicals may be a consideration. Treatment chemicals stabilize sediment through coagulation or flocculation, processes that aggregate sediment particles into larger masses (often referred to as "floc") that are easier to remove through settling or filtration. The application of treatment chemicals to soil or to erosion control matting, a practice referred to as chemical stabilization, can also reduce erosion and sediment export.

A number of treatment chemicals are available for reducing stormwater-based sediment export from construction sites, including polyacrylamide (PAM—a generic term for a broad class of compounds), chitosan, gypsum, alum (aluminum sulfate), and DADMAC (diallyldimethylammonium chloride). Stormwater treatment chemicals are predominately water-soluble and, depending on their structure, may carry an electric

A truck equipped to spray chemical stabilizers throughout a construction site can be more effective at suppressing dust than water alone.

charge—cationic polymers carry a positive charge, and anionic polymers carry a negative charge. Some polymers are nonionic (no charge), and others are amphoteric (the charge depends on the pH of the water).

Although treatment chemicals can be effective at reducing sediment export, studies have shown significant toxicity in aquatic organisms from the application and misapplication of certain polymers. Cationic polymers are particularly toxic to aquatic organisms. As a result, some federal and state permitting authorities have restricted polymer use in stormwater management. Some require any construction site operator proposing to use cationic chemicals for sediment control to obtain prior approval to ensure proper use. Permits may also require that users of any other types of treatment chemicals comply with restrictions regarding their selection, application and storage to minimize the risk of a chemical release into the aquatic environment. Other state permitting programs have established restrictions (or prohibitions in some cases) on the types of chemicals that construction staff can use, the conditions under which they can apply them, the minimum training required for construction staff, and/or whether residual toxicity testing before and during application is a requirement. Therefore, before

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using any chemicals to treat construction site stormwater discharges, construction staff should contact their local stormwater permitting authorities to ensure that their use complies with federal, state and local requirements.

Siting and Design Considerations

Construction staff can apply treatment chemicals in several ways to reduce sediment levels in their stormwater discharges, such as on dry land or directly to stormwater discharge using passive or active systems, as described below. In all cases, consider using conventional erosion and sediment controls before and after the chemical treatment controls, both to improve overall effectiveness and to reduce the chance of downstream impact from the use of chemicals (U.S. EPA, 2019).

Passive Treatment Systems

Passive treatment refers to systems that apply treatment chemicals to existing soils, water impoundments, dispersion areas or conveyance features. Passive treatment systems are common, owing to their simplicity and generally lower cost. The following are several examples of passive treatment chemical applications.

Chemical soil stabilization

In a soil application, treatment chemicals help maintain soil structure by binding soil particles together. This makes soil more resistant to the erosive forces of wind or water and helps maintain infiltration rates early in a rain event (McLaughlin, 2015; Sojka et al., 2007). Treatment chemical application can be directly onto soil through the mixing in of dry granular powder or in liquid spray form. Liquid application is more effective for chemicals that require uniform application at low concentrations, such as PAM. Using liquid treatment chemicals in a hydroseeding mix can bind the seed, fertilizer and other additives to the soil until new vegetation establishment occurs. Applying a powdered treatment chemical over erosion control matting, straw or mulch can enhance its effectiveness.

Dust control

Construction sites can use treatment chemicals to control dust from haul roads, tailings piles, waste dumps and open areas. Similar to soil applications, application of the treatment chemical often involves dissolving it in water and then spraying it directly onto the road or other ground surface. Common chemical methods of dust control include water absorbing, organic non-petroleum, organic petroleum, synthetic polymer emulsion, concentrated liquid stabilizer and clay additive (Jones, 2017). Using treatment chemicals to bind the dust particles can also reduce the amount of water necessary to spray dusty construction areas.

Dispersion fields

Construction sites can use treatment chemicals within a dispersion field to help reduce sediment in their stormwater discharges. Dispersion fields reduce the velocity, erosive force and turbidity of rapidly flowing water and allow it to spread out over a relatively level area. These fields often use checks or wattles that are perpendicular to the flow to further reduce stormwater velocity. The addition of treatment chemicals to erosion control matting covering the dispersion field can facilitate a reduction in construction site stormwater discharges by binding together suspended particles that settle and adhere to the matting.

Treatment ditches

Treatment chemicals can enhance sediment removal in stormwater treatment ditches. For example, tethering soluble polymer along the upstream portion of a ditch that receives sediment-laden stormwater enables settleable floc formation. Applying erosion control matting to the lower portion of the ditch can reduce the water's velocity and allow the sediment to settle and adhere to the matting. Check dams can serve a similar purpose by reducing stormwater velocity and promoting settling.

