CHAPTER 3

Verification Project Results

Close-up of a trench installation shows excessive piping of water under the silt fence.

3.1 Trenching Installation Results

The results for trenching installations were grouped in accordance with the descriptions given in Section 2.2.

Installation Efficiency

Figure 3 provides a comparison of the installation efficiency associated with various installation techniques. The trenching methods all required significant manual labor. Manual labor was required for hand-shoveling to both clean out and backfill the trench, for holding the fabric in place while trying to attach it to the posts, for holding the loose fabric in the trench while backfilling, and for the posting/tying effort.

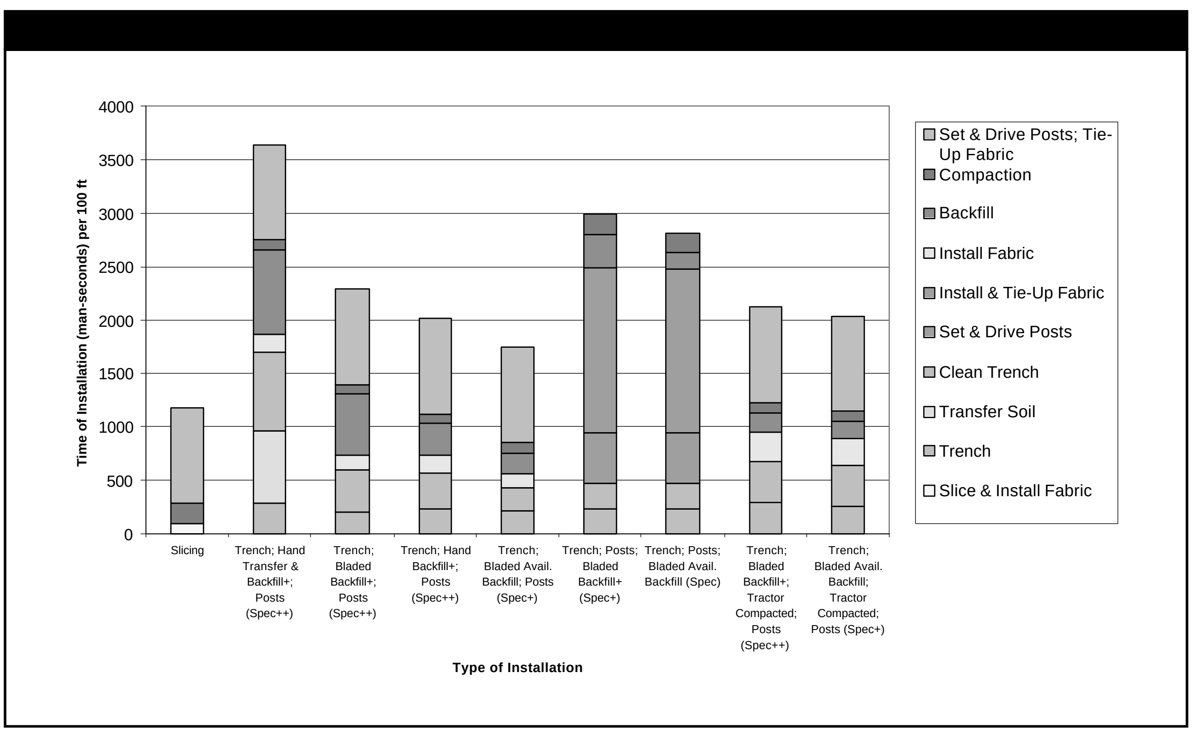

Figure 3. Silt fence productivity.

Clearly, any type of installation that included trenching required substantially greater installation time than the slicing technique. Among various trenching installations, those involving hand-cleaning of the trench, hand-transfer of the soil, and/or installation of posts prior to fabric installation and soil compaction took considerably longer to construct. If posts are installed before backfilling, fabric installation can be especially problematic – and time consuming – as the fabric must be held and stretched between posts while being tied to the posts, a task made more difficult by wind or too few laborers.

Figure 3 indicates that the time associated with digging a trench was comparable to the entire time required to slice the soil while simultaneously installing the fabric and subsequently compacting the soil with four passes. The time required to set and drive posts and tie-up fabric is basically the same for all installation techniques if fabric installation, backfilling (if required), and compaction are completed first, as long as the trencher can mechanically drive the posts. On average, slicing was more than twice as fast an installation technique than was trenching. As expected, installation efficiency improved with more mechanized installation practices.

Retention Performance

In general, improved performance was related to more rigorous installation efforts. More rigorous installation efforts include setting and driving posts and tying fabric to posts after compaction, over-backfilling the trench, mechanically compacting the filled trench, or any combination of these enhancements. The Spec installations consistently performed poorly, while the installations that included Spec + installation techniques performed much better. Figures 4, 5, and 6 provide comparisons of the retention performance of the various classes of installation. Figure 4 presents the relative performance of all tests, including a variety of flow conditions, installation configurations, and soil types, while Figure 5 presents the relative performance of only those runs using standard conditions as outlined in Chapter 2.4. Figure 6 presents the relative performance of only those tests performed at Site #2 (new site or NS).

