CHAPTER 2

Field Verification Activities

Straight line efficiency testing for trenched and sliced silt fence.

2.1 Site Description

All sites were located within the Greater Des Moines area. The two primary sites used for the evaluation were recently graded for development purposes. Site #1 was comprised largely of fill material excavated from a nearby property and transported to the site. The fill was placed and compacted to relatively gentle grades ranging from 2 to 10 percent. The fill was high in clay content and moist to the touch. Site #2 was generally cut with grades reflecting the natural terrain of the area. Slopes were in the range of 2 to 6 percent. The soil reflected a higher composition of silts and organics (topsoil).

Copies of the soil gradation reports for Site #1 and Site #2 are available upon request from EvTEC. Two additional sites were selected to facilitate the limited evaluation of uniquely challenging soil conditions. Site #3 was an old fertilizer plant that had thick layers of coarse stone in old roadbeds. Site #4 was a very wet, vegetated area at the lower end of a multi-acre drainage area. Sites #1 and #2 had been graded within the previous two weeks and the surfaces were prepared immediately prior to testing. Sites #3 and #4 were not prepared prior to testing.

As shown in Table 1, 36 tests were conducted at Site #1 using 30 “smile,” or arc segment, installations. Twenty of the smiles used some variation of trenching while 10 smiles were installed using the static slicing method. Six tests involved re-application of water to a previously tested smile. An additional six tests were conducted at Site #2 using the smile configuration in order to investigate the effects of soil type on fence performance. At Site #2, two smiles were sliced and four smiles were trenched. Ten 100-foot straight sections were constructed at Site #1 to evaluate installation efficiency. Additional straight sections were installed at Sites #2, #3, and #4 to evaluate slicing on a steep slope, in rocky soils, and through wetlands, respectively.

Table 1. Breakdown of constructed segments and tests performed

Site #	Type of Installation	Number of Segments	Number of Tests per Segment	Total Number of Tests
1	Slicing	10	6 @ 1 test; 3 @ 2 tests; 1 @ 3 tests	15
1	Trenching	20	19 @ 1 test; 1 @ 2 tests	21
1	Slicing	2	0[1]	0[1]
1	Trenching	8	0[1]	0[1]
2	Slicing	2	2 @ 1 test	2
2	Trenching	4	4 @ 1 test	4
2	Slicing	1	0[2]	0[2]
2	Trenching	1	0[2]	0[2]
3	Slicing	1	0[2]	0[2]
3	Trenching	1	0[2]	0[2]
4	Slicing	1	0[2]	0[2]

[1]straight sections used for efficiency measurements
[2]straight sections used for qualitative evaluations

2.2 Trenching Installation Approach

Silt fence installation using trenching involves several steps (see Figure 1). Typical installation specifications allow the sequence of these steps as well as the details of each step to vary at the discretion of the installer. For instance, the installer can trench, install fabric, backfill, compact, and then install posts and tie-up the fabric, or he can install the posts before installing the fabric and backfilling. Alternately, the installer can use only the soil available on the upstream side of the fence, or he can make the special effort to obtain sufficient backfill to slightly over-backfill the trench so that, when compacted, it is completely full. Additional variations on installation approaches include the degree of compaction, the use of mechanical versus foot compaction of backfill, the depth of the trench, the spacing of posts, and the type of fabric used for the fence.

The rather substantial array of possible “traditional” installation methods made standardizing on one sequence rather limiting. Therefore, the decision was made to try a range of installation procedures in an effort to broaden the applicability of the evaluation findings. In general, procedures were classified in accordance with the likelihood of obtaining a fully backfilled and densely compacted trench. The following classifications were assigned:

Trenching to the Minimum Installation (Spec). Minimum silt fence specifications typically allow for the following practices, and are typically installed in this order:

- Trenching (6 inch x 6 inch excavation);
- Post setting and driving (6.5 foot spacing);
- Fabric installation and tie-up to the posts (three ties per post);
- Backfilling (fill to level, if sufficient excavated soil is available); and,
- Compaction (required effort not usually defined, detailed, or quantified in the specification).

“Better” Installation (Spec+). A better-than-specified installation of silt fence would include all of the steps included in the minimum (Spec) installation plus one or more of the following:

- Fabric installation, use of available backfill, and compaction before setting and driving posts;
- Over-backfilling the trench; or,
- Posting and then mechanically compacting the filled trench.

“Best” Installation (Spec++). A “best” installation would include multiple enhancements, such as hand-cleaning the trench prior to installing the fabric, mechanically compacting an over-filled trench, and posting as the final action.

