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# Airside Applications for Artificial Turf

June 2006

Final Report



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16. Abstract

A study to investigate the considerations and concerns associated with airside applications of artificial turf was conducted using input from the artificial turf manufacturers and by administering and discussing questionnaire surveys via site visits to airports. These site visits were scheduled with some airports that already had installed artificial turf plots and during the installation of artificial turf plots at other airports.

To address the safety concerns and performance expectations of airside artificial turf installations, several tests were done. The majority of the tests performed to date were to quantify and qualify the artificial turf product. During the airport surveys, airport personnel were asked what concerns they had with an artificial turf installation. The results of the surveys and discussions with airport personnel indicated that the main reasons for considering artificial turf are for safety, soil erosion mitigation, and foreign object debris reduction. Additional and secondary considerations for the use of artificial turf were found to be abatement of turf management (i.e., low maintenance), jet blast erosion, wildlife control, and visual enhancements.

The majority of airport concerns for accepting the artificial turf applications concentrated on:

- Jet blast resistance
- Environmental and contaminant (fuel, deicing fluid) resistance
- Safety vehicle load support
- Skid and fire resistance
- Access for lighting and equipment maintenance

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

## LIST OF TABLES

## LIST OF ACRONYMS

| | |
|---|---|
| 26N | Ocean City Municipal Airport |
| 2D | Two-dimensional |
| ARFF | Airport Rescue and Firefighting |
| ATL | Hartsfield—Jackson Atlanta International Airport |
| BOS | Boston Logan International Airport |
| DTW | Detroit Metropolitan Airport |
| FAA | Federal Aviation Administration |
| FOD | Foreign object debris |
| FSC | Flame spread classification |
| HNL | Honolulu International Airport |
| MDW | Midway International Airport |
| NE | Northeast |
| ORD | Chicago O'Hare International Airport |
| SD | Smoke developed |
| SFO | San Francisco International Airport |

# EXECUTIVE SUMMARY

A study to investigate the potential applications of artificial turf at airports was conducted. Specific objectives were to identify safety concerns, to list applicable acceptance and performance tests and standards, and to address cost-effectiveness compared to other standard alternatives. During the investigation, a limited number of tests were conducted at the Federal Aviation Administration William J. Hughes Technical Center. These tests were safety related, and the focus was on fire and jet blast resistance. In addition, a number of airports were visited. The purpose of these visits was to review demonstration projects setup by the artificial turf manufacturers and to survey these airports regarding the interest, purpose, and actual use of artificial turf.

The two main reasons for the use of artificial turf installations were to control soil erosion, and to mitigate foreign object debris issues. Other considerations for the use of artificial turf included lower turf maintenance, wildlife mitigation, and visual enhancements.

The majority of airport concerns focused on the ability to resist jet blast, weather effects and contaminants (fuel, deicing fluids, hydraulic fluids), and to support the load of safety vehicles as well as being skid and fire-resistant.

All of the airports were satisfied with the performance of their respective installations. Sufficient data was not available to report on the specific cost-effectiveness of the installations, but all of the airports indicated that the turf was cost-effective in comparison to alternative solutions to their specific problems.

This study concluded that available data to thoroughly investigate the use of artificial turf was limited and additional monitoring of current installations for long-term operational performance and cost-effectiveness was needed. This study also concluded that product specification acceptance tests and standards were incomplete and that additional performance tests and standards needed to be developed.

# 1. INTRODUCTION AND OBJECTIVES.

Over the last few years, a number of U.S. airports have started to consider the use of artificial turf to control and mitigate a number of specific airside problems. These problems, such as lack of drainage or serious soil erosion, could not be typically solved by conventional methods in a cost-effective manner. At airports, the extent of using artificial turf has been limited to small demonstration projects mostly paid for by the artificial turf manufacturers themselves. Each demonstration project was focused on one or more specific airport airside problems. The broad categories of problems were soil erosion, jet blast erosion, lack of drainage, foreign object debris (FOD) reduction, visual enhancement, and wildlife mitigation.

The Federal Aviation Administration (FAA) does not have specific standards to accept, install, and monitor artificial turf. As a result, this study was conducted with the specific objectives to investigate the potential applications of artificial turf at airports, to identify safety concerns, to address cost-effectiveness compared to other standard alternatives, and to list applicable acceptance and performance tests and standards.

To meet the study objectives, existing demonstration projects were reviewed, surveys were distributed to airports, limited in-house testing was conducted, and FAA tests and standards were reviewed for their applicability to artificial turf products.

The artificial turf demonstration projects reviewed were located at:

- Chicago O'Hare International Airport (ORD)—Five test locations to examine erosion, drainage, and visual enhancement: four sites installed during December 2001 were 89′ by 15′ at taxiway D2, 100′ by 10′ drain on island A6, 21,000 $ft^2$ island at runway 32R, two 450′ by 15′ strips at runway 14L/32R. One site installed on June 2003 was a 150′ by 15′ strip at taxiway D7.

- Chicago Midway International Airport (MDW)—Three test locations to examine erosion and visual enhancement (plot size information requested).

- Boston Logan International Airport (BOS)—A single (9000 $ft^2$) test location to examine erosion.

- Detroit Metropolitan Wayne County Airport (DTW)—A single (10,000 $ft^2$) test location to examine drainage and jet blast.

- Honolulu International Airport (HNL)—A single (10,000 $ft^2$) test location to examine FOD and drainage.