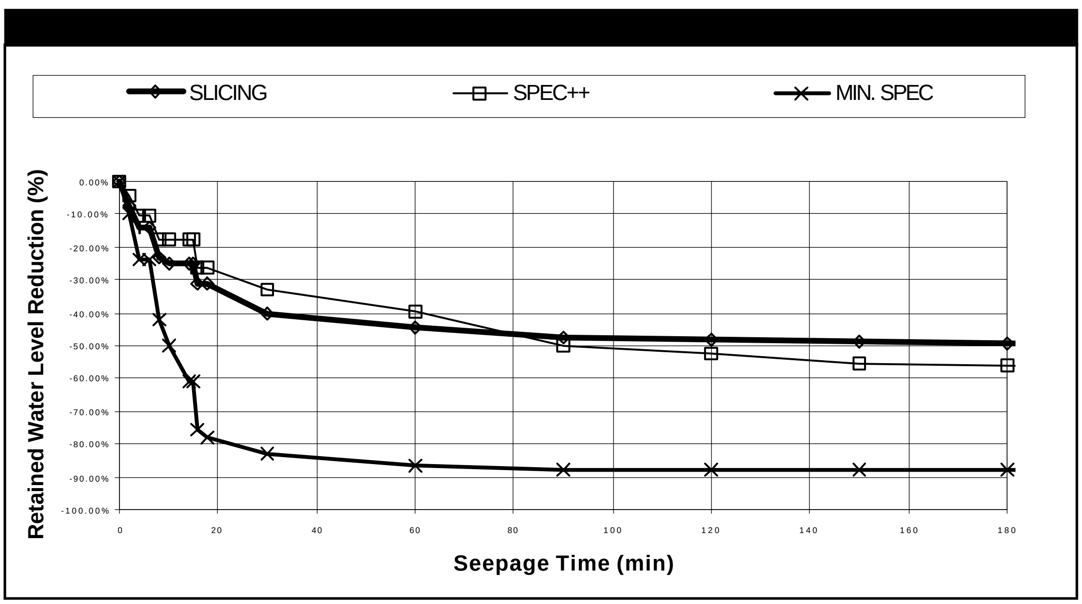

Figure 4: Average results of all runs: water level vs. time.

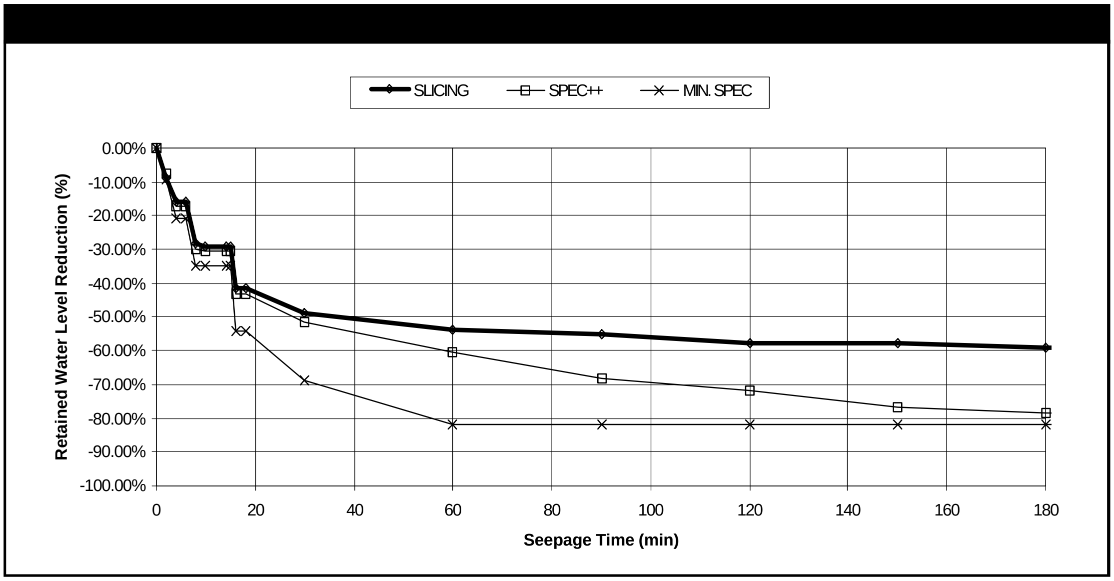

Figure 5. Average results of standard runs (6.5 ft post spacing/Amoco 2130/1000 gals/ concentrated application): water level vs. time.

