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EVALUATION OF FLARED-END INLET PROTECTION PRODUCTS FOR SEDIMENT RETENTION

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16. Abstract

Construction sites are considered one of the main sources of sediment and contaminants that can create water quality concerns in the receiving waters. When rainfall occurs, loose soil particles are disintegrated and eroded from the bare soil area and transported to roads and parking lots. When earthwork is performed to construct buildings and highways, the rate of erosion increases. The sediment from these areas mixes with water and enters the roadside when it rains or snow melts. This can lead to clogging of drainage systems and street flooding. This can also escalate treatment cost due to increased sediment load for the wastewater treatment facilities.

Various tests were performed to analyze the effectiveness of flared-end inlet protection products. The tests were conducted at the Erosion Control Research and Training Center (ECRTC) of the University of Illinois at Urbana-Champaign. These tests analyzed the ability of the products to prevent sediment from entering curb and gutter inlets via site runoff. The goal of these tests was to compare the various products and determine which would perform the best in preventing sediment from entering the inlets at construction sites. Several criteria were used in testing in order to make the best recommendations to the Illinois Department of Transportation (IDOT). The products analyzed in testing were (1) sediment log, (2) silt fence (with woven monofilament fabric), (3) silt fence (with IDOT-approved fabric), (4) straw bale, and (5) stone.

The duration of the test was 30 minutes with a discharge rate of 158 gpm (10 L/s). One 5 gallon bucket of clay soil was initially mixed into a 300 gallon filled tank. Another 5 gallon bucket was later poured at 10 and 20 minutes. This mixture would spill over into the channel, where samples would be collected before and after the product was installed. The water samples were collected every 5 minutes and were oven-dried to determine sediment concentration. With this procedure, it was possible able to determine how efficient each product was in terms of sediment retention. It was found that the sediment log and silt fence with woven monofilament fabric performed better than the other products tested. Although several products were able to filter efficiently, they often created heavy amounts of ponding. The evaluation was based on two criteria: water should be able to infiltrate the product without creating heavy ponding and the product should retain a large fraction of the sediment.

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EXECUTIVE SUMMARY

Construction sites are considered one of the main sources of sediment and contaminants that can create water quality concerns in the receiving waters. When rainfall occurs, loose soil particles are disintegrated and eroded from the bare areas. When earthwork is performed to construct buildings and highways, the rate of erosion increases. The sediment from these areas mixes with water and enters the roadside when it rains or snow melts. This can lead to clogging of drainage systems and street flooding. This can also escalate treatment cost due to increased sediment load for the wastewater treatment facilities.

Various tests were performed to analyze the effectiveness of flared-end inlet protection products. The tests were conducted at the Erosion Control Research and Training Center (ECRTC) of the University of Illinois at Urbana-Champaign. These tests analyzed the ability of the products to prevent sediment from entering curb and gutter inlets via site runoff. The goal of these tests was to compare the various products and determine which would perform the best in preventing sediment from entering the inlets at construction sites. Several criteria were used in testing in order to make the best recommendations to the Illinois Department of Transportation (IDOT). The products analyzed in testing were (1) sediment log, (2) silt fence (with woven monofilament fabric), (3) silt fence (with IDOT-approved fabric), (4) straw bale, and (5) stone.

The duration of the test was 30 minutes with a discharge rate of 158 gpm (10 L/s). One 5 gallon bucket of clay soil was initially mixed into a 300 gallon filled tank. Another 5 gallon bucket was later poured at 10 and 20 minutes. This mixture would spill over into the channel, where samples would be collected before and after the product was installed. The water samples were collected every 5 minutes and were oven-dried to determine sediment concentration. With this procedure, it was possible able to determine how efficient each product was in terms of sediment retention. It was found that the sediment log and silt fence with woven monofilament fabric performed better than the other products tested. Although several products were able to filter efficiently, they often created heavy amounts of ponding. The evaluation was based on two criteria: water should be able to infiltrate the product without creating heavy ponding and the product should retain a large fraction of the sediment.

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SECTION 1: INTRODUCTION

Sediment in water bodies originates from soil erosion of bare land. Sediment from construction sites finds its way into inlets on roadsides that are commonly used to drain water from roads. If proper protection measures are not taken, inlets can be clogged by the accumulated sediment and debris in the sewer system. This can cause flooding of roadways and potentially create hazardous condition for the drivers.

With such concerns becoming more common, preventive measures should be adopted for sediment entering a water body through inlets. Suspended sediments can be trapped by inlet protection products, reducing wastewater treatment costs and sediment load to the receiving waters. Although coarse sediment particles can't pass through the products, smaller particles such as clay can easily pass through them. Inlet protection products not only act as a barrier to the sediment, but they also help dissipate the flow energy of water. This reduction in velocity increases the amount of time it takes flowing water to enter the inlet, preventing overflow into drains. Implementing these products helps reduce the cost of treating the water and helps prevent flooding of the sewer system.

These products should be able to retain sediment while creating minimum ponding. Products must be porous enough to prevent flooding—but not so porous that sediment particles can flow through it without restriction. It is important to evaluate products on these merits, along with the extent to which they reduce the amount of sediment entering the inlet. If a product stops all sediment from coming through, high levels of ponding will occur. This scenario is not ideal for roadways and may make them unusable.

Another consideration when evaluating a product is its installation method. A products should be installed in accordance with manufacturer's instructions. Improper installation can lead to flooded roadways and additional maintenance costs. It is also important to determine which installation methods can be improved and which ones lead to product failure due to insufficient filtration and/or excessive ponding.