Stormwater pipes

Anchoring soluble polymer blocks in split or closed stormwater pipes allows sediment particles to bind in flowing water, which in turn allows settling to occur in downslope practices before discharge of the water.

Active Treatment Systems

Active treatment systems provide a greater level of effectiveness and control but generally require more equipment and greater expense. These types of systems are applicable when traditional control measures or passive treatment systems cannot meet water quality standards. Active treatment systems typically require on-site chemical storage, chemical mixing, a reaction and clarification tank or basin, and media filtration. They often contain automated instrumentation to monitor water quality, flow rate and dosage control of treatment chemicals for both influent and effluent flows.

Chemical Selection

One of the most important factors when considering chemical treatment for erosion control or turbidity management is chemical selection. Even within major chemical groups, there is considerable variation to take into account and evaluate based on site-specific conditions. Factors that affect chemical effectiveness, and therefore chemical selection, include sediment type and composition (e.g., relative fractions of clay, silts, sand and organic matter). If treating stormwater directly, construction staff should consider additional water quality parameters such as hardness, pH and dissolved organic carbon. If chemicals are land-applied, factors like vehicle traffic and rainfall (or lack thereof) are important considerations.

When using liquid-based chemical treatment for turbidity management, preliminary jar tests are a good way to test a range of chemicals using actual site soil and water. Jar tests allow for the screening of multiple chemicals as well as the determination of the optimal dose. Chemical manufacturers generally provide specific testing protocols and will often do the testing themselves if sites provide them with site water and soil. Soil testing is also possible for land-based applications.

Once a design engineer selects a specific chemical, they should determine the proper dosage to both optimize effectiveness and limit the potential for export of unreacted chemical. Again, manufacturers are a good source of preliminary information. However, depending on the chemical and specific site conditions, field-based testing may be necessary to measure effectiveness and chemical residuals in stormwater. In all cases, design engineers should consult local permitting authorities, who can often provide guidance on chemical-handling requirements, appropriate application methods and downstream water quality requirements.

Effectiveness

The effectiveness of chemical treatment depends on site-specific conditions as well as overall water quality goals of the project. Any one polymer is not effective for all soils and increasing the treatment chemical application rate will not necessarily result in better performance; in fact, over-application often causes more harm than good.

The goals of most system designs are to reduce sediment export, often measured in terms of turbidity, to a level that local regulations consider acceptable. The definition of this level is typically within 5 NTU of background turbidity, but it can be more stringent for environmentally sensitive waters. As such, some projects may require greater than 90 percent reduction in turbidity, while others may require less than 50 percent. For active and passive systems, concentration reductions from around 300 NTU to 5 NTU are common, while a properly designed active treatment system is effective for treatment of waters up to 1000 NTU (Druschel, 2014).

Cost

Chemical treatment costs vary widely depending on the chemical type and application method. In a review of construction projects using liquid-based active treatment systems, Druschel (2014) cited work from McLaughlin and Zimmerman (2009) that found reported treatment costs for continuous treatment (in-line) systems were between $0.01 and $0.03 per gallon and costs for batch reactor (off-line) systems were as high as $0.08 per gallon. Where water requires less treatment, passive treatment systems may allow for cost savings. Land application may also be less expensive. McLaughlin (2015) notes that at a cost of $6 per pound and a standard application rate of 20 pounds per acre, material application costs for PAM are around $120 per acre.

Additional Resources

- U.S. Department of Agriculture. (2016). *Conservation practice standard for anionic polyacrylamide (PAM) application* (450-CPS-1).

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Stormwater Best Management Practice

Vegetated Buffers

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Sediment Control

Description

Vegetated buffers are areas of natural, existing or established vegetation that protect the water quality of neighboring areas and waterbodies during construction. Buffer zones provide an area where stormwater can permeate the soil and replenish the groundwater (WES, 2008). They also slow the flow of stormwater, which helps to filter sediment, decrease soil erosion and prevent streambank collapse.

Applicability

Q22

Vegetated buffers are applicable in most areas able to support vegetation. They are most effective and beneficial on floodplains, near wetlands, along streambanks and on unstable slopes. Local requirements or a construction general permit may require natural vegetated buffers based on a site's proximity to waterbodies or if a site discharges to a sensitive water, such as impaired waters, exceptional waters or wetlands.