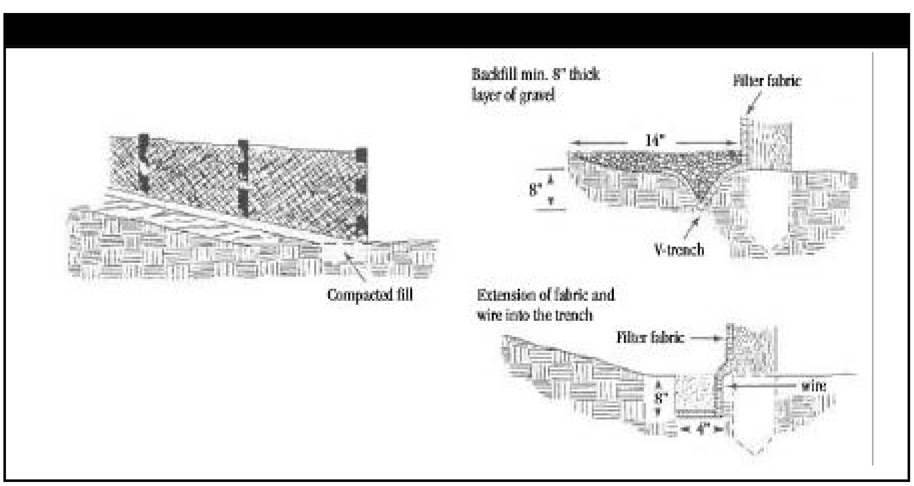

Figure 1. Typical silt fence trenching installation detail.

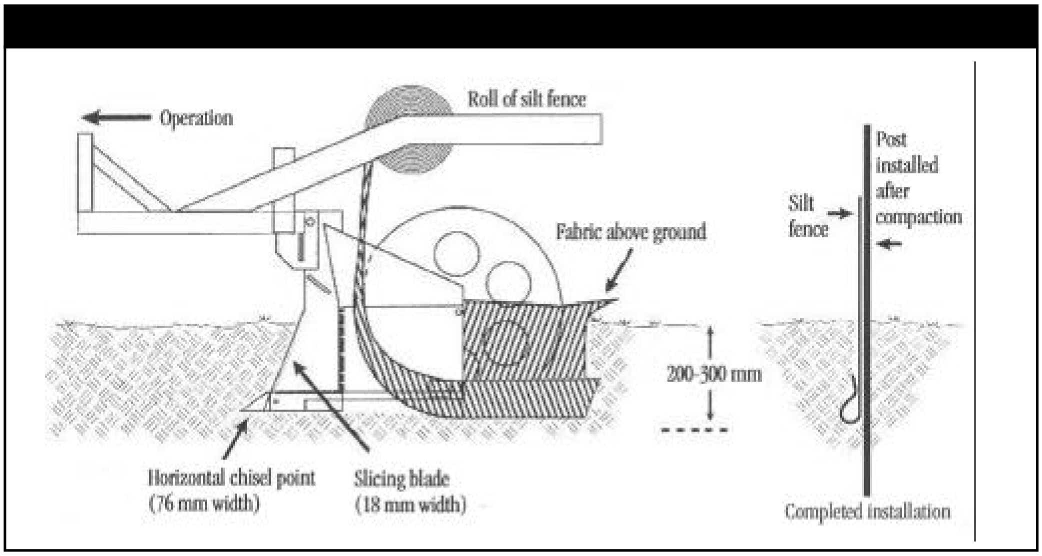

Figure 2. Typical silt fence detail using slicing method.

2.3 Tommy Static Slicing Machine Approach

Static slicing is defined as the insertion of a narrow, custom-shaped blade at least 10 inches into the ground and the simultaneous pulling silt fence fabric into the opening created as the blade is pulled through the ground. The blade imparts no vibration or oscillatory motion. Compaction, typically consisting of four passes with a tractor tire, follows. Post setting and driving and tying the silt fence fabric to the posts finalizes the installation (see Figure 2).

2.4 Deviations from Evaluation Plan

The original Evaluation Plan envisioned the evaluation being performed at and by an independent research agency facility. Responses to the Request for Proposals to implement the evaluation plan indicated that substantial and perhaps excessive costs would be incurred to create a suitable test site for the evaluation since this type of large-scale field testing had never before been undertaken by the proposing organizations. The vendor observed that the costs of preparing a new site could better be directed toward running tests and proposed to conduct the evaluation at available sites in the vendor's local area. As a result, more tests involving more installation variables could be performed. A majority of the EvTEC Panel agreed to this revision to the Evaluation Plan.