- San Francisco International Airport (SFO)—A single (15,000 $ft^2$) test location to examine jet blast erosion and FOD on runways.

- Ocean City Municipal Airport (26N)—Two (3750 and 5940 $ft^2$) test locations to examine drainage and erosion issues. Additionally, two signs and six light cans have a special turf installation (5′ by 5′ turf tray) around them to mitigate damage caused by mowing.

The surveys were initially developed and conducted with airport personnel and were further refined after each site visit.

## 2. CONSIDERATIONS FOR AIRSIDE APPLICATIONS OF ARTIFICIAL TURF.

All the artificial site installations reviewed are shown in appendix A. The survey contained in appendix B focused on asking airport personnel if they investigated the use of an artificial turf product to solve or mitigate a specific problem, what factors convinced them to install the artificial turf product, and to rank a series of factors from most important to least important for considering an artificial turf installation. Some of the ranked factors for installing artificial turf that can be explained in greater detail are listed below. The order of the factors in the report is based on the ranking received in the survey results. (Note: abatement of turf management and low maintenance were considered to be similar, their results were combined and averaged out.)

### 2.1 EROSION CONTROL (SOIL STABILITY) FOR ORD, BOS, MDW, AND 26N.

In December 2001, ORD was one of the first airports to consider artificial turf as a way to mitigate a reoccurring soil stability issue. Near taxiway D2 (figures 2-1 and 2-2 and appendix A, figure A-1) was chosen for a test installation site because airport service vehicles would frequently travel off the access road near the taxiway and onto the grass, tracking mud and dirt onto the runways. The turf was installed as shown in figures 2-3 and 2-4. Airport service vehicles have been trafficking across the area since the installation, and no additional maintenance to the turf or to the airport pavement surfaces, outside of regular maintenance schedules, has been needed.

FIGURE 2-1. PROBLEM AREA AT TAXIWAY D2 (ORD) VIEW 1


FIGURE 2-2.  PROBLEM AREA AT TAXIWAY D2 (ORD) VIEW 2

FIGURE 2-3.  ARTIFICIAL TURF INSTALLED AT TAXIWAY D2 (ORD)

FIGURE 2-4.  ARTIFICIAL TURF AT ORD TAXIWAY D2

A second erosion test location for the artificial turf was placed over the entire island at the end of runway 14L/32R, as shown in figure 2-5.  The island subgrade was angled at a 3% grade off the island edge to direct the water flow to the drain located in the center of the island.  Airport maintenance workers stated that there have been no problems with any type of erosion or water pooling at this location since the installation.


FIGURE 2-5.  ARTIFICIAL TURF INSTALLATION AT ORD RUNWAY 14L/32R

MDW experienced a similar erosion problem at a turnoff near taxiway N. The area was eroding as a result of the jet blast of passing aircraft. Airport operations staff decided to test the artificial turf to mitigate this problem and installed a section in June 2001, as shown in figure 2-6 and appendix A, figure A-2. No problems have been recorded since the artificial turf was installed.

FIGURE 2-6. ARTIFICIAL TURF INSTALLATION AT MDW NEAR TAXIWAY N

On June 6, 2003, BOS installed a 9000-$ft^2$ test section on taxiway N near runway 15L/33R, as shown in figures 2-7 and 2-8 and appendix A, figure A-4 where erosion, drainage, and winter sand buildup was excessive. Airport personnel had to close runway and taxiway operations to rework the soil. The shutdowns were becoming too costly, so an area of artificial turf was installed as a possible solution. Two strips of turf were sewn together and installed on the island next to taxiway N from the points were the most rutting and erosion occurred, with natural grass still surrounding the installation. A French drain outside the taxiway object free zone runs along the backside of the turf and leads to a drain along the edge of the artificial turf. Since the artificial turf has been installed, there has not been a reoccurrence of the issues.

FIGURE 2-7.  TEST LOCATION AT BOS TAXIWAY N, PREINSTALLATION

FIGURE 2-8.  TEST LOCATION AT BOS TAXIWAY N, POSTINSTALLATION

In November 2004, Ocean City Municipal airport decided to install artificial turf (see appendix A, figure A-7) as a solution to a soil erosion problem along runway 6/24, where the natural grass was eroding away from the runway edge and water pooling problems that mainly dealt with soil erosion along runway 6/24.  Figures 2-9, 2-10, and 2-11 show the magnitude of these problems.  Ocean City Municipal Airport is located on a bay.  During times of heavy rain and high-tide conditions, the bay floods and the excess water spills over the runway, eroding the soil between the runway and taxiway. The proposed location of the artificial turf installation is an area that experienced heavy soil erosion directly along the edge of the runway. Figures 2-12 and 2-13 show the finished installation of the artificial turf.

FIGURE 2-9. TEST PLOT LOCATION PRIOR TO ARTIFICIAL TURF INSTALLATION ON RUNWAY 6/24 (SOIL EROSION)

FIGURE 2-10. CLOSE-UP VIEW OF SOIL EROSION ALONG THE EDGE OF RUNWAY 6/24


FIGURE 2-11. PONDING WATER ALONG THE EDGE OF RUNWAY 6/24 ADJACENT TO ARTIFICIAL TURF INSTALLATION LOCATION


FIGURE 2-12. ARTIFICIAL TURF INSTALLATION ALONG THE EDGE OF RUNWAY 6/24 VIEW 1

FIGURE 2-13. ARTIFICIAL TURF INSTALLATION ALONG THE EDGE OF RUNWAY 6/24 VIEW 2

## 2.2 REDUCTION OF FOD (HNL).

In June 2003, HNL personnel decided to install the artificial turf (see figures 2-14 and 2-15 and appendix A, figure A-3) to stop the coral from being blown onto the pavement areas. HNL was experiencing shutdowns on taxiway E, a major taxiway, every time a Boeing 747 taxied by. The site previously had a large amount of loose coral, and when a B-747 taxied by the location, the outboard engine would blow the loose coral onto the taxiway and runway 4R-22L. Deemed a major FOD hazard by airport personnel, the airport would have to shutdown the area to conduct proper clean up.