SECTION 2: OBJECTIVES

The purpose of this study was to examine several products for sediment retention in flared-end inlets, and provide recommendations to the Illinois Department of Transportation (IDOT) based on the results of performance tests and analysis. The analysis was based on several criteria, such as the extent ponding effects, sediment trapping efficiency, and product durability.

The specific goals of the project were as follows:

- Conduct a field experiment and collect samples to test product effectiveness in sediment retention.
- Examine the extent of flooding created by each product.
- Provide recommendations about which products worked best under the test conditions.

SECTION 3: METHODOLOGY

3.1 FLARED-END INLET PROTECTION PRODUCTS

Seven products were tested at the Erosion Control Research and Training Center (ECRTC) at the recommendation of the Illinois Department of Transportation (IDOT).

3.1.1 Sediment Log

Manufactured by American Excelsior, Curlex sediment logs (Figure 3.1) are made of curled excelsior wood fiber rolls of various diameters. They are designed to reduce hydraulic energy and to filter runoff. Sediment logs provide temporary, biodegradable channel interruption by slowing water velocity to reduce shear stress over the channel, thereby minimizing soil degradation in the channel and enhancing vegetation establishment (American Excelsior 2015).

Figure 3.1 Sediment log.

Installation method:

1. Dig a trench 0.5 foot (6 inches) deep; place product in front of the flared-end inlet.
2. Place product into trench; hammer stakes 2 feet into the ground at 45 degrees toward the flow.
3. Place stakes every 2 feet around the log.
4. Backfill the trench with excess soil; compact soil to secure product firmly.

3.1.2 Silt Fence (With Woven Monofilament Fabric)

The silt fence with woven monofilament fabric (Figure 3.2) is more porous than standard IDOT silt fence fabric. It holds sediment particles while letting water pass through the product.

Figure 3.2 Silt fence with woven monofilament.

Installation method:

1. Dig a trench 0.5 foot (6 inches) deep in front of the flared-end inlet.
2. Staple the fabric to wooden stakes, if they are not already attached.
3. Hammer wooden stakes at least 2 feet within the trench.
4. Backfill trench with excess soil; compact soil to secure product firmly.

3.1.3 Silt Fence (IDOT-Approved Fabric)

The silt fence with IDOT-approved fabric (Figure 3.3) is used to filter sediment particles from construction sites, barren land, and tilled agricultural land. It prevents sediment from entering water bodies, helping to ensure that water quality will not suffer and aquatic life remains safe (EPA 2012). Silt fences should be installed on level land and kept in place until the soil becomes stabilized. The installation method is the same as for the silt fence with woven monofilament fabric.

Figure 3.3 Silt fence with IDOT-approved fabric.

3.1.4 Straw Bales

Straw bales (Figure 3.4) are temporary sediment retention products commonly used on construction sites to filter sediment. They are usually installed by placing straw bales in a row and tying them with wire or nylon or polypropylene string. When used in a channel, straw bales should weigh at least 50 pounds. An average straw bale should contain at least 5 cubic feet of material and be 30 inches in length (Broz et al. 2003). The straw bale tested in this study was purchased from a local store and was 41 inches long, 19 inches wide, and 12 inches high.

Straw bales should be used for short durations only (around 3 to 6 months) because they likely will deteriorate and rot after that time. Straw bales are best suited for use with low flow rates because their impermeability will cause most of the water to immediately pond. They cannot be used on the roadside, primarily because they must be installed and secured with wooden stakes.

Figure 3.4 Straw bales.

Installation method:

1. Dig a trench 0.5 foot (6 inches) deep; place product in front of the flared-end inlet.
2. Place product inside trench; ensure firm placement.
3. Hammer wooden stakes through the bales, making sure that the stakes are buried at least 2 feet deep underneath the bales.

3.1.5 Stone

Another product that was evaluated as a flared-end protection measure was a stone check dam (Figure 3.5). The structure consisted of riprap stones that were layered in front of the inlet. This setup caused water to pond upstream of the product, allowing sediment to settle before entering the inlet. Stone can be used under any flow and is often best used in conjunction with other best management practice (BMP) products. Large stones are primarily used for high flows, while small stones are used for low flows for trapping fine sediment. Upon installation, they can be designed for temporary or permanent use.

Figure 3.5 Flared-end inlet protection using stone.

Installation method (Dane County 2007):

1. Dig a 0.5 foot (6 inches) deep trench to extend across the channel in front of the flared-end inlet.
2. Place geotextile fabric inside trench.
3. Place 4 to 6 inch diameter stone on top of geotextile fabric with the structure size to stand between 1 to 5 feet in height as needed.
4. Place 0.75 inch diameter stone on upstream side of the structure.
5. Ensure the structure has a minimum width of 2 feet and extends around the inlet.

3.2 TESTING PROTOCOL

3.2.1 Field Setup

To test the sediment filtration by flared-end inlet protection products, certain procedures were followed. Before the field tests began, the test channel was tilled and leveled to an approximately parabolic shape (Figure 3.6).

Figure 3.6 Preparation of field for testing.

3.2.2 Flow Calibration

To calibrate flow, a volume time measurement using a 158 gallon (100 L) graduated water bucket (Figure 3.7). The time duration to fill the bucket entirely to 158 gallon (100 L) was noted with a stopwatch, and the flow rate was calculated by dividing the total volume by time. The average time to fill 158 gallon (100 L) was calculated to be around 10 seconds, providing a flow rate of 158 gallons/minute (gpm) or 10 L/s.

Figure 3.7 Graduated water bucket (with 158 gallons capacity) used for flow calibration (Source: Yankee Containers®).