The decision to use existing sites resulted in more extensive testing on a single "typical" site and soil type rather than the more limited number of tests in a range of three soils originally called for in the Evaluation Plan. A second site was included in the revised Evaluation Plan to allow for a limited evaluation of the effect of soil type on performance.

Further, the vendor requested a more detailed description of a "typical" trenching and backfilling process, including required trench and backfill depths. The vendor observed that in general practice, soil is excavated by a trenching machine that deposits the soil on both sides of the trench. When the silt fence is erected in the trench, often only the soil deposited on the up-slope side of the trench is redeposited and compacted in the trench. Thus, the entire trench may not be filled with compacted soil. This means that a specified six-inch deep trench may only have three or four inches of compacted backfill adjacent to the installed fence. The vendor felt that this is an unfortunate reality with many installed silt fences that is a root cause of many failures and should be replicated in this evaluation. Therefore, the vendor requested permission to compare the static slicing technique to both a "standard" condition (6-inch trench filled completely with compacted soil) and a "real world" condition (6-inch trench using only partial depth of compacted backfill).

The original Evaluation Plan called for two straight segments on one site (one sliced and one trenched) for efficiency evaluations and 27 test segments (12 sliced and 15 trenched) spread over three sites for performance evaluations. The revised Evaluation Plan included 15 straight segments spread over four sites (five sliced and 10 trenched) for efficiency measurements and qualitative evaluations and 36 test segments (12 sliced and 24 trenched) spread over two sites for performance evaluations.

Both the original and revised plans called for a 24-hour re-test (reapplication) of water on each segment. A number of re-tests were done and found to provide very little additional information, so they were discontinued. Of greater impact was the use of concentrated flow from the end of a hose rather than the distributed flow envisioned in the original Evaluation Plan. The distributed flow technique was used initially and found to be too gentle and unable to create and carry sediments to the fence. An alternate technique in which the discharge from a hose was sprayed onto the ground in a fan pattern proved to create sufficient sediment to produce a more realistic test. With the concentrated flow, sediments were carried to and deposited on the fence, causing blinding (blocking) of the fence and the associated retention of runoff. This created the desired build-up of silt and sediment behind the fence. Two test segments were constructed using an impermeable fabric to simulate complete clogging of the fence.

In light of the many variations proposed for testing, an attempt was made to perform a substantial number of tests under "standard" conditions, to control the number of variables and to assure comparability of results. For the purposes of this evaluation, therefore, standard conditions included a 30-foot radius, Amoco 2130 fabric, 6.5-foot post spacing, and 1,000 gallons of water applied using a concentrated application technique.

2.5 Overview of Silt Fence Configuration and Testing Approach

Installations

Locations/Soil Types. The evaluation was performed primarily on two distinct soil types representing clayey (Site #1) and silty (Site #2) soil. The majority of tests were performed on Site #1 (i.e., 36 out of 42 timed test trials).

Fence Configuration and Materials. For the performance evaluation, a "smile" installation was used to demonstrate occurrences that stress silt fences at a specific point. For the productivity assessment, straight-line segments were used.
The installation consisted of a curved segment of silt fence having the following characteristics:

- The radius of each installation was generally 30 feet. Four sections with a radius of 12 feet were installed to evaluate the effects of a tight radius.
- The depth of installation was no less than 10 inches for the slicing method (no more than 22 inches of fence above ground) and 6 inches deep by at least 4 inches wide (using a 4-inch wide bar trencher) for the traditional trench method as per the ASTM D 6462 method. The "real world" installation used only partial backfilling.
- For both installation methods, steel posts were spaced 6.5 feet apart with three ties used to hold the fabric to the post. A limited number of tests using alternative post spacing were also performed.
- For both installation methods the silt fence fabric was a slit film woven textile, 36 inches wide, designated Amoco 2130. Amoco 2127 fabric was tried and found to be too permeable to allow sufficient retention to observe any undermining from either installation type.
- For both installation methods, the vendor created runoff with a concentrated flow from a hose. The vendor attempted discharging through a perforated pipe extending across the upper extent of the "smile" and found that this method created insufficient sediment load in the runoff to cause the necessary blinding of the silt fence. The runoff hose was connected to a tank reservoir that permitted measurement (i.e., volumetric metering) of the outflow. The flow was introduced in 8 to 10 minutes for approximately 1000 gallons of water (flow rates were increased or doubled when two hoses and tank reservoirs were used simultaneously).

Ten straight-line segments, representing nine different installation techniques, were installed to facilitate an economic "efficiency" evaluation. For the straight-line installation, no runoff was introduced; these 100-foot segments were constructed to provide productivity information for comparison purposes.