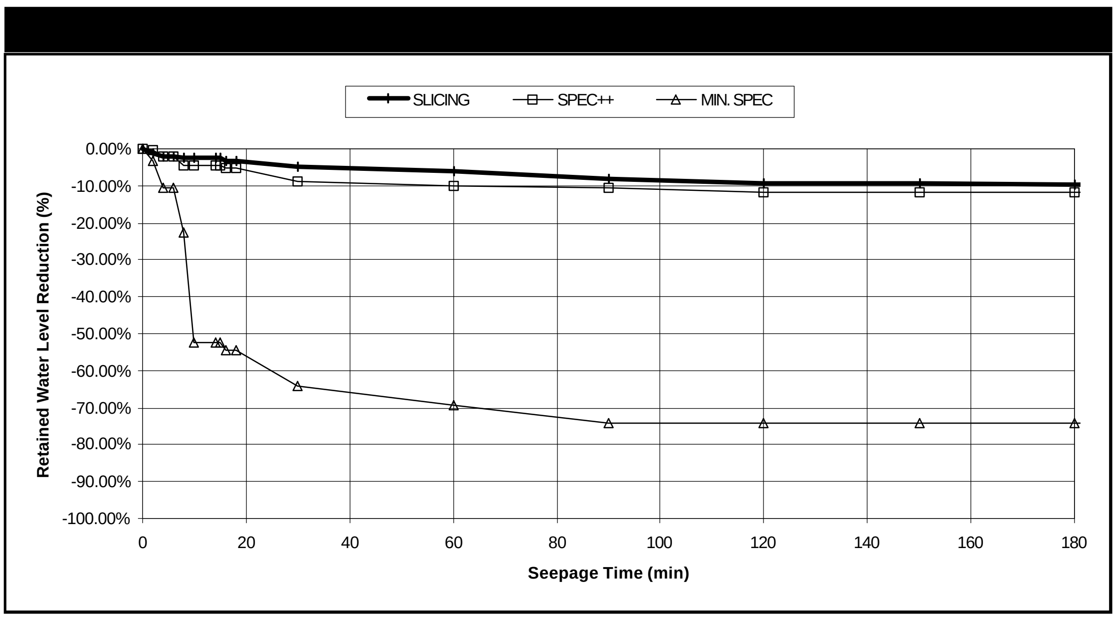

Figure 6. Average results (new site or site #2) runs: water level vs. time.

Minimum (Spec) trenching-based specifications and Spec + trenching-based specifications performed much more poorly than did the Spec + + trenching-based installations. This appeared to be directly related to the degree of compaction achieved in the trench as shown in Figure 7. Significantly lower compaction was achieved when posts were installed before compaction, when inadequate compaction effort was provided, and when there was insufficient backfill in the trench.

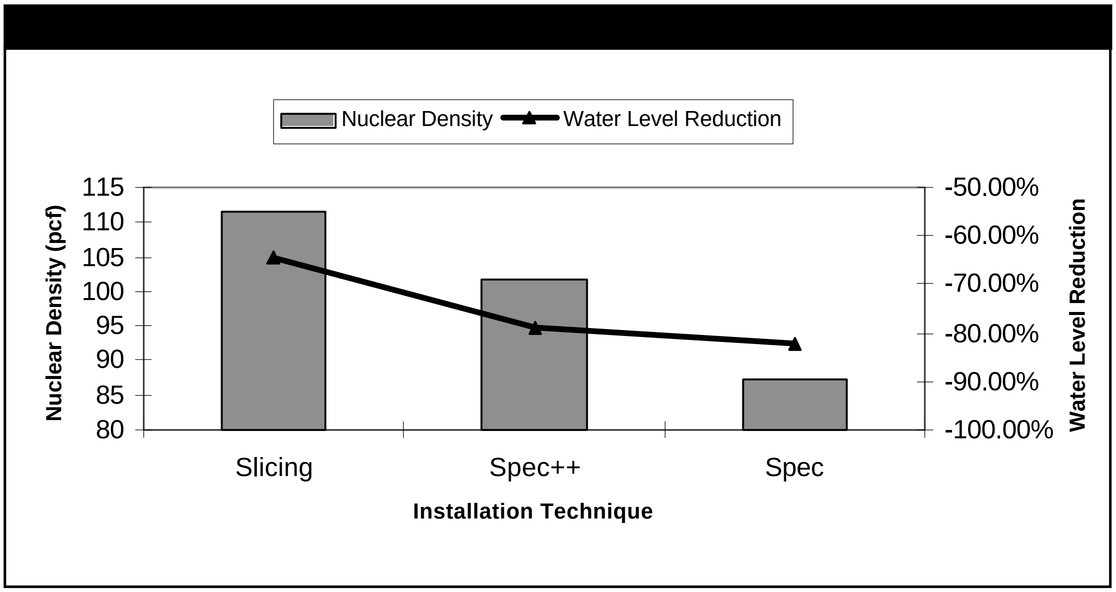

Figure 7. Backfill density vs. retained water level (average of "standard" tests).

While the Spec + + trenching-based installations were able to retain 50 percent of the initial water level, less rigorous trenching-based installation techniques retained less than 20 percent as measured by the retained water level. In limited testing of the more erodible Site # 2, the Spec + + trenching-based installation technique lost only 10 percent of its water level while the Spec installation experienced a 75 percent water level reduction.

In all cases, static slicing produced silt fence installations as good as or better than the very best trench-based installations. This finding combined with the findings noted above provides an important argument for toughening trenching-based specifications with more specific requirements for backfilling and mechanically compacting the soil. Specifications should allow a static slicing alternative to obtain both more efficient, and thus more economical, better performing installations.

3.2 Tommy Static Slicing Machine Results

Installation Efficiency

In general, installation efficiency using the Tommy static slicing method was superior to all trenching techniques and was 1.75 to 4 times faster depending on the trenching-based installation technique. On average slicing is more than twice as fast an installation technique than is trenching. Slicing productivity is approximately 1,200 man-seconds per 100 feet, or approximately 0.33 man-hours per 100 feet of installation using a two-man crew.

Retention Performance

Figures 4, 5, and 6 show clearly that the Tommy static slicing method performed consistently as well as or better than the Spec + + trenching installation technique, better than the Spec + installation technique for trenching, and much better than the Spec trenching techniques as defined in Chapter 2.2.