Siting and Design Considerations

When siting vegetated buffers, design engineers should first identify existing and proposed natural buffer zones on a site map (MDE et al., 2011). Prior to construction, construction staff should mark clearing limits to keep all construction activities out of natural buffer zones and limit damage to vegetation (Washington Department of Ecology, 2019).

It is important to not overwhelm vegetated buffers with fast, erosive, and/or concentrated flows. If upstream flowpaths generate concentrated flows, design engineers should incorporate other practices such as sediment traps or check dams to moderate discharges onto buffers. Design engineers can also use level spreaders upstream of buffers to reestablish sheet flow conditions.

Additional siting and design considerations include:

Using a vegetated buffer along the perimeter of a construction site can deter sediment from moving off site.
Photo Credit: Steven Chase for USEPA

- Preserving natural, existing or established vegetation in clumps, block or strips.
- Preserving natural, existing or established vegetation on unstable, steep slopes.
- Making sure slopes are shallow enough to allow establishment of vegetation.
- Making sure soils are not compacted.
- Where possible, intermixing layers of vegetation (native vegetation in particular), including grasses, deciduous and evergreen shrubs, and understory and overstory trees.

Limitations

Adequate land should be available for a vegetated buffer. If land costs are high, a buffer zone may not be the most cost-effective practice. Vegetated buffers work well with sheet flow, but they are not appropriate for mitigating concentrated stormwater flows. In addition, construction staff should maintain adequate vegetative cover to keep buffers effective.

Maintenance Considerations

Keeping buffer vegetation healthy requires routine maintenance. Maintenance needs depend on vegetation species, soil type and climatic conditions. Maintenance can include weed and pest control, mowing, fertilizing, liming, irrigating, and pruning. Inspection and maintenance are most important during buffer installation. Following establishment, vegetated buffers only require routine maintenance and periodic inspections. Construction staff should inspect them after heavy rainfall and at least once a year. Inspections should focus on encroachment, erosion, vegetation density, evidence of concentrated flows, and any damage from foot or vehicular traffic.

Effectiveness

The effectiveness of vegetated buffers depends on buffer width, buffer slope, vegetation type, soil conditions and geographic location. For 50-foot natural buffers in combination with perimeter controls, the EPA's Construction General Permit Appendix G reports sediment removal efficiencies ranging from approximately 25 to 90 percent.

Cost Considerations

A vegetated buffer can be a low-cost practice when there is adequate area for preserving natural, existing or established vegetation. Establishing a vegetated buffer includes the cost of clearing, plants or seeding, and maintenance.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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Disclaimer

Stormwater Best Management Practice

General Construction Site Waste Management

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Good Housekeeping/Materials Management

Description

Construction staff manage and dispose of building materials and other construction site wastes to reduce the risk of pollution to stormwater. Practices such as trash disposal, recycling, proper material handling, and spill prevention and cleanup measures can reduce the potential for stormwater flow to mobilize construction site wastes and contaminate surface or ground water.

Applicability

Proper management and disposal of wastes will reduce pollution in stormwater discharge from any construction site. Good waste management practices include properly locating refuse piles, covering materials that stormwater discharges might displace, and preventing spills and leaks from hazardous materials.

Siting and Design Considerations

Waste management practices vary depending on the type of waste being managed, whether it is hazardous, and whether it might contaminate stormwater. Below are examples of management practices for different categories of construction site waste.

General Solid Wastes:

- Designate a waste collection area on-site that does not receive a substantial amount of stormwater flow from upland areas and does not drain directly to a waterbody.
- Ensure that containers have lids to cover them when it rains, or keep containers in a covered area whenever possible.
- Schedule waste collection to prevent the containers from overfilling.
- Clean up spills immediately. Use an absorbent material such as sawdust or cat litter to contain the spill.
- During the demolition phase of construction, provide extra containers and schedule more frequent pickups.
- Collect, remove and dispose of all construction site wastes at authorized disposal areas. Contact a local environmental agency to identify these disposal sites.

Construction waste should be collected in designated waste collection areas on-site, such as metal dumpsters.