Variables Examined

As described in section 2 above, three different trench installation classifications (Spec or minimum, Spec +, and Spec ++) and static slicing were evaluated and compared. Variation in amount of fill, compactive effort, and sequence of tasks were evaluated. These variations were evaluated for one primary soil type. Limited additional data were collected on installations in a second soil type.

The performance, or water retention, of the silt fence when installed and subjected to runoff was of primary importance in the evaluation. One factor expected to adversely affect the retentive ability of the silt fence was excessive seepage under the fence (undermining) related to the compaction of soil within the trench and/or adjacent to the fabric. Therefore, the evaluation for each soil type and each installation sequence measured the degree of compaction achieved and the associated resistance of the installed system to pullout along with retention.

System economics were assessed, as was the importance of equipment maneuverability as defined by the radius of the slicing/trenching. These variables were examined using the 42 tests outlined in Table 2 (see p. 11).

Observations

Measurements. The following measurements were made during and subsequent to the installation of a representative number of silt fence sections before runoff was induced:

- Geometry of installation, including length and radius of "smile," slope of contained area, and height of silt fence above the ground surface;
- Time to excavate/slice, install, backfill (trenched system), and compact the silt fence system for all installations (including the two straight installation methods);
- The density of the soil/backfill adjacent to the silt fence; and,
- Force (in pounds) to pull the silt fence out of the ground measured at the upper reaches of the "smile," 2.5 feet from the last post.

The following measurements were made during and subsequent to the introduction of runoff to the silt fence installation:

- Rate of runoff application;
- Time until seepage/undermining of silt fence initially occurred;
- Height of ponding behind fence versus time; and,
- Time to failure (blowout). Blowout is defined as total failure and extensive loss of compacted soil and/or the point in time when exit flow volume is approximately equal to the introduced runoff rate. This was a qualitative observation made by the testing organization.

Testing Equipment. The following testing equipment was used:

- Field surveying equipment;
- Time measurement equipment;
- A nuclear density gauge for soil density measuring. (A hand-held penetrometer was used in addition to the nuclear density gauge); and,

- A fence pullout device with load scale (provided by Carpenter Erosion Control. The device was independently operated and calibrated by TRI and EvTEC personnel.

Evaluation Criteria

Qualitative Criteria. General observations were made concerning the ease, uniformity, and commercial practicality of the installations.

Quantitative Criteria. The primary means of evaluating the relative merits of the slicing versus the trenching methods for silt fence installation were quantitative and used the measurements outlined previously. The primary criteria were:

- Time to install each system; and,
- Effectiveness of runoff retention, including time of retention.

Of secondary importance, and generally as a tool to estimate quality of installation, were:

- Degree of compaction attained adjacent to buried edge of silt fence; and,
- Resistance (in pounds) to pullout of buried silt fence.

Data Collection

Procedures and Instrumentation. Set-up procedures and running of each test included:

- Final site grading and surface preparation;
- Trench excavation/slicing, silt fence installation, compaction adjacent to the upstream side of the fence, post setting, and tie attachment; and,
- Introduction of runoff into the area contained by the silt fence.

Site # 1 is comprised of soil excavated from a nearby site that was under development. The soil was trucked to Site # 1, dumped, spread, and modestly compacted. At the time of this evaluation, the site had relatively long, smooth slopes ranging from 2 to 10 percent. Initially, the surface was compacted with a steel-wheeled roller to maximize uniformity. When it became clear that insufficient sediment was being generated, apparently because the soil surface had been compacted, the soil surface was roughened. Site # 2 was freshly graded with slopes generally following natural terrain. The topsoil had been replaced, but not compacted, on the graded slopes.

Trench excavation and slicing were both conducted by the same installation crew. TRI observed the crew's techniques during the installation of the straight-line segments and, based on these observations, approved them to perform both installations. A representative of TRI provided visual oversight of the test segment installations to ensure that there was no bias. The evaluation sponsor, Carpenter Erosion Control, provided the slicing machine.

Compaction for the slicing installations was accomplished by wheel rolling with the tractor used for installation. The tractor used a fully loaded bucket. In accordance with standard slicing specifications, compaction was performed twice on each side of the fence, once in each direction. Compaction for the trenching installations was accomplished by wheel rolling with the trenching machinery. Compaction was performed twice on the trench side of the fence, once in each direction. The complete installation was timed for representative test set-ups.

The runoff was introduced by concentrated flow applied in a fan pattern across the width of the "smile." Flow volume was predetermined for each test, and the resulting depth of retained runoff was recorded. Thus change in depth over time rather than actual depth provided more meaningful comparisons because the initial depths varied widely. In some cases, a second introduction of runoff, with the same volume and flow rate, was made 24 hours after the first application to evaluate the effects of subsequent storm events.