3.3 Impact of Other Variables on the Verification Testing and Results

Fabric Type

Testing was initiated using Amoco 2127 fabric, 5-foot spacing between posts, and distributed application of water. Soon after test initiation, it became apparent that insufficient retention of the water needed to be addressed. Limited testing with a less permeable fabric, Amoco 2130, did show an improvement in retention when coupled with the concentrated flow application (see section on "Water Application" for description of application change). As a result, the decision was made to standardize on the somewhat more durable and slightly lower permeability Amoco 2130 fabric and to examine the effects of post spacing and water application technique.

Post Spacing

Several tests were conducted using various post spacing. As shown in Figure 8, post spacing affected the permeability of the silt fence. Closer post spacing resulted in higher permeability while, conversely, greater spacing between posts reduced flow through the fabric. Visual examination of silt fence withvarying post spacing appeared to indicate that at close spacing, the hydraulic pressure on the fence produced less stretching of the fence between posts. This tended to keep openings in the fabric from closing off. The opposite effect appeared with greater post spacing, resulting in fence heights at midpoint between the posts that were clearly much lower than at the posts. This appeared to stretch the fence horizontally and reduce the size of the fence openings.

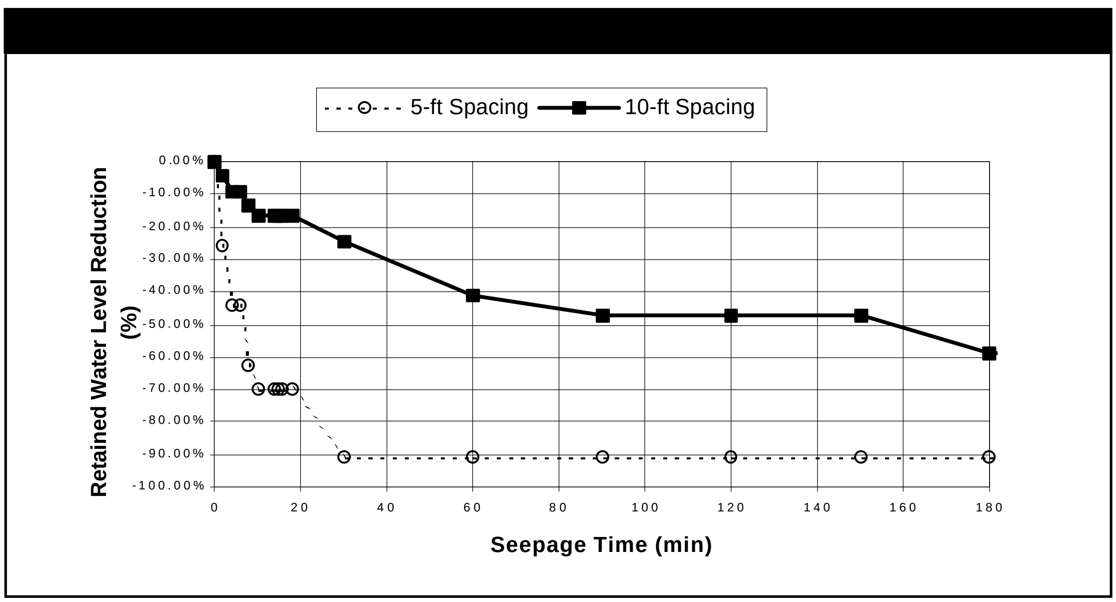

Figure 8. Effects of post spacing: water level vs. time.

The tests reported in Figure 8 reflect tests using runoff with a rather modest sediment load. As a result, initial tests resulted in excessive seepage using the 5-foot post spacing. To encourage retention, blinding of the fabric was enhanced by increasing post spacing to the maximum distance permitted in ASTM D 6462. It should be noted that there was also a trade-off between post spacing and the volume of runoff that could be retained.

Closer spacing of posts prevented sagging of the fence at the mid-point between posts, enabling the silt fence to pond, or retain greater volumes of water. Closer spacing of posts may be more appropriate, especially when retaining highly sediment-laden run-off; the sediments in the water will quickly block off the fabric openings, and the runoff will quickly impound behind the fence. Closer spacing of posts will both minimize fence sagging - increasing capacity - and maximize fence support - which will be needed to resist the increased pressure of the retained water. When the effects of post spacing became clear, a 6.5-foot spacing was selected as the standard for all additional testing in accordance with maximum spacing allowed in ASTM D 6462.

Water Application

The initial Evaluation Plan called for applying simulated storm water runoff to the test segments using a perforated pipe lying on the ground across the upper end of the “smile.” Water would seep out of the pipe along its full length and run down to, and be retained by, the fence. Testing on the first two segments included applying water in this way. It became apparent that this method generated insufficient sediment to cause the blinding (i.e., blocking the openings) of the fence required to prevent seepage through the fence and thereby promote retention. Beginning with the third test, a much more aggressive, concentrated application of the water was used. The concentrated application involved spraying water from a hose directly on the ground in a fan pattern from left to right and back approximately 10-15 feet from the installed fence. This application tech, increasing surface erosion and, therefore, the amount of sediment in the runoff. This technique increased dramatically the retention of runoff in the test. Subsequently, a concentrated water application technique was used for all testing.