FIGURE 2-14. SITE VIEW PRIOR TO INSTALLATION OF ARTIFICIAL TURF (HNL)


FIGURE 2-15. SITE VIEW WITH ARTIFICIAL TURF INSTALLED (HNL)

Although HNL considered FOD control a primary reason to test an artificial turf installation, airport personnel tested the drainage capabilities of the artificial turf by oversaturating the artificial turf using an Airport Rescue and Firefighting (ARFF) vehicle until water pooling could be observed. After the area was oversaturated, airport operations staff observed the area to see how long it took for the pooling water to disappear. The water pools dissipated within 2-3 minutes and were completely gone within 5 minutes. The area was dry to the touch within 30 minutes of the test.

## 2.3 ABATEMENT OF TURF MANAGEMENT AND LOW MAINTENANCE (26N).

Ocean City Municipal Airport (see appendix A, figure A-7) does not have a staff to maintain the grass runway safety area at the end of runway 6, as shown in figure 2-16. Therefore, the effort had to be contracted out on a regular basis. Cutting the grass in that area frequently led to the replacement of the eight end runway lights. Ocean City decided to install artificial turf to reduce the grass cutting and light replacement costs. The installation area was 3000 $ft^2$. Figures 2-17 and 2-18 show the final installation of the artificial turf.

FIGURE 2-16. TEST PLOT LOCATION PRIOR TO ARTIFICIAL TURF INSTALLATION IN RUNWAY SAFETY AREA

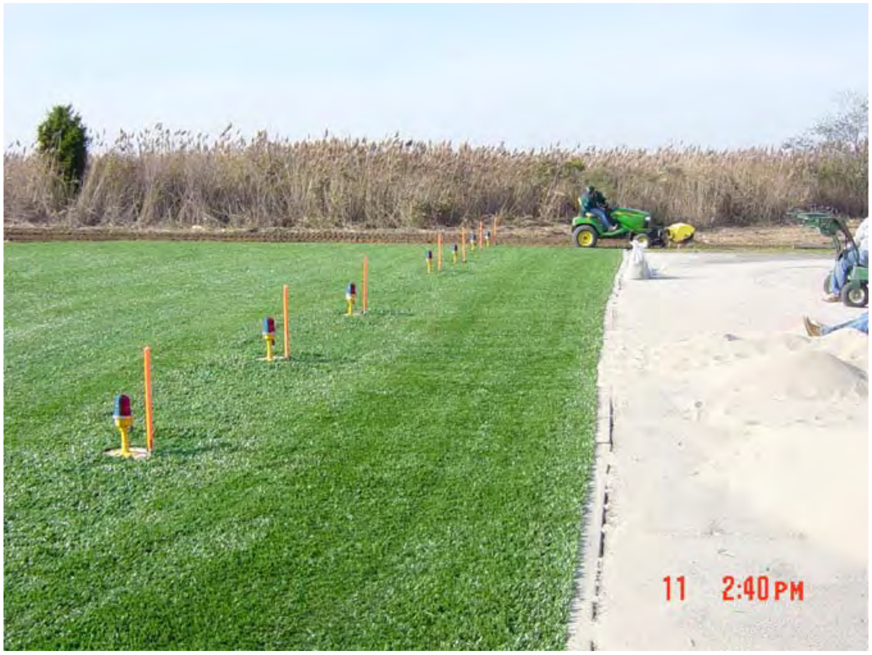



FIGURE 2-17. TEST PLOT LOCATION DURING ARTIFICIAL TURF INSTALLATION IN RUNWAY SAFETY AREA

FIGURE 2-18.  TEST PLOT LOCATION AFTER ARTIFICIAL TURF INSTALLATION IN RUNWAY SAFETY AREA

## 2.4 JET BLAST (DTW, MDW, AND SFO).

### 2.4.1 Detroit Metropolitan Airport.

In June 2002, DTW installed a second test section of artificial turf adjacent to a drainage problem area.  This test section was installed to mitigate soil erosion caused by jet blast on a shoulder to the main carrier runway 4R/22L (see figure 2-19 and appendix A, figure A-5). Complaints had been filed by the Airline Pilots Association, airline tenants, and the FAA regarding large plumes of dust created by a B-747-400 aircraft following takeoff.  Air traffic controllers eventually deemed it necessary to increase separation of departures following heavy aircraft.  The previous modus of addressing this problem by the airport was installing topsoil and hydroseeding, which proved to be a very short-term resolution.

FIGURE 2-19.  TEST LOCATION AT DTW RUNWAY 4R/22L, POSTINSTALLATION

2.4.2 San Francisco International Airport.

In May 2004, SFO (see figure 2-20 and appendix A, figure A-6) was looking for a solution to its natural grass problems that included jet blast soil erosion at the high-speed turnoff at taxiway K and FOD debris from the B-747 outboard engine blowing natural grass and dirt onto runway 28L-10R. The airport operator decided that the runway and taxiway shutdowns necessary to rework the soil were becoming too costly. A test plot (approximately 10,000 $ft^2$) of artificial turf was installed to alleviate the problem.