3.3 TEST SETUP

The total duration of the test was 30 minutes. Water from the pump was discharged at a rate of 158 gpm (10 L/s) and was poured into a 300 gallon tank. At the beginning of the test, one 5 gallon bucket of clay soil was added to the tank and stirred continuously throughout the experiment (Figure 3.8). Another 5 gallon bucket of clay soil was added to the tank 10 and 20 minutes after the initial addition (Figure 3.9). Continuous mixing prevented any soil from settling to the bottom.

Figure 3.8 Sediment mixing.

Figure 3.9 Adding clay soil.

3.4 SAMPLE COLLECTION

Samples were collected before the product (Figure 3.10) and after the product (Figure 3.11). Samples were collected every 5 minutes until the 30 minute mark, along with a sample taken when the test initially began. The soil mixture tank was stirred continuously to ensure that the samples would have a consistent homogenous soil concentration.

Figure 3.10 Sample taken before product.

Figure 3.11 Sample taken after product.

3.5 LABORATORY ANALYSIS

Collected samples were taken to a lab to measure sediment concentrations. If possible, turbidity readings were taken for the samples in nephelometric turbidity units (NTUs).

As samples were acquired during the experiment, they were organized based on time duration from initial to final (Figure 3.12). These samples were collected in cylindrical glass jars and taken to the lab where they were initially weighed (W1) (Figure 3.13). Jars were then placed in an oven at ~105°C for ~48 to 72 hours for to evaporate the water (Figure 3.14). Once the water evaporated, the bottles containing soil residue were weighed again (W2) (Figure 3.15). The bottles were washed and weighed (W3). The weight of the soil residue was obtained by subtracting W3 from W2 (W4 = W2 – W3).

Figure 3.12 Sample collection.

Figure 3.13 Soil sample weighing (W1).

Figure 3.14 Heating the samples.

Figure 3.15 Soil residue weighing (W2).

SECTION 4: OBSERVATIONS

4.1 SEDIMENT LOG

The sediment log proved to drain efficiently under the experimental flow rate of 158 gpm (10 L/s). Water started to pond around the product at 3-1/2 minutes (Figure 4.1). Slight undercutting of the product was observed, likely due to increased ponding (Figure 4.2). The channel was completely drained 9-1/2 minutes after testing concluded. At the end of testing, it was observed that the product was free of any rips or tears. This product worked well for sediment retention but created ponding at the same time.

Figure 4.1 Sediment log at 158 gpm (10 L/s) flow rate.

Figure 4.2 Undercutting observed underneath the product.

4.2 SILT FENCE (WITH WOVEN MONOFILAMENT)

The silt fence with woven monofilament fabric (Figure 4.3) proved to drain efficiently under the experimental flow rate of 158 gpm (10 L/s) (Figure 4.4). Due to the product's permeable mesh, water passed through with minimal amounts of ponding (Figure 4.5). This was evidenced by the slight water level difference, around 1 to 3 inches, between the upstream/downstream sides (Figure 4.6). Slight ponding occurred through the experiment, with no observed undercutting. This product worked well for sediment retention but created ponding at the same time.

Figure 4.3 Silt fence (woven monofilament).

Figure 4.4 Silt fence (woven monofilament) at 158 gpm (10 L/s) flow rate.

Figure 4.5 Flow through the silt fence (woven monofilament) during the test.

Figure 4.6 Observed water level difference upstream and downstream of the silt fence (woven monofilament).

4.3 SILT FENCE (IDOT-APPROVED FABRIC)

Water passed through the IDOT-approved fabric of the silt fence (Figure 4.7) at 1-1/2 minutes, with heavy ponding at 4-1/2 minutes (Figure 4.8). As ponding increased, water pressure on the material and stakes also increased (Figure 4.9). By 8 minutes, signs of severe undercutting were observed (Figure 4.10). Despite meticulous effort to ensure compacting was done well around the silt fence, the hydrostatic pressure created by ponded water caused undercutting. The undercutting started initially near the center, but it eventually was observed at every stake. By the end of the experiment, the entire channel was flooded due to the ponding. Based on the observations of severe undercutting, it can be concluded that the product failed during the experiment and is inadequate for field use for a flow rate of 158 gpm (10 L/s) or higher.

Figure 4.7 Silt fence with IDOT-approved fabric.

Figure 4.8 Heavy ponding (silt fence with IDOT-approved fabric).

Figure 4.9 Water pressure stressing the silt fence with IDOT-approved fabric.

Figure 4.10 Product undercutting (silt fence with IDOT-approved fabric).

4.4 STRAW BALE

It was observed during the test that it took around 2 minutes for flow to penetrate the product (Figure 4.11). Ponding started to occur around 3 minutes after the test began. Heavy ponding occurred at 6-1/2 minutes, along with undercutting near the center of the product (Figure 4.12). Due to extensive ponding, hay and other debris circulated in front of the product, clogging the product. Extreme ponding occurred around 10 minutes into testing, which nearly flooded the entire channel, with deep undercutting at multiple locations (Figures 4.13). As a result of this undercutting, it was observed that a heavy amount of sediment entered the inlet (Figures 4.14 and 4.15). It was also observed that loose hay straws entered the inlet along with the flow. This can lead to clogging of the inlet over the time. Due to heavy amounts of ponding and undercutting, the straw bale can be considered a product failure and inadequate for field use for a flow rate of 158 gpm (10 L/s) or higher.

Figure 4.11 Straw bale.

Figure 4.12 Product undercutting.

Figure 4.13 Extreme ponding during testing.

Figure 4.14 Unfiltered sediment passing through product.