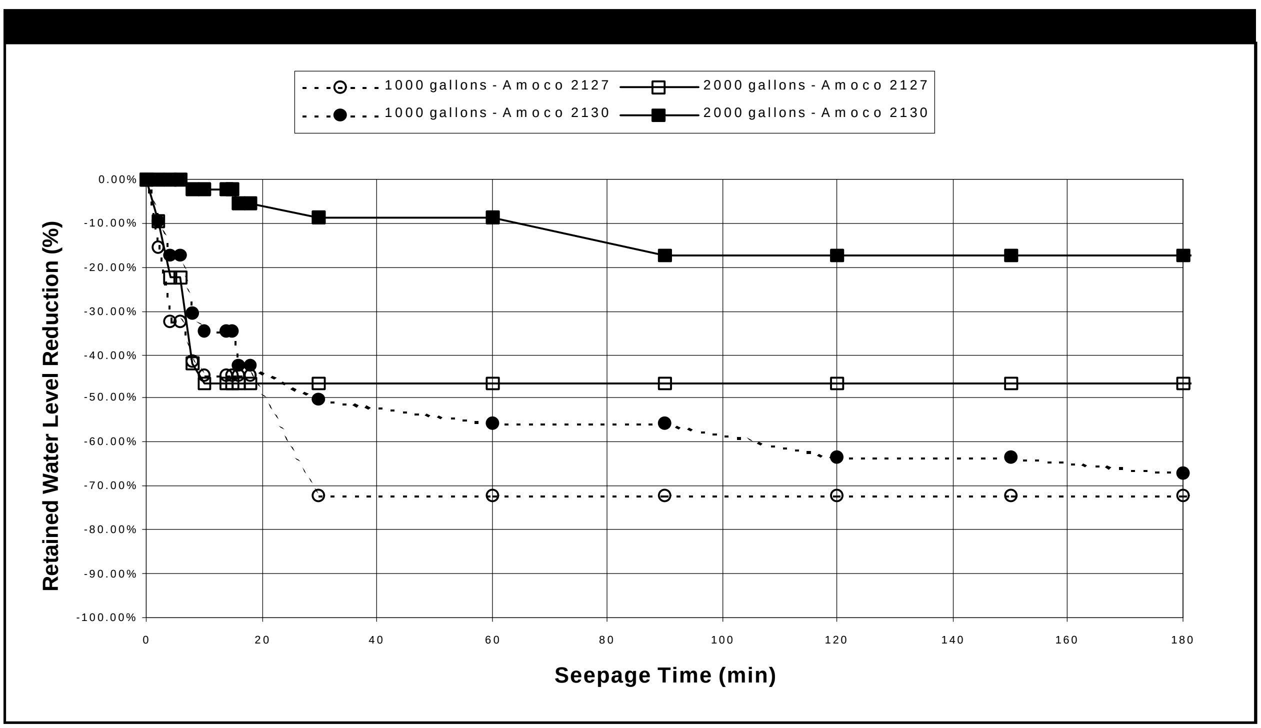

Figure 9. Effects of water applied - static slicing: water level vs. time.

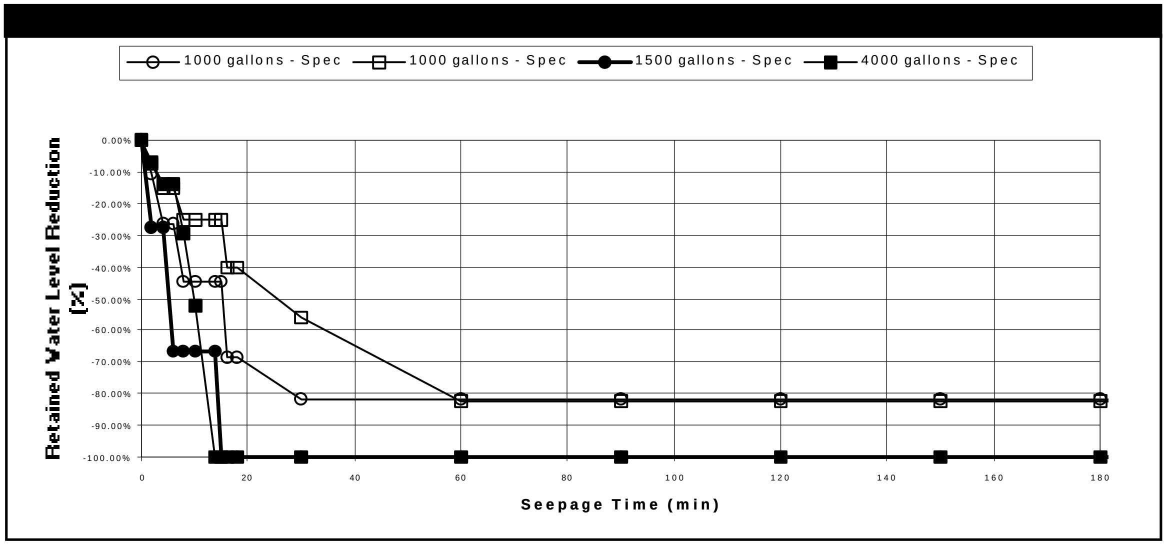

Figure 10. Effects of amount of water applied - trenching (spec): water level vs. time.

Amount of Runoff

One question that remained unanswered throughout the planning process concerned the amount of water required to create the desired level of retained runoff. Based on the sponsor's experience with similar tests, an initial application rate of 1,000 gallons was chosen. The water was applied over a 10-minute period, and the seepage was measured beginning at the end of the water application. Two trucks, each with a 1,000-gallon water tank, were available as sources of water. Standard tests were run using 1,000 gallons of water. During the testing program, greater amounts of runoff were applied in some tests to examine the effects of the amount of runoff. The results are shown in Figures 9 and 10.