FIGURE 2-20. TEST PLOT LOCATION PRIOR TO ARTIFICIAL TURF INSTALLATION

2.4.3 Midway International Airport.

MDW installed artificial turf at the blast area of runway 31C (see figure 2-21 and appendix A, figure A-2) in June 2001. This installation was not used to solve any problem, but to test the durability of the turf. The idea was to determine how the artificial turf would react with everyday airport usage. To date, the test strip has not become dislodged, caused any FOD damage, or shown any signs of uplift or movement.

FIGURE 2-21.  INSTALLATION AT BLAST PAD NEAR RUNWAY 31C (MDW)

## 2.5 DRAINAGE CONTROL (ORD AND DTW).

### 2.5.1 Chicago O'Hare International Airport.

In December 2001, ORD also installed a test area on the island between taxiways A6 and A7 (see figure 2-22 and appendix A, figure A-1) where water runoff from heavy rain and melting snow pooled around a drain and saturated the soil.  Concreting the entire area between the taxiway and runway had been tried previously but water pooled at the drain because there was nothing to slow down the water flow (and it was noted that the concreting diminished the visual distinction between the runway and taxiway).  A single strip of artificial turf was installed from the top of the island to the drain.  This strip replaced most of the existing eroded and rutted grass. Airport staff noted that the strip of artificial turf slowed the flow of water similar to natural grass, but the surrounding area did not become over saturated, allowing water to stand on the surface until it was absorbed or evaporated.

Also at ORD, a second installation of artificial turf was placed over the entire island that separated runway 32R from taxiway P, as shown in figure 2-23.  The island subgrade was angled so that the water flowed to the drain located in the center of the island.  Airport maintenance workers stated that there have been no problems with any type of erosion or water pooling at this location.

FIGURE 2-22.  ARTIFICIAL TURF INSTALLATION AT ORD TAXIWAYS A6 AND A7

FIGURE 2-23.  ARTIFICIAL TURF ON AN ISLAND ADJACENT TO RUNWAY 32R (ORD)

2.5.2  Detroit Metropolitan Airport.

In June 2002, an artificial turf test section was installed at DTW to investigate a possible solution to a drainage problem that was causing water to pool on the shoulder of the main carrier runway 4R/22L (see figures 2-24 and 2-25 and appendix A, figure A-5).  The airport addressed this problem by installing topsoil and hydroseeding, which proved to be a very short-term resolution. Airport personnel stated that there have been no problems with any type of water pooling at this location since the artificial turf was installed.

FIGURE 2-24. TEST LOCATION AT DTW RUNWAY 4R/22L, PREINSTALLATION

FIGURE 2-25. TEST LOCATION AT DTW RUNWAY 4R/22L, POSTINSTALLATION

## 2.6 WILDLIFE DETERRENCE.

There is a lake adjacent to the artificial turf installation at BOS. Before the artificial turf was installed, many types of small birds (starlings, hawks, etc.) were noted resting and nesting on the grass. Although the artificial turf area was not installed to deter wildlife, airport operations staff noticed that the birds that were previously nesting in the area were no longer present. (There was no formal census completed to support this statement.)

## 2.7 VISUAL ENHANCEMENTS (ORD AND MDW).

### 2.7.1 Chicago O'Hare International Airport.

At ORD, an island located off taxiway M5 (near airline docking stations) had been painted green to provide some visual distinction of where a taxiway ended and a runway began, (see figure 2-26 and appendix A, figure A-1). However, after 1 or 2 years of use, the paint had faded and started to chip and peel. The airport found that it was too costly to shutdown and repaint the area every year, so an artificial turf was installed to replace the painted area.

FIGURE 2-26. VISUAL ENHANCEMENT AT ORD

### 2.7.2 Midway International Airport.

Aircraft returning to maintenance facilities located along taxiway N at MDW would sometimes veer onto a grass island that separated the maintenance facilities from the taxiway (see figure 2-27 and appendix A, figure A-2). MDW personnel theorized that the natural grass area was not providing enough visual distinction between the grassy and paved areas, so artificial turf was installed to test their theory. To date, no follow-up information has been obtained.

FIGURE 2-27. VISUAL ENHANCEMENT AT MDW

# 3. INSTALLATION METHODS.

During the time of this study, there were only two companies, Air FieldTurf, Inc. and AvTurf L.L.C., that provided and installed artificial turf for airside use. Both companies have ongoing research, development, and testing programs. However, each company has its own installation method as described in the following sections.