Figure 4.15 Unfiltered sediment entering inlet.

4.5 STONE

Water passed through the stone check dam (Figure 4.16) product within 1 minute and immediately ponded the channel. Water went through the stone unrestricted, with no signs of undercutting (Figure 4.17). Water passed through the product unfiltered, as evidenced by the observation that water entering the flared-end inlet was dark (Figure 4.18). This continued through the entire experiment, with ponding steadily increasing with time. Upon the completion of the experiment, it was observed that the product took around 15 minutes to drain entirely into the inlet. It was therefore determined that this product is inadequate for field use.

Figure 4.16 Stone check dam.

Figure 4.17 Flooding observed during testing at around 5 minutes.

Figure 4.18 Flow with high sediment leaving the product.

SECTION 5: RESULTS AND DISCUSSION

5.1 SEDIMENT LOG

Sediment decreased with increasing time, and occurred throughout the experiment (Figure 5.1). The measured sediment concentration was the highest for the first sample collected at the beginning of the experiment. This was likely due to loose particles picked up from the dry surface. Despite the added sediment at 10 and 20 minutes, there was a consistent trend of efficient filtration, as shown in the graph. This product worked efficiently and consistently kept sediment concentrations low despite undercutting.

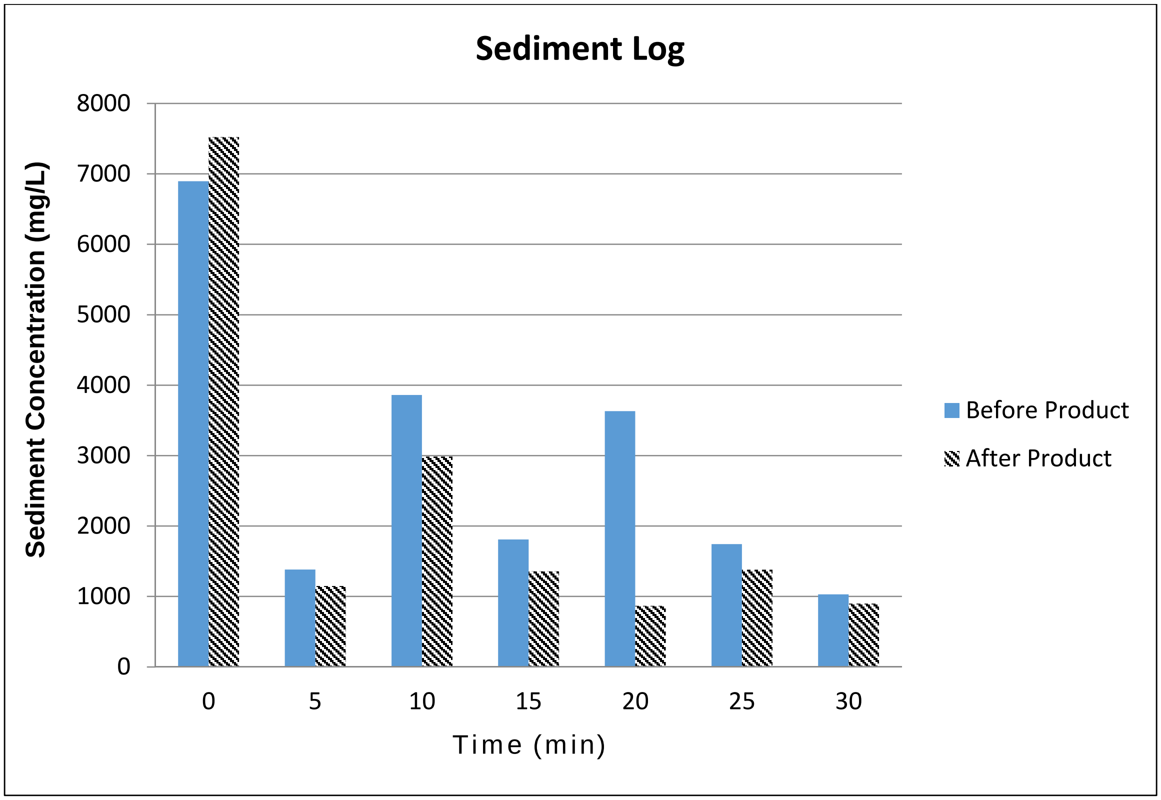

Figure 5.1 Sediment concentrations for sediment log.

5.2 SILT FENCE (WOVEN MONOFILAMENT FABRIC)

Sediment decreased with increasing time, and occurred throughout the experiment (Figure 5.2). The measured sediment concentration was the highest for the first sample collected at the beginning of the experiment. This was likely due to loose particles picked up from the dry surface. Despite the increased ponding, the silt fence was still able to filter efficiently. These observations provide evidence that the woven monofilament fabric performs considerably better than the standard IDOT-approved silt fence fabric.