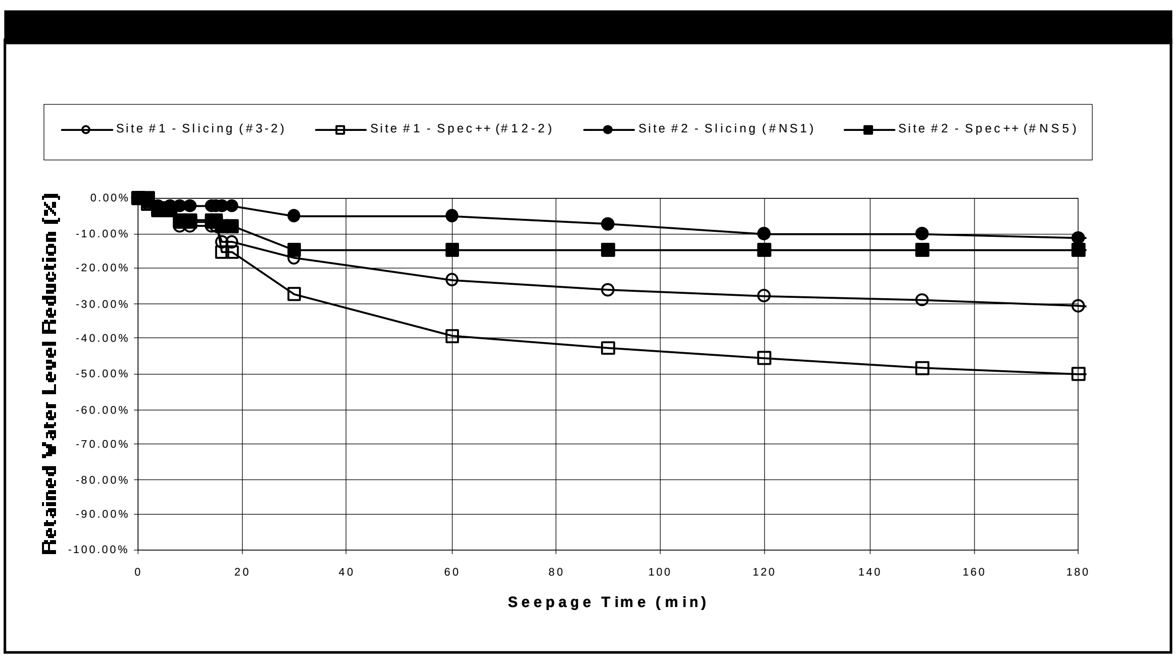

Figure 11. Effects of soil type: water level vs. time.

Slicing and Spec + + installations held up well under the higher head pressure created by the greater water volume, without the water undermining the installation. The greater hydraulic load stretched and tightened the fabric without causing undermining. Spec and Spec + installations failed to hold the higher pressure and experienced increased seepage under the fabric. As mentioned earlier, Spec and Spec + cannot be compacted as well as slicing and Spec + + installations because the posts are typically installed first, interfering with mechanical compaction.

Soil Type

Figure 11 illustrates the difference soil type can make in fence performance. The figure shows testing results from both Site #1, a site composed of silty clay soils, and from Site #2, which was characterized by clay loam soils. The clay loam soil was more erodible, producing more sediment, and thus more quickly blinded the silt fence fabric. Additionally, the silt loam soils were more easily compacted. However, the modestly compacted silt loam backfill was prone to piping beneath the silt fence. The figure shows the importance of compaction. When high levels of compaction are achieved–as is characteristic with the slicing and Spec + + trenching-based installation techniques–high levels of performance can be expected. Where only modest compaction is achieved–as is typical in Spec trenching-based installations–much poorer performance can be expected.

Figures 3 and 4 show results for the majority of tests run. The soil in these tests was a clayey material that tended to break up into clods. These clods were very stable against piping and were resistant to progressive piping and erosion when backfilled in the trench. However, the voids between clods in the trench backfill provided channels for water to seep along the trench and, at points, beneath the silt fence.

When using static slicing, minor soil disruption takes place. Thus, the soil is conditioned for a better compactive effort resulting in a fairly non-permeable status. Similarly, the slicing installation in the clay loam soil (Site #2) minimized disruption of the soil, and the performance shown in Figure 6 indicates that little seepage occurred.

It should be noted that, in this evaluation, trenches were hand-cleaned prior to fabric placement and backfilling. This procedure was used to optimize trenching-based installation performance but is commonly skipped in actual, non-test installation in the "real world." It is likely that typical trenching-based installations would have many clods left in the trench, creating more channels for seepage to undermine the fence.

Compaction

Two primary objectives of the evaluation were to determine if 1) greater compaction, and therefore higher density, of the soil adjacent to the embedded silt fence relates to performance, and 2) greater compaction is obtained adjacent to the embedded silt fence using the static slicing technique. An additional objective of the evaluation was to examine different methods for measuring compaction at the base of the silt fence and determine if it is possible to correlate density or other measurements with relative compaction. If possible, such a measurement could provide a practical quality control tool for site inspectors to assure satisfactory silt fence installation.

Though not easily quantified, the benefits of compaction appear obvious from a review of Figures 3 through 7. Consistent trends in performance are reflected in all figures, showing that maximum compactive effort (static slicing and Spec + + installations) significantly out-performs minimum compactive effort (Spec and Spec +).