Frequency, Timing, and Quantity of Data. Generally, the data reflect duplicate tests. The vendor conducted pullout,

Table 2. Testing Program Outline

Test #	Installation Details								Water Application Details	
	Radius (ft)	Exca-vation	Silt Fence Fabric	Backfill	Compaction	Post Spacing (ft)	Posts	Type	Amount (gals)	Concentrated vs. Distributed
1-1	30	Slice	2127	-	Tractor/4 passes	5	After	Slicing	1000	Distr.
1-2	30	Slice	2127	-	Tractor/4 passes	5	After	Slicing	2000	Distr.
1-3	30	Slice	2127 + ppr twl	-	Tractor/4 passes	5	After	Slicing	1000	Distr.
2-1	30	Slice	2130	-	Tractor/4 passes	5	After	Slicing	1000	Distr.
2-2	30	Slice	2130	-	Tractor/4 passes	10	After	Slicing	1000	Distr.
3-1	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
3-2	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	Rough + 2000	Conc.
4	30	Trench	2130	Full+	Trencher/2 passes	6.5	After	Spec++	1000	Conc.
5	30	Trench	2130	Full+	Trencher/2 passes	6.5	After	Spec++	1000	Conc.
6	30	Trench	2130	Full+	Trencher/2 passes	6.5	After	Spec++	1000	Conc.
11	30	Trench	2130	Full+	Trencher/2 passes	6.5	Before	Spec++	1000	Conc.
12-1	30	Trench	2130	Full+	Trencher/2 passes	6.5	Before	Spec++	1000	Conc.
12-2	30	Trench	2130	Full+	Trencher/2 passes	6.5	Before	Spec++	Rough + 2000	Conc.
9	30	Trench	2130	Avail./Level	Foot	6.5	Before	Spec	1000	Conc.
8	30	Trench	2130	Avail./Level	Foot	6.5	Before	Spec	1000	Conc.
2B-1	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
2B-2	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
24	30 Trap.	Trench	2130	Avail./Level	Foot	6.5	Before	Spec	1000	Conc.
23	30 Trap.	Trench	2130	Avail./Level	None	6.5	Before	Spec -	1000	Conc.
22	30	Slice	2130	-	None	6.5	After	Slicing	1000	Conc.
18	30 Trap.	Trench	2130	Avail./Level	Foot	6.5	Before	Spec	1000	Conc.
33	12	Trench	2130	Avail./Level	Foot	6.5	Before	Spec	1000	Conc.
34	12	Trench	2130	Avail./Level	Foot	6.5	Before	Spec	1000	Conc.
16	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
21	12	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
27	12	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
40	30	Trench	2130	Full	Skid Ldr./2 passes	6.5	After	Spec++	Rough + 4000	Conc.
41	30	Trench	2130	Avail.	Foot	6.5	Before	Spec	4000	Conc.
42	30	Slice	2130	-	Tractor / 4 passes	6.5	After	Slicing	2000	Conc.
63*	30	Trench	2130	Full/Level	Trencher/2 passes	6.5	Before	Spec+	1000	Conc.
64*	30	Trench	2130	Full/Level	Trencher/2 passes	6.5	Before	Spec+	1000	Conc.
62*	30	Trench	2130	Full/Level	Trencher/2 passes	6.5	Before	Spec+	4000	Conc.
65*	30	Trench	2130	Full/Level	Trencher/2 passes	6.5	After	Spec++	4000	Conc.
67*	30	Trench	2130	Avail.	Foot	6.5	Before	Spec	1500	Conc.
I #1	15	Slice	Imperm	-	Tractor/4 passes	6.5	After	Slicing	1000	Conc.
I #2	15	Trench	Imperm	Full+	Trencher/2 passes	6.5	After	Spec++	1000	Conc.
NS 1	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	2000	Conc.
NS 2	30	Slice	2130	-	Tractor/4 passes	6.5	After	Slicing	2000	Conc.
NS 3	30	Trench	2130	Avail./Level	Trencher/2 passes	6.5	After	Spec++	2000	Conc.
NS 4	30	Trench	2130	Avail.	Foot	6.5	Before	Spec	2000	Conc.
NS 5	30	Trench	2130	Avail./Level	Trencher/2 passes	6.5	After	Spec++	2000	Conc.
NS 6	30	Trench	2130	Avail.	Foot	6.5	Before	Spec	2000	Conc.

***no independent oversight/not used in evaluation**
I = impermeable; NS = new site, i.e., Site #2