Hazardous Materials and Wastes:

- For spills of hazardous materials, follow cleanup instructions on the package or, if applicable, the Safety Data Sheet.
- Consult with local waste management authorities about the requirements for disposing of hazardous materials.
- Never remove the original product label from the container—it contains important safety information. Follow the manufacturer's recommended method of disposal, which should appear on the label.
- Never mix excess products when disposing of them, unless the manufacturer specifically recommends doing so.
- For soils containing hazardous substances, consult with state or local solid waste regulatory agencies or private firms to ensure proper disposal. Some landfills might accept contaminated soils, but they require laboratory tests first.
- Construction staff often use sandblasting to remove paint and dirt from surfaces. This produces sandblasting grits—sand and paint and dirt particles. Sandblasting grits from older structures are hazardous, because they are more likely to contain lead-, cadmium- or chrome-based paints. To ensure

proper disposal of sandblasting grits, contract with a licensed waste management or transport and disposal firm.

Pesticides and Fertilizers:

- Follow all federal, state and local regulations that apply to the use, handling or disposal of pesticides and fertilizers.
- Do not handle the materials any more than necessary.
- Store pesticides and fertilizers in a dry, covered area.
- Construct berms or dikes to contain stored pesticides and fertilizers in case of spillage.
- Follow the application rates and methods specified on the product label.
- Have equipment and absorbent materials available in storage and application areas to contain and clean up any spills.

Petroleum Products:

- Store new and used petroleum products for vehicles in covered areas with berms or dikes in place to contain any spills.
- Immediately contain and clean up any spills with absorbent materials.
- Have equipment available in fuel storage areas and in vehicles to contain and clean up any spills.

Detergents:

- Detergents that contain phosphorus and nitrogen are common in wash water for cleaning vehicles. Excesses of these nutrients can be a major source of water pollution. Use detergents only as recommended and limit their use on the site. Do not dump wash water containing detergents into the storm drain system; direct it to a sanitary sewer or capture and contain it for transport to a wastewater treatment plant for proper treatment.

Limitations

An effective waste management system requires training and signage to promote awareness of the hazards of improper storage, handling and disposal of wastes. Site superintendents should be aware of worker habits and inspect storage areas regularly. They may need to spend extra management time to ensure that all workers are following the proper procedures.

Maintenance Considerations

Construction staff should inspect storage and use areas and identify containers or equipment that could malfunction and cause leaks or spills. In addition, it is important for staff to check equipment and containers for leaks, corrosion, support or foundation failure, or other signs of deterioration, and test them for soundness. Construction staff should immediately repair or replace any defective containers.

Effectiveness

Waste management practices are effective only when all construction staff follow them consistently. In storage and use areas, site superintendents should post the guidelines for proper handling, storage and disposal of construction site wastes. In addition, site superintendents should ensure that workers receive training in these practices to ensure that everyone is knowledgeable enough to participate.

Cost Considerations

The costs associated with construction site waste management include purchasing and posting signs, increased management time for oversight, additional labor needed for special handling of wastes, transportation costs for waste hauling, and fees charged by disposal facilities to take the wastes.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

Stormwater Best Management Practice

Spill Prevention and Control Measures

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Good Housekeeping/Materials Management

Description

Liquid and solid products may enter the environment when they leak or spill from containers during use or transfer. These materials may then directly enter nearby storm drains or receiving waters, or stormwater may carry them there (WES, 2008). Federal requirements for the construction and development industry require that any stormwater discharge permit for construction sites include requirements to "minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures" (40 CFR §450.21(d)(3)). Most state Construction General Permits (CGPs) and EPA's CGP require that stormwater pollution prevention plans (SWPPPs) identify measures to prevent, contain, clean up and dispose of material leaks or spills. Managers of small municipal separate storm sewer systems (MS4) should develop, implement and enforce a program to reduce stormwater pollutants from any construction activity within the MS4 that results in a land disturbance of greater than or equal to one acre, as well as any construction activity that is part of a larger common plan of development or sale that would disturb one acre or more. Managers should share these procedures with construction personnel as part of the program and examine those procedures when doing inspections/reviews.

Applicability

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Spill prevention and control measures apply to construction sites that store or use materials such as pesticides, paints, cleaners, petroleum products, fertilizers, concrete wash, metals, solvents, soil stabilizers and binders, and contaminated groundwater. Construction staff should develop spill prevention and control measures for material storage areas, refueling stations (both mobile and stationary), material transfer locations, storm drain inlet and outlet locations, and waterways (WES, 2008). The spill prevention, control and countermeasure (SPCC) rule (40 CFR §112) covers every site with a total aboveground oil storage capacity greater than 1,320 gallons or a buried oil storage capacity greater than 42,000 gallons of petroleum products. The SPCC rule requires every such site to prepare and implement an SPCC plan, which may differ from SWPPP requirements for spill prevention and control measures (U.S. EPA, 2007).