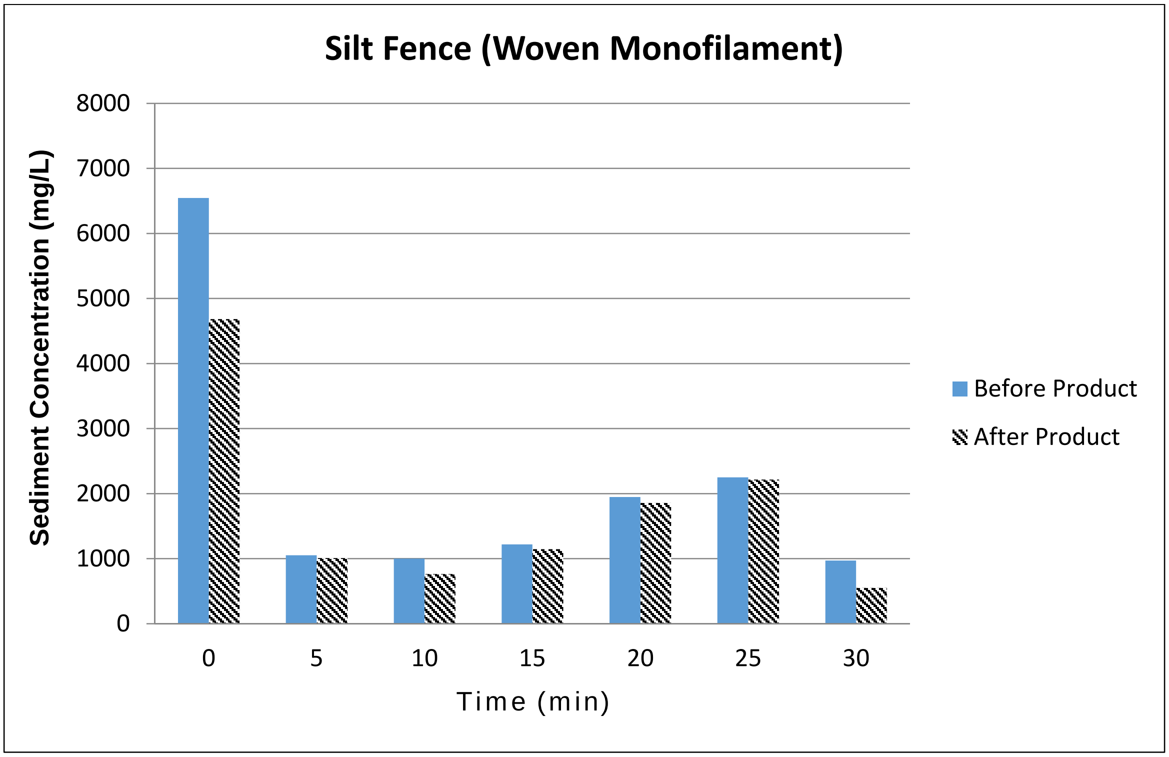

Figure 5.2 Sediment concentrations for silt fence (woven monofilament).

5.3 SILT FENCE (IDOT-APPROVED FABRIC)

Sediment concentration increased throughout the experiment (Figure 5.3). The channel immediately flooded, which led to increased water pressure on the silt fence. The high pressure of water from the increased ponding led to undercutting, as shown in the graph, where higher values occurred after the product. Sediment concentration changes slightly fluctuated before the product throughout the entire experiment, as the channel was completely flooded at that point. Ponding caused soil to settle upstream, thus explaining the low sediment concentrations before the product. Because there was immense ponding, any added soil would merely swirl in the pool formed in front of the fence. This explains why the sediment concentrations showed little variability throughout the duration of the experiment.

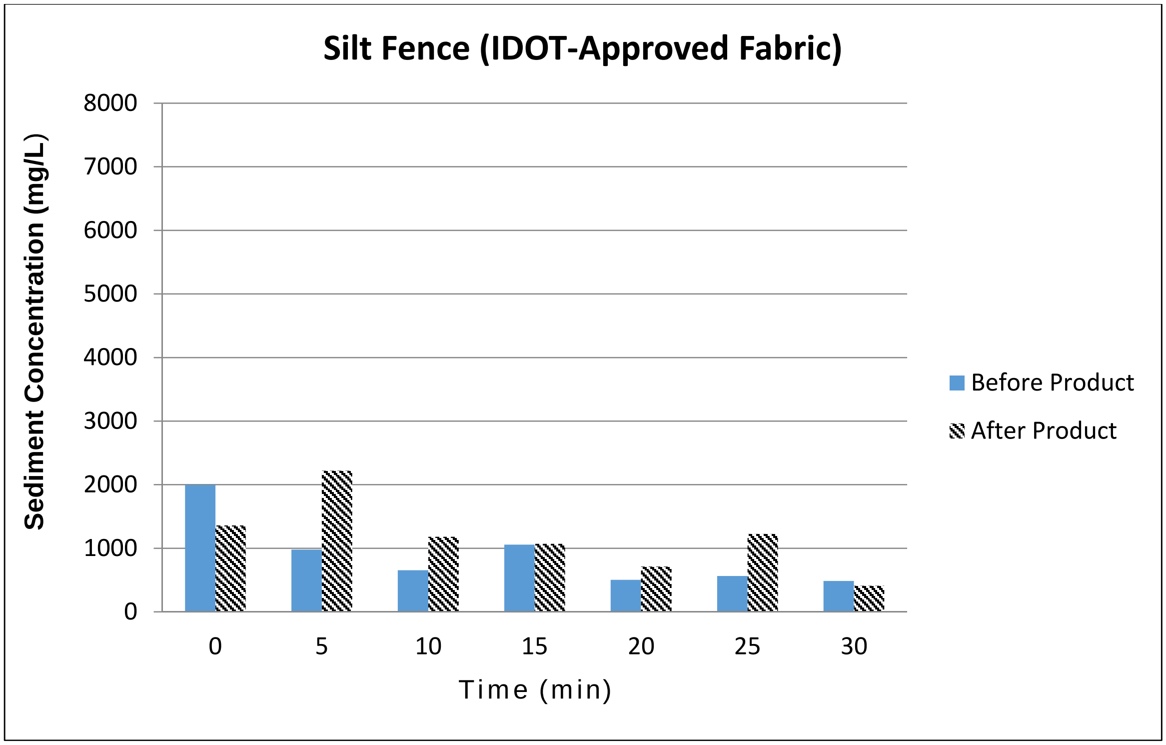

Figure 5.3 Sediment concentrations for silt fence (IDOT-approved fabric).