Figures 12 through 14 compare data collected using the nuclear density gauge, a cone penetrometer, and a pullout apparatus (vendor created field devise). Data for all three measuring techniques were collected from the same locations. The nuclear density gauge was assumed to provide the most accurate representation of the in situ soil conditions, as it is routinely calibrated and its use is standardized. Figure 15 shows a significant correlation between the cone penetrometer readings and the nuclear density measurements. This may indicate that the much easier, and less expensive, hand penetrometer can be used effectively as a field quality assurance tool.

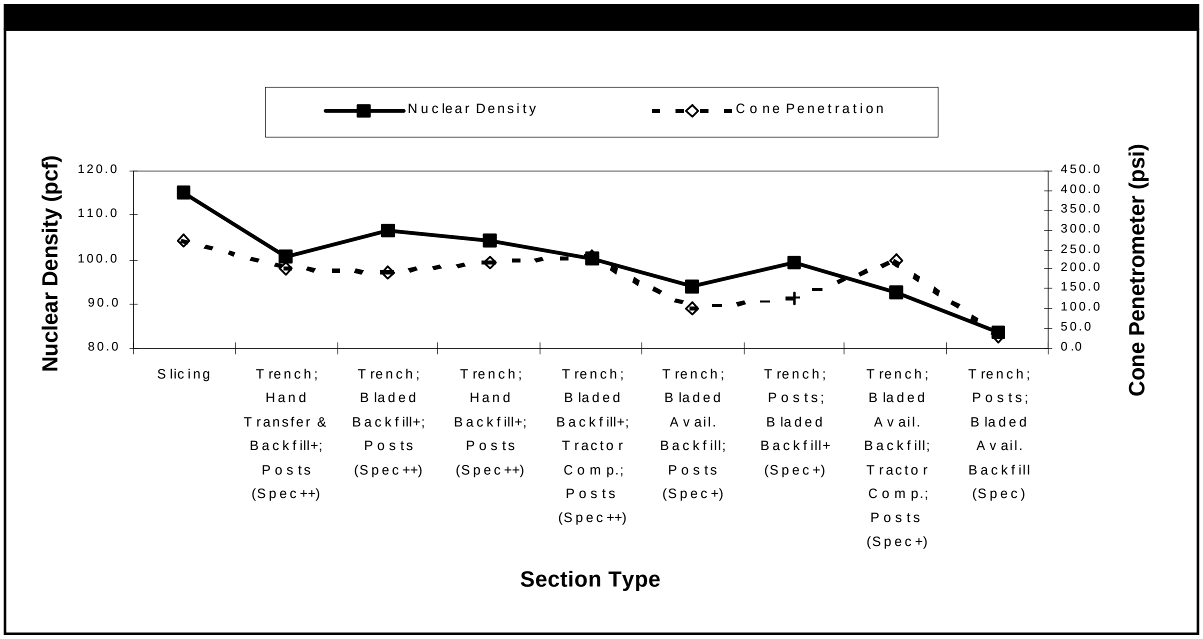

Figure 12. Nuclear guage vs. cone penetrometer.

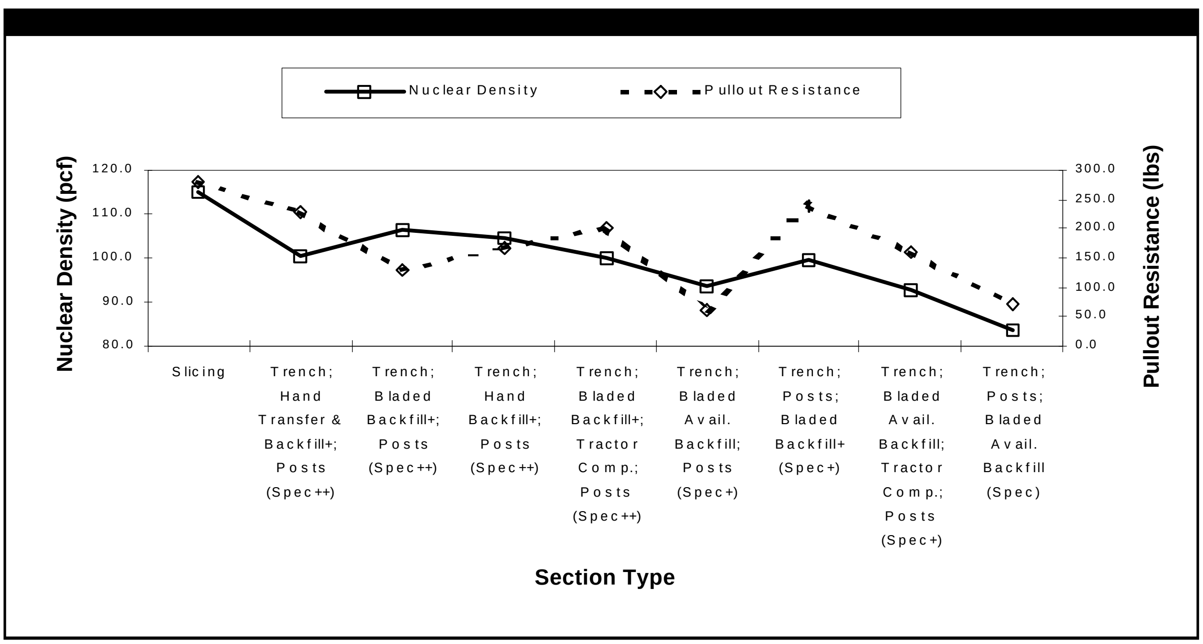

Figure 13. Nuclear guage vs. pullout resistance.