Skill kit at a construction site.

Siting and Design Considerations

As the name implies, spill prevention and control measures consist of pollution prevention measures and measures to control and minimize impact if a spill does occur. Prevention measures should be routinely implemented by construction staff while spill control measures are generally included within a spill plan such as an SPCC plan. All construction staff should be familiar with both prevention and control measures.

When developing spill prevention and control measures, construction staff should identify areas where spills are likely to occur, such as loading and unloading areas, storage and processing areas, places where dust or particulate matter is generated or handled, areas where

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equipment maintenance and fueling occur, chemical storage areas, and areas designated for waste disposal. Construction staff should also evaluate the spill potential for stationary facilities—including manufacturing areas, warehouses, service stations, parking lots and access roads—during the project planning phase and re-evaluate that potential during each phase of construction. Designing projects to minimize or use the right amount of herbicides, fertilizers and petroleum-based fuels can also be an important way to reduce stormwater pollutants (PWD, 2018). If construction staff need any of these materials on-site, they should use them as quickly as possible upon delivery to minimize the risk of a spill.

The most successful spill prevention and control measures include both structural and operational controls. Routine prevention measures include (SPU, 2017a, 2017b; U.S. EPA, 2019):

- Recycling, reclaiming or reusing materials, thereby reducing the amount of process materials that are brought on-site.
- Installing leak detection devices, overflow controls and diversion berms.
- Installing inlet protection on storm drains.
- Performing preventative maintenance on storm tanks, valves, pumps, pipes and other equipment.
- Using material transfer procedures or filling procedures for tanks and other equipment that minimize spills.
- Substituting less toxic or non-toxic materials for toxic materials.
- Storing materials in covered areas and within adequate secondary containment structures.
- Leaving hazardous materials in original, labeled containers and keeping Safety Data Sheets on-site.
- Storing materials off the bare ground and away from vehicular traffic and drainage pathways.
- Maintaining a clearly labeled and prominently displayed spill kit that includes, at a minimum, absorbent pads, sorbent booms or socks, absorbent granular material, protective clothing (such as latex gloves and safety glasses), thick plastic garbage bags, and drain covers.
- Following good housekeeping practices at project sites, such as appropriately disposing of unwanted or unused waste material and immediately cleaning up spills or debris.

In the event of a spill, it is critical that a plan and appropriate equipment be in place and responsible parties be identified to carry out control measures immediately. A spill plan, such as an SPCC plan, should include components such as (SPU, 2017a, 2017b; U.S. EPA, 2019):

- Identification of individuals responsible for implementing control measures as well as personnel to contact in case of a spill.
- Identification of spill response procedures for small, medium and worst-case discharges, as appropriate.
- Definition of safety measures for each kind of waste.
- Instructions for how to notify appropriate authorities, such as police and fire departments, hospitals, or municipal sewage treatment facilities, for assistance.
- Description of procedures approved by state and local governments for containing, diverting, isolating and cleaning up spills.
- Description of spill response equipment to use, including safety and cleanup equipment, location of spill kits, and proper disposal methods for used materials.

For any spill, construction staff should avoid the use of water for cleaning to prevent contaminated stormwater from reaching storm drains; dry spills can be swept up while wet spills can be contained and absorbed using the equipment included in standard spill kits.

Limitations

Training is necessary to ensure that all workers are aware of and knowledgeable about spill prevention and control measures. All staff on-site should receive training on spill prevention and control measures, including regular refresher training. Construction staff should make equipment and materials for cleanup readily accessible and mark them clearly so workers can follow procedures quickly and effectively.

Maintenance Considerations

Construction staff should update the spill prevention and control measures regularly to accommodate any changes to the site, procedures or responsible staff (this may include a site diagram showing the locations of spill kits, drainage pathways and evacuation routes). They should regularly inspect areas where spills may occur to ensure that procedures are posted and cleanup equipment is readily available. They should also replace spill kit materials as soon as workers use them and ensure spill kits always remain easily accessible.

Effectiveness

Spill prevention and control measures can be highly effective at reducing the risk of surface and groundwater contamination; however, to ensure workers follow the procedures, construction staff should provide worker training, appropriate materials and equipment for cleanup, and adequate staff time. If a spill occurs, prompt action is the most effective measure to limit environmental harm and cleanup costs.