5.4 STRAW BALE

This product was very ineffective in trapping sediment, with a consistent increase of sediment concentration over time (Figure 5.4). The channel immediately flooded and resulted in increased water pressure against the straw bale. With increased pressure, undercutting inevitability occurred, transporting sediment into the inlet. This undercutting lead to higher sediment concentration after the product, as illustrated in Figure 5.4. Ponding caused the soil to settle upstream, thus explaining the low sediment concentrations before the product.

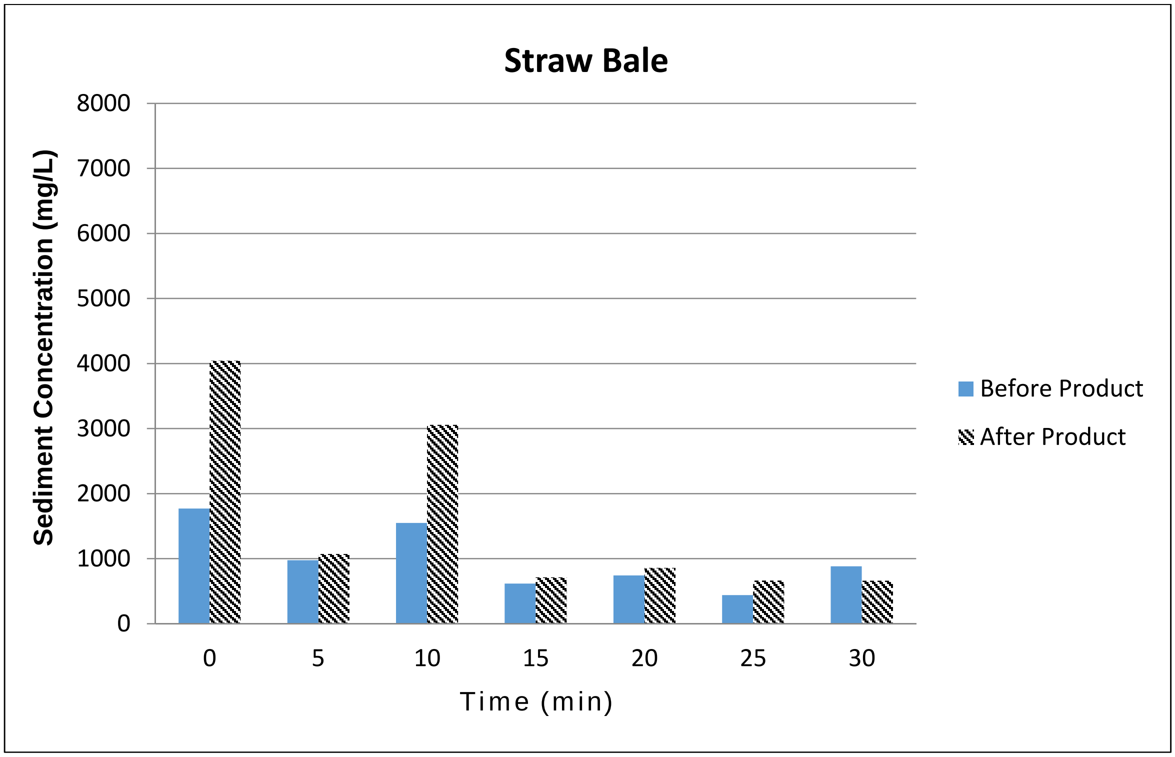

Figure 5.4 Sediment concentrations for straw bale.

5.5 STONE

Sediment concentrations were consistently higher after the product compared to before the product (Figure 5.5). Sediment concentration values were fairly consistent before the product, due to the ponding created by the product. The flooding caused a pool to form in front of the product. Consequently, any added soil merely swirled around in the pool formed in front of the product and could not alter the sediment concentration substantially