## 3.1 AIR FIELDTURF, INC.

### 3.1.1 Prepared Base Installation Method.

If the installation location of the artificial turf is on grass or soft soil, the area is excavated. If the area is in a critical area where aircraft loading is possible, the subgrade is compacted to be able to support the weight of one or two passes of the heaviest aircraft at the airport. This is done with an aggregate base course using both FAA P-209 and FAA P-154 (reference Advisory Circular 150/5370-10 for FAA aggregate information) materials compacted to 90-100 percent maximum density. A 6- by 6-recycled plastic notched curbing is attached to the ground with a 5/8-inch coated steel rod 30 inches long. The curbing is what attaches the turf flush with the adjoining pavement (see figures 3-1 through 3-4). To close the joint between the notched curbing and a runway or taxiway, a sealant is placed to prevent the growth of weeds and the intrusion of other foreign objects. The artificial turf is then layered over the compacted aggregate. Air FieldTurf uses a proprietary fiber and backing process. According to the manufacturer, this eliminates the need for a weed barrier to be put down prior to the turf installation. However, during the course of investigation, no tests were conducted by the FAA for drainage or weed growth. Air FieldTurf also installs both permeable and nonpermeable turf for use in the different areas within the confines of an airport environment, thus providing design alternatives for drainage runoff. The artificial turf surface is attached to the notched curbing with hot-melt glue, as recommended by the manufacturer, and fastened with galvanized or stainless steel nails. The adhesive acts as a gasket to seal the turf edge. The other side of the turf facing any grassy area is buried into the ground, secured with turf pegs, and compacted back-fill soil (see figures 3-1, 3-2, and 3-5). Once the turf surface is secured, sand is brushed into the entire surface to help act as ballast and to aid in fluid and debris retention (see figures 3-1, 3-2, and 3-6). If the installation site is wider than the manufactured turf width, sections of the artificial turf is sewn together, then placed in the installation site. Any excess artificial turf is trimmed.

Signs, manhole covers, access drains, and other existing airport markers (see figures 3-7 and 3-8) are not affected by the installation process because the artificial turf can easily be cut to fit the area that is needed. Air FieldTurf has a turf that has a Velcro seal specifically designed to permit access to future electrical or other airport equipment installations that would be buried under the turf.

Damaged turf surfaces can be repaired by removing and replacing the damaged portion, using a seaming fabric and glue supplied by Air FieldTurf. The repair process is the same if electrical work is needed on signs or other electrical equipment after the installation has been completed. The repair work can be done by the manufacturer or by trained airport staff.