Cost Considerations

Spill prevention and control measures can be inexpensive to implement; however, construction staff need adequate time and resources to properly handle and dispose of spills. Good housekeeping is the cheapest and most cost-effective way to control a spill. Once a spill has occurred, the cost of cleanup can be significant.

. Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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Stormwater Best Management Practice

Vehicle Maintenance and Washing Areas at Construction Sites

Minimum Measure: Construction Site Stormwater Runoff Control
Subcategory: Good Housekeeping/Materials Management

Description

Ideally, vehicle maintenance and washing should occur in garages and wash facilities, not on active construction sites. However, if these activities must occur on-site, operators should follow appropriate best practices to prevent untreated wash water containing soaps, solvents, detergents, nutrients, sediment, grease or hazardous wastes from discharging into storm drains, surface waters or groundwater. For information on washing down truck tires, see the Construction Entrances fact sheet.

A truck having its tires washed before leaving a construction site.

Applicability

Vehicle maintenance and washing best practices apply to all construction sites where these activities occur. For municipal separate storm sewer system permittees, municipalities consider untreated wash water to be an illicit discharge. Construction staff should therefore direct the wash water to a sanitary sewer or treat it on-site before discharge.

Implementation

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Construction site operators should prevent vehicle and equipment wash water and water from maintenance activities from commingling with stormwater or discharging to the stormwater system. Fuels, oils or other pollutants from vehicle and equipment operation and maintenance, as well as soaps, solvents or detergents from vehicle and equipment washing, are all prohibited discharges from construction sites (40 CFR 450). Helpful practices include (U.S. EPA, 2007; MPCA, 2019):

- *Inspecting construction vehicles daily and repairing any leaks immediately.* The most effective method for reducing costs and environmental concerns associated with vehicle maintenance is to prevent leaks and spills from occurring. Regularly maintain and inspect vehicles to remedy issues with leaking vehicle fluids. Place drip pans and spill pads beneath stored vehicles/equipment as a preventative containment practice in the event that a leak occurs. Perform vehicle maintenance activities in a covered, designated area with impervious surfaces.
- *Disposing of all used oil, antifreeze, solvents and other automotive-related chemicals and materials (e.g., oily rags) according to manufacturer instructions*. These wastes require special handling and disposal. Designated facilities can recycle used oil, antifreeze and some solvents, but construction staff should dispose of other chemicals at a hazardous waste disposal site. Local government agencies can help identify such facilities. Store raw and used hazardous chemicals, oils, and other products in a covered area with secondary containment. Should any material spills occur, sites should implement the procedures outlined in their site-specific spill prevention and spill cleanup plans. Make spill kits readily available and strategically place them throughout the site.
- *Designating special paved areas for vehicle and equipment washing.* Vehicle and equipment washing should occur in designated areas with overhead coverage and containment. Clearly mark all washing

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areas and inform workers that all washing should occur in this area. Do not perform other activities, such as vehicle repairs, in the wash area. Because water alone can adequately remove most dirt, use high-pressure water spray without detergents at vehicle washing areas. If you need to use detergents, avoid phosphate- or organic-based cleaners to reduce nutrient enrichment and biological oxygen demand in wash water. Use only biodegradable products that are free of halogenated solvents. Direct wash water from washing activities to treatment facilities, haul the wash water off-site for proper disposal or direct the water to the sanitary sewer (if applicable). Use blowers or vacuums instead of water to remove dry materials from vehicles, if possible.

Limitations

The techniques and practices mentioned above effectively reduce discharges of untreated automotive wastes and wash water to receiving waters. Their effectiveness highly depends on personnel training and level of commitment to following procedures. Limitations for these practices primarily pertain to cost, as maintenance of vehicle wash areas is minimal and may involve repairing berms and disposing of collected vehicle wash water. Vehicle maintenance and washing area limitations can include disposal costs for wash water (fees that hazardous waste disposal facilities charge); construction costs for an enclosed maintenance area; connection to a sanitary sewer (if applicable); and labor costs for hazardous waste storage, handling, and disposal. Depending on the volume of wash water construction staff generated and the type of detergents they use, vehicle wash areas may also require permits.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

References

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U.S. Environmental Protection Agency (U.S. EPA). (2007). *Developing your stormwater pollution prevention plan: A guide for construction sites* (EPA 833-R-06-004).

Disclaimer

This fact sheet is intended to be used for informational purposes only. These examples and references are not intended to be comprehensive and do not preclude the use of other technically sound practices. State or local requirements may apply.