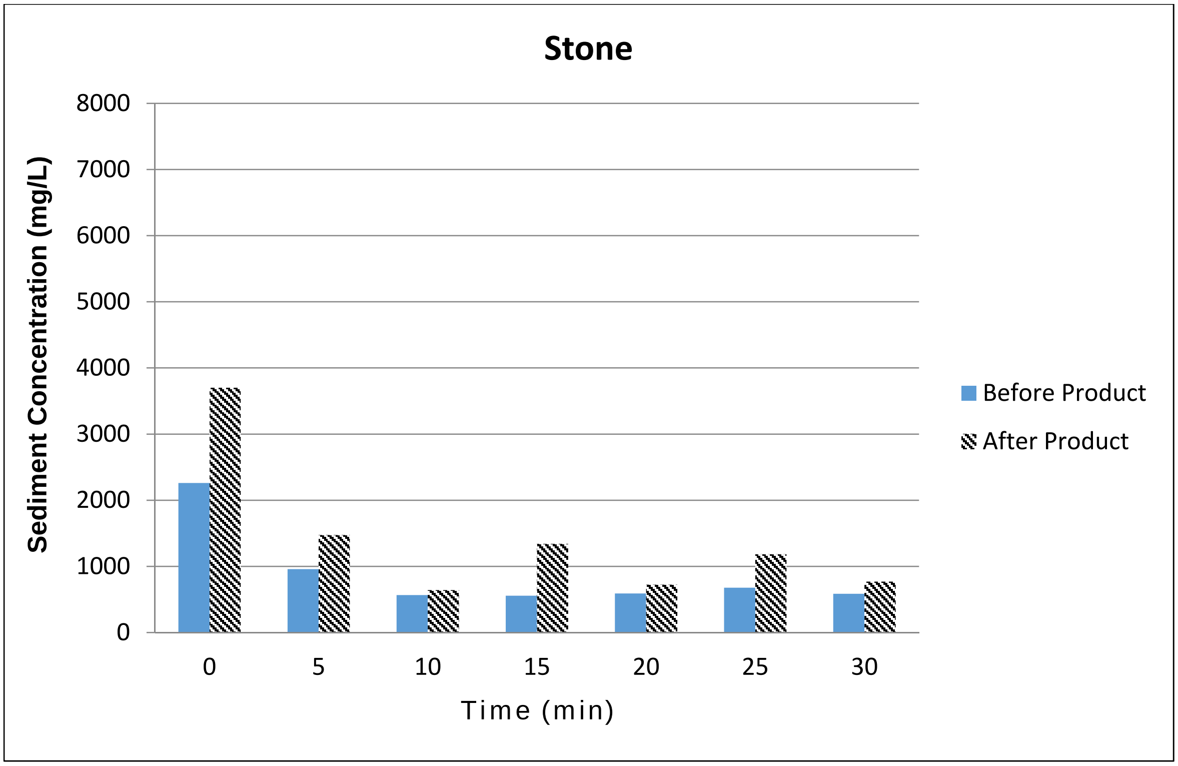

Figure 5.5 Sediment concentrations for stone.

SECTION 6: RECOMMENDATIONS

6.1 PRODUCT COMPARISON

Figure 6.1 summarizes the comprehensive performance of each product. The following product recommendations are made based on observations and results, along with ease of installation.

The percent change in sediment concentration before and after each product is as follows:

- Sediment log: 25.97%
- Silt fence with woven monofilament fabric: 22.44%
- Silt fence with IDOT-approved fabric: –23.69%
- Straw bale: –37.06%
- Stone: 1.89%

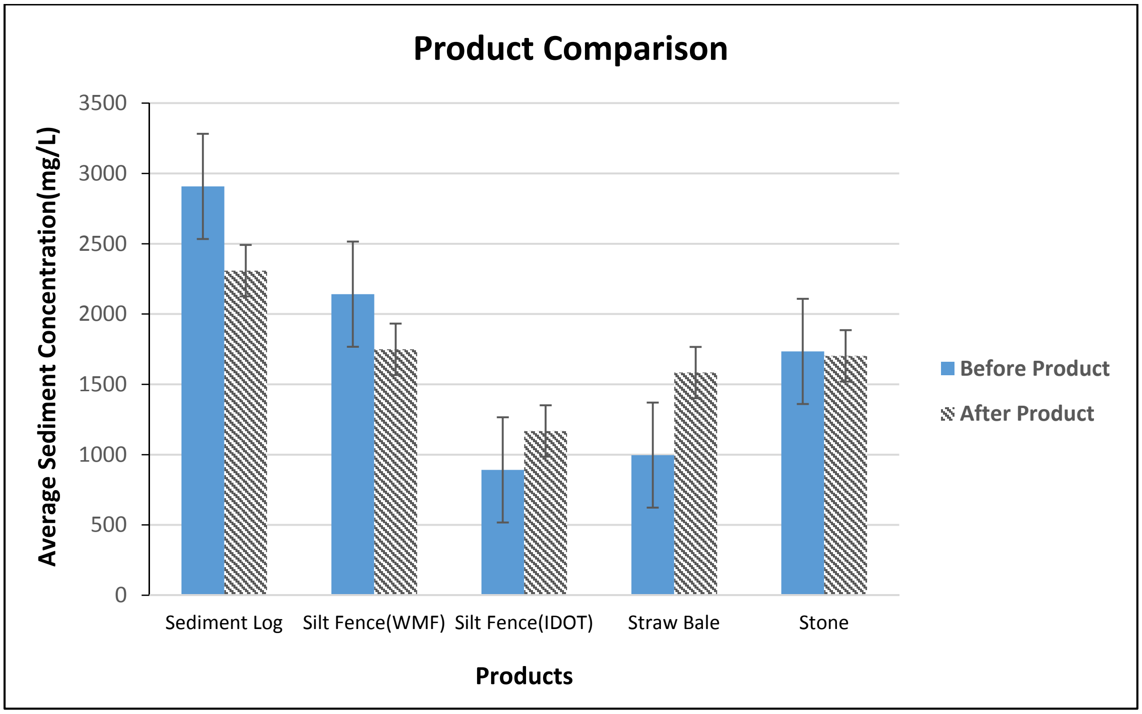

Figure 6.1 Comparison of average sediment concentration of flared-end inlet protection products.

Based on the observations and data analysis, the sediment log and silt fence with woven monofilament fabric performed better than the other products for reducing sediment concentration. The sediment log performed the best of the products tested, achieving the highest percent reduction in sediment concentration. The sediment log can also considered a better alternative to the silt fence with woven monofilament fabric because it is biodegradable and less affected by wind (due to product height). It was observed that both products created some ponding during the tests. Both products provided a good balance between sediment retention and ponding with routine cleanup and maintenance, making those products better than other products tested. Based on observations, the sediment log and silt fence with woven monofilament fabric may work better with a flow rate of less than 158 gpm (10 L/s). Stone was not observed to filter any sediment. It may, however, work better for a flow rate of less than 158 gpm (10 L/s).