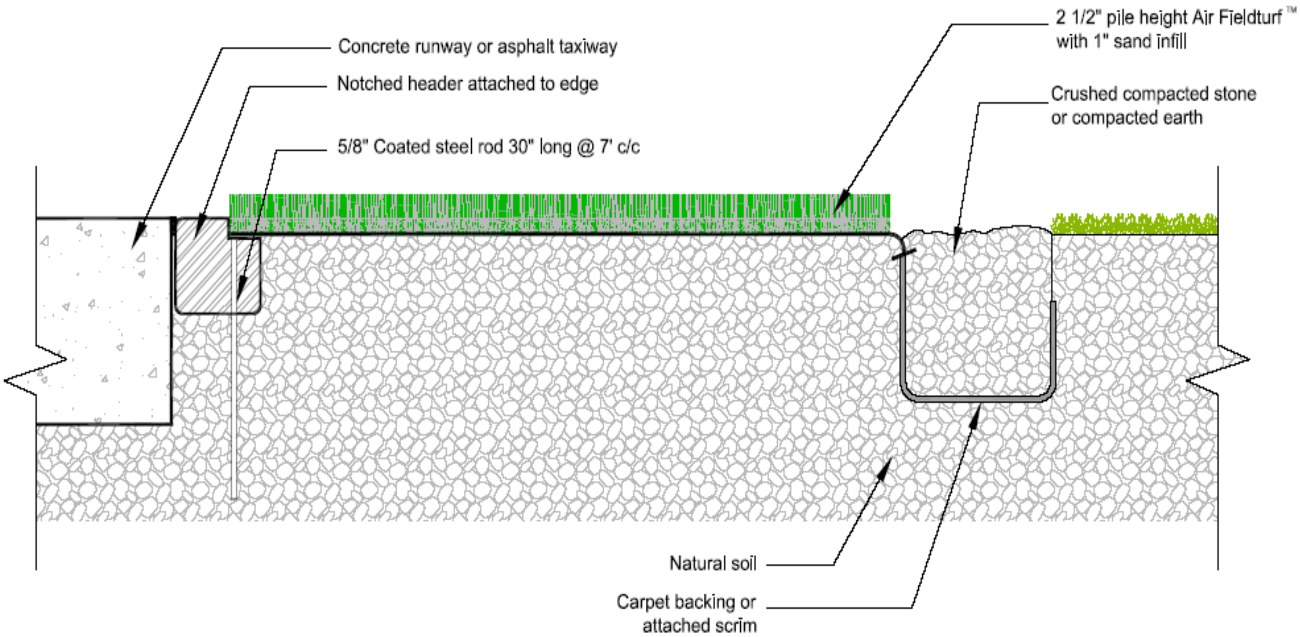



FIGURE 3-1. AIR FIELDTURF CROSS SECTION ON A LOAD-BEARING BASE

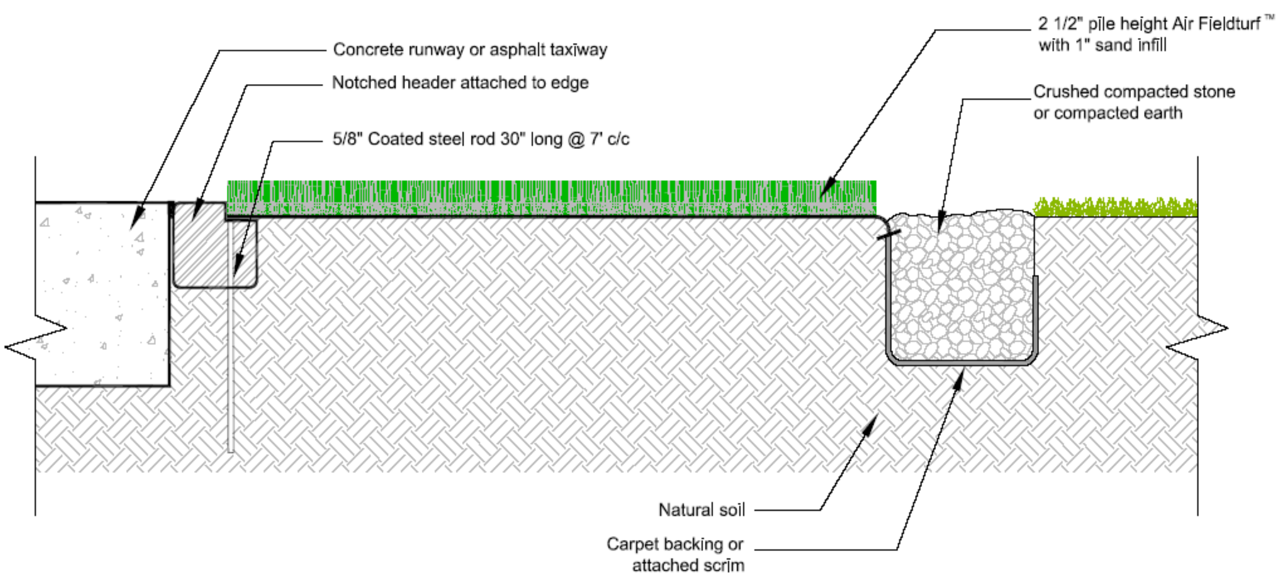



FIGURE 3-2. AIR FIELDTURF CROSS SECTION ON A
NON-LOAD-BEARING BASE

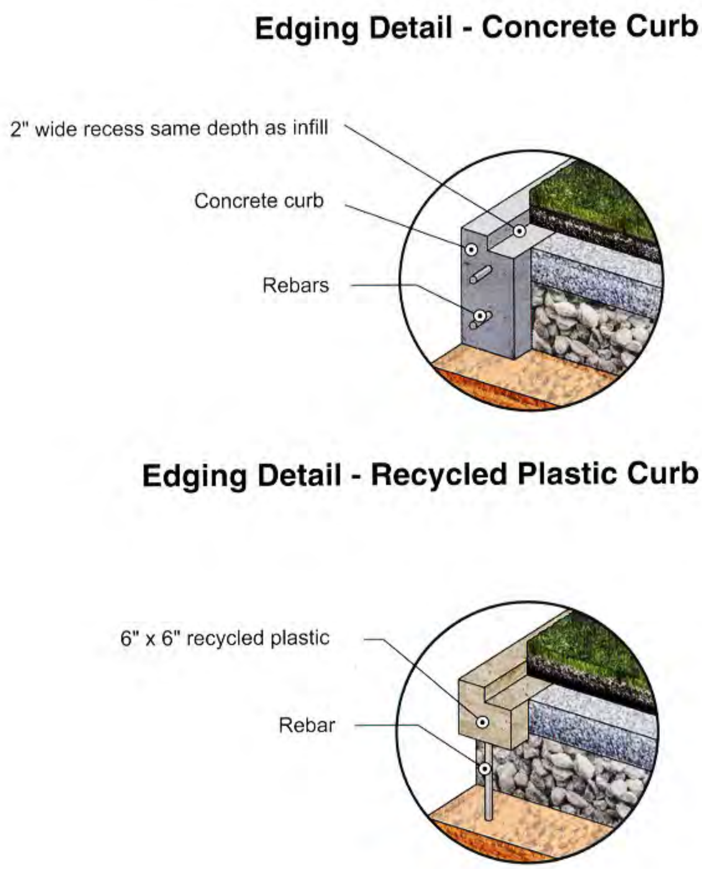



FIGURE 3-3.  AIR FIELDTURF EDGING DETAIL CROSS SECTION

FIGURE 3-4.  ARTIFICIAL TURF PAVEMENT SIDE ATTACHMENT

FIGURE 3-5. ARTIFICIAL TURF BACKSIDE TRENCHING AND ATTACHMENT

FIGURE 3-6. CLOSE-UP VIEW OF ARTIFICIAL TURF WITH BALLAST SAND, TOP VIEW

FIGURE 3-7. ARTIFICIAL TURF INSTALLED AROUND EXISTING MANHOLE COVER

FIGURE 3-8. ARTIFICIAL TURF INSTALLED AROUND EXISTING ACCESS DRAIN

3.1.2 Existing Concrete and Asphalt Base Glue Application.

If the artificial turf is to be installed over concrete, as shown in figure 3-9, or asphalt, as shown in figure 3-10, the edge of the installation area will be milled to allow the turf edge to be placed below the existing surface, allowing a smooth transition of traffic across the turf (e.g., snow plows during winter months). Alternatively, a precast concrete ramp (see figure 3-11) will be placed on the hard surface and the turf edge to anchor the turf, allowing vehicular traffic to cross the turf edge without damage to the wheels. Additionally, the entire surface area of the installation site was coated with glue to provide an additional means to prevent the turf from dislodging. Currently, Air FieldTurf used two different types of glue: a two-part mixture called Environstick and Nordot 34N, shown in figures 3-12 and 3-13. Once the turf was placed on top of the glue and secured in the milling and concrete ramp, ballast sand can be added, if desired.