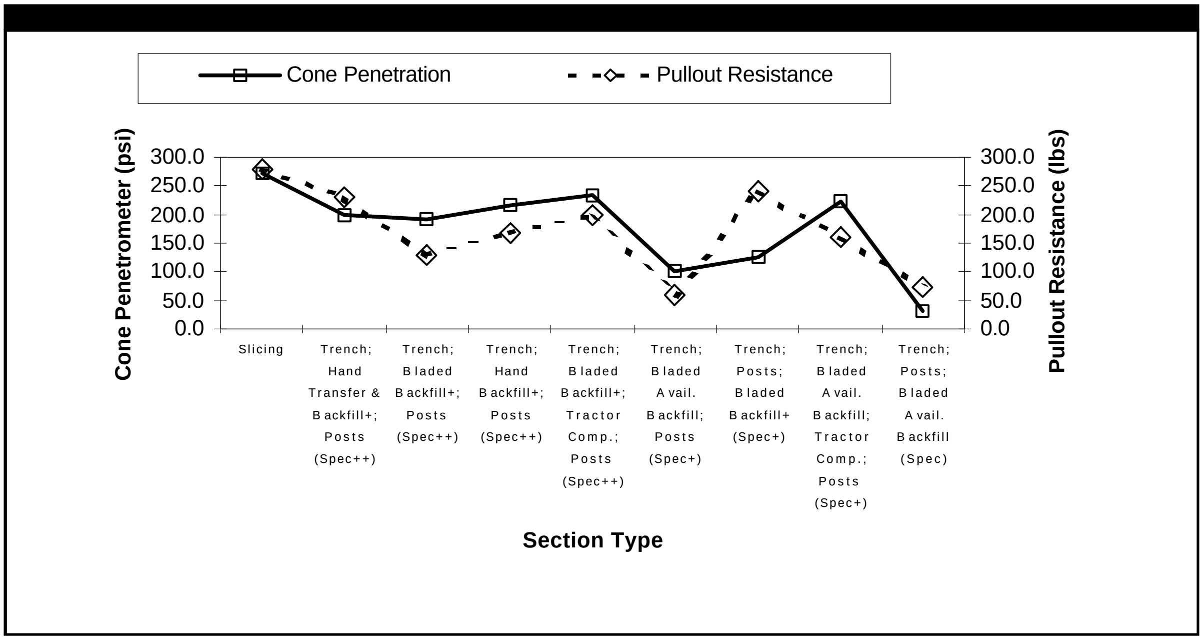

Figure 14. Cone penetrometer vs. pullout resistance.

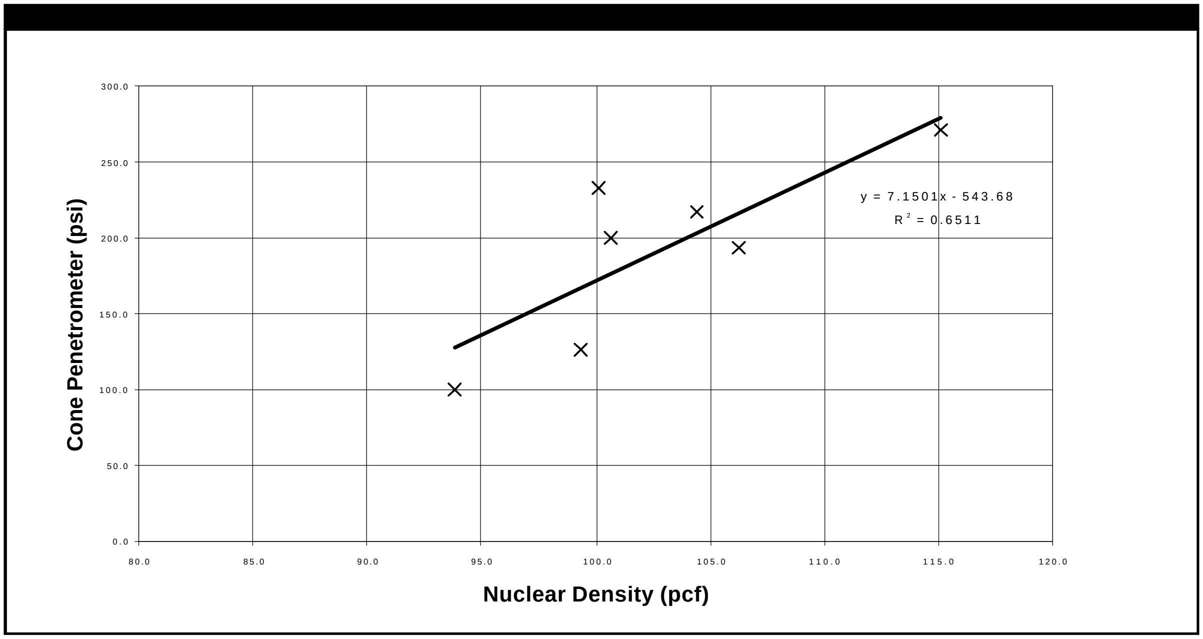

Figure 15. Nuclear density vs. cone penetrometer (excluding tractor/trench compaction).