The silt fence with woven monofilament fabric performed better than the silt fence with IDOT-approved fabric because of the former's higher material permittivity. Less-permeable fabrics create more ponding. This was the factor that led to failure of the IDOT-approved fabric. The silt fence with IDOT-approved fabric is not recommended due to a low percent reduction in sediment concentration. It was observed during the test that excessive ponding upstream of the product led to significant undercutting. A high level of erosion appeared to occur around the stakes, which compromised the stability of the product.

Straw bales are not recommended because they had a low percent reduction in sediment concentration. This is primarily due to ponding, which caused soil to settle in front of the product. Hydrostatic pressure from the increased ponding increased the water height and led to undercutting. At that point, soil underneath the product eroded, causing more sediment enter the flared-end inlet. The United States Environmental Protection Agency (EPA) strongly discourages the use of straw bales. It says the product is "maintenance-intensive and can be expensive to purchase. Because many applications of straw and hay bales have been ineffective, EPA recommends that other BMP options are carefully considered" (NNSA 2011).

6.2 PRODUCT ANALYSIS

6.1 Sediment Log

- **Sediment removal:** This product was quite effective; it filtered the most sediment compared to other products tested. Despite some ponding, the product was efficient in reducing sediment concentration as the sediment-laden water passed through the product. Observations during this study suggested that this product may work better with a flow rate of less than 158 gpm (10 L/s).
- **Ease of installation:** This product was difficult to install due to the need for proper trenching, staking, and tightness between the stakes. Proper maintenance is encouraged after storms because the sediment logs are capable of tearing and ripping.
- **Ponding:** Ponding was apparent but average compared to other products tested. This product be routinely cleaned after each rainfall event. Ponding resulted in undercutting near the stakes, which eroded soil within the trench.
- **Product failure:** Undercutting was the biggest issue with this product, which is primarily associated with improper trenching. Therefore, proper installation and maintenance are strongly recommended for this product. If not properly maintained, sediment logs are capable of tearing or ripping.

6.2 Silt Fence (Woven Monofilament Fabric)

- **Sediment removal:** This product was quite effective; it filtered more sediment than the other products tested. Despite increased ponding, the silt fence was able to handle sediment loads and filtered efficiently. Observations during testing provide evidence that this fabric is a significant improvement over previous fabrics. Observations suggested that this product may work better with a flow rate of less than 158 gpm (10 L/s).

- **Ease of installation:** This product was quite difficult to install due to the need for proper trenching, staking, and tightness between the stakes. It was observed that undercutting will occur regardless of how well the product is installation and may lead to product failure if neglected.
- **Ponding:** Ponding was apparent but average compared to other products tested. For optimal use, routine cleaning should be done after each rainfall event.
- **Product failure:** Undercutting could be the biggest potential problem with this product if it is not installed properly. Poor compaction can lead to undercutting and cause erosion around the stakes, causing them to wobble and fail.

6.3 Silt Fence (IDOT-Approved Fabric)

- **Sediment removal:** This was among the least effective of the products tested. As flow rate increased, the product’s performance steadily worsened. Once failure occurred, higher amount of sediment entered the flared-end inlet.
- **Ease of installation:** This product was quite difficult to install due to the need for proper trenching, staking, and tightness between the stakes. If the product is not installed correctly, severe undercutting will occur.
- **Ponding:** This product performed very poorly; it immediately ponded after testing started. Ponding resulted in undercutting near the stakes, which eroded soil within the trench.
- **Product failure:** Undercutting can the biggest potential problem with this product. The poor porosity of the material creates significant ponding. Extreme ponding puts a considerable amount stress on the product as the water level rises, which will lead to increased chances of failure. Extreme ponding can also lead to undercutting and will cause erosion around the stakes, causing them to wobble and fail.

6.4 Straw Bale

- **Sediment removal:** This product was among the least effective products tested. As flow rate increased, the product’s performance steadily worsened. Once failure occurred, higher amount of sediment entered the inlet.
- **Ease of installation:** This product was quite difficult to install due to the need for proper trenching, staking, and tightness between the stakes. If the product is not installed correctly, severe undercutting will occur. Hay came off the straw bale, creating additional debris before and also after the product. Once the test was completed, the product was very difficult to remove due to its weight. The water was retained in the product for several days, and hay continued to be shed.
- **Ponding:** This product performed very poorly; it immediately ponded after testing started. Ponding resulted in undercutting near the stakes, which eroded soil within the trench.
- **Product failure:** Undercutting was a large problem with this product. Extreme ponding puts a considerable amount of stress on the product as the water level rises, leading to increased chances of product failure.

6.5 Stone

- **Sediment removal:** This was among the least effective products tested. Water was able to pass through the stone media more easily than it did with other products.
- **Ease of installation:** This product was quite difficult to install; the required volume of stone took a long time to install. This product required much time, precision, and resources and will create problems in the field if crews do not install the product correctly. Once installed, it would be very difficult to remove the product from the channel.
- **Ponding:** This product resulted in ponding as soon as the experiment started.
- **Product failure:** This product was unable to filter any sediment.

6.3 SUMMARY OF PRODUCT COMPARISON

Table 6.1 is an overview of the results discussed in this section and is provided for easy reference.

Table 6.1 Comparison Table

Product/Criteria	Sediment Removal	Ease of Installation	Ponding	Product Failure
Sediment log	Good	Good	Good	No
Silt fence (woven monofilament)	Good	Decent	Good	No
Silt Fence (IDOT-approved fabric)	Bad	Decent	Bad	Yes
Straw bale	Bad	Decent	Bad	Yes
Stone	Bad	Bad	Bad	No

Note: Good: 8–10, Decent: 5–7, Bad: 0–4

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