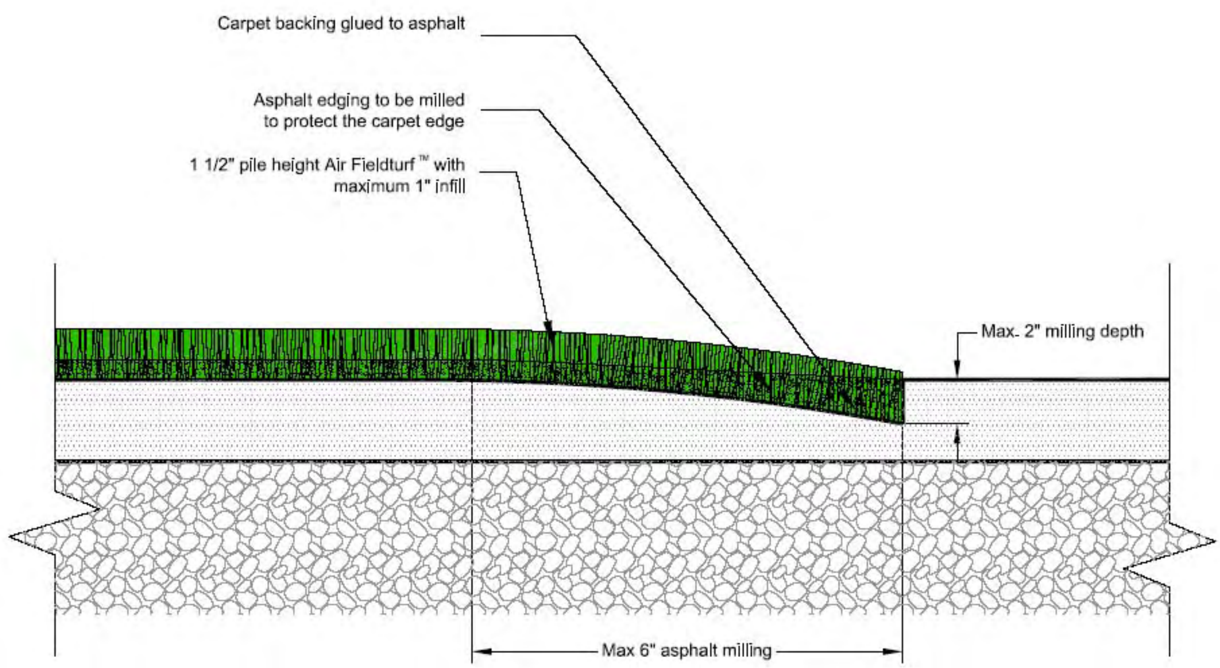



FIGURE 3-9. BURIED EDGE DETAIL FOR INSTALLATION ON ASPHALT

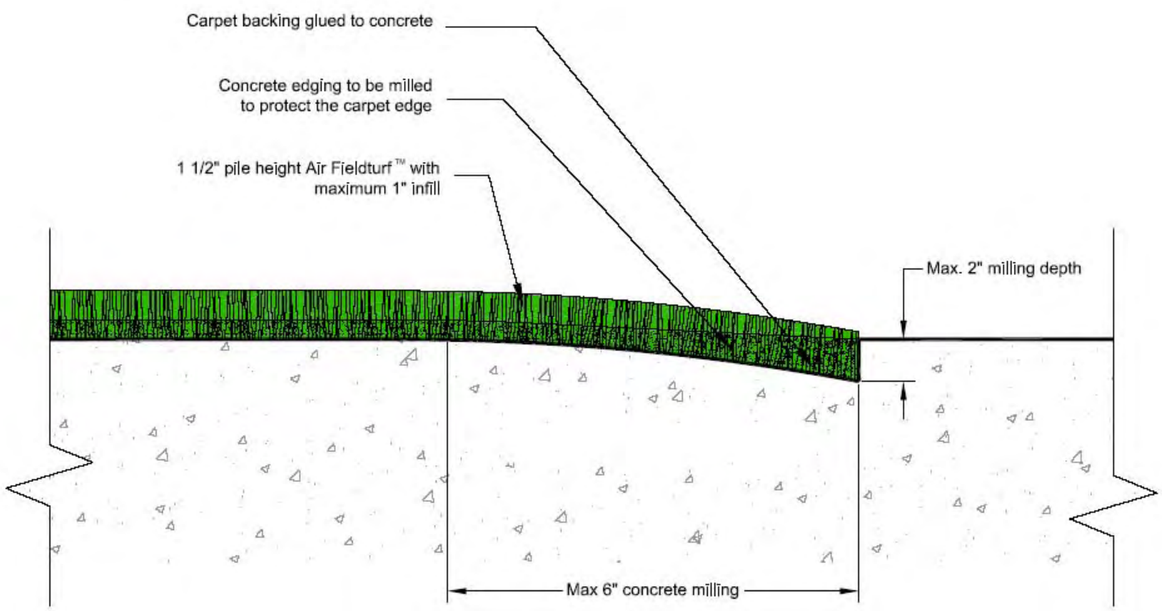



FIGURE 3-10. BURIED EDGE DETAIL FOR INSTALLATION ON CONCRETE

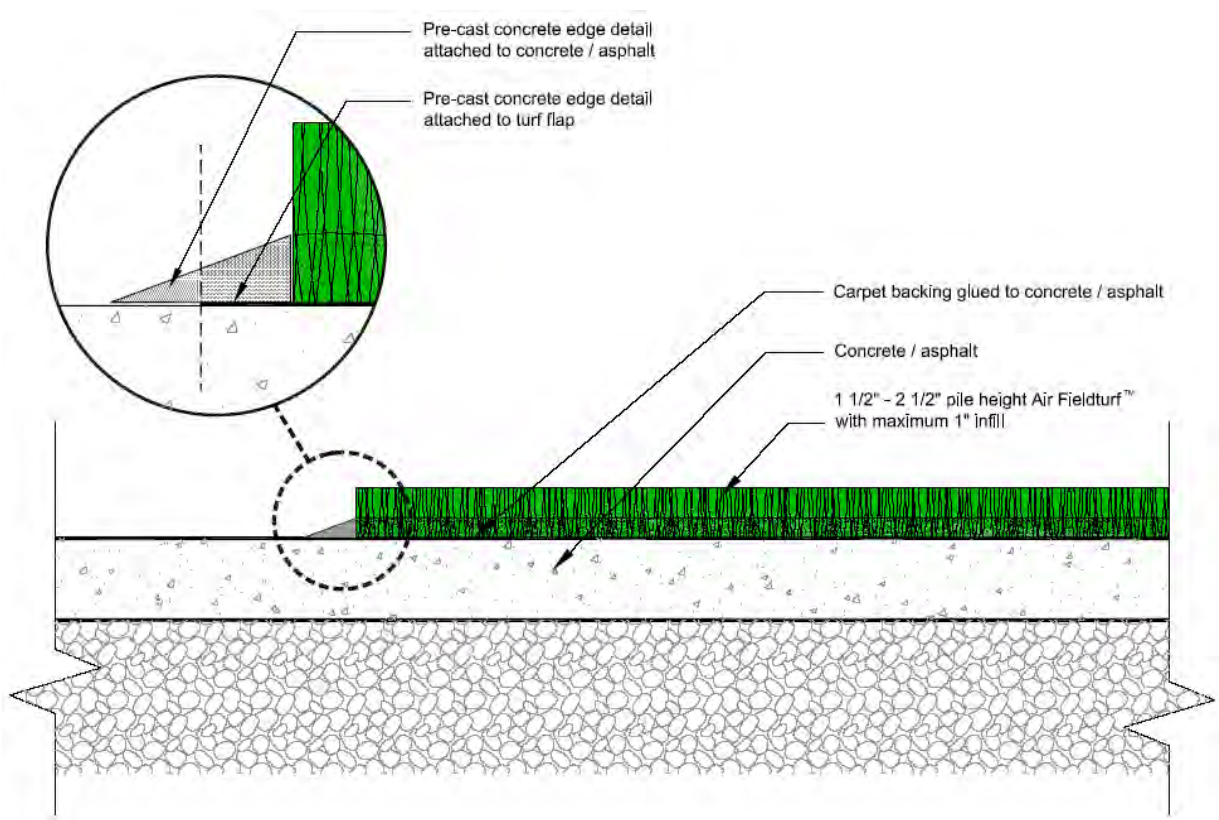



FIGURE 3-11. PRECAST CONCRETE EDGE DETAIL FOR INSTALLATION ON CONCRETE AND ASPHALT


FIGURE 3-12. APPLICATION OF ENVIRONSTICK TWO-PART GLUE ON ASPHALT

FIGURE 3-13. APPLICATION OF NORDOT 34N ON CONCRETE

3.1.3 Sign and Light Can Installation.

Air FieldTurf has a specific installation for signs and light cans, using a tray system. The tray is approximately a 5 by 5 area of artificial turf that can be attached to the ground by either being trenched and buried into the surrounding area or turf-pegged directly into the ground.

3.1.3.1 Installation Description for Turf-Pegged Edge Detail.

a. The area around the light can or sign (approximately a 5 by 5 area) was marked to find the limits of the top soil to be removed (figure 3-14).

b. Using standard sod cutter equipment, the existing grass was excavated to a depth of 1 1/2 inches (figure 3-15).

c. The excavated area was cleaned and smoothed (sand or top soil is sometimes added) prior to placement.

d. A flexible L angle was attached (figure 3-16) to the light base-mounting fixture. Adhesive was placed on the horizontal edge of the fixture to form a seal (preventing growth from coming through), or the turf was cut around the light base-mounting fixture and affixed with a zip tie (figure 3-17).

e. The turf was then pressed down around the perimeter of the light base-mounting fixture edges to have the sealer or adhesive bond to the turf.

f. A stapler or nail gun was used to install nails or staples at each corner vertically thorough the turf.

g. Turf pegs were used to fasten the turf into the ground at each corner and evenly along the edges at 12-inch centers (figure 3-18).

h. After the turf was anchored into the ground, the artificial turf area was filled in with ballast sand (figure 3-19).


FIGURE 3-14. LIGHT CAN PRIOR TO ARTIFICIAL TURF BOX INSTALLATION

FIGURE 3-15.  LIGHT CAN WITH INSTALLATION AREA DUG OUT

FIGURE 3-16.  LIGHT CAN WITH FLEXIBLE L ANGLE INSTALLED


FIGURE 3-17. LIGHT CAN WITH ZIP TIE ATTACHMENT


FIGURE 3-18. TURF-PEGGING ARTIFICIAL TURF TO GROUND


FIGURE 3-19. COMPLETED INSTALLATION AROUND LIGHT CAN

Figure 3-20 provides a cross-section view of a typical Air FieldTurf sign or light can installation. Figure 3-21 shows a detailed view of how the artificial turf attaches to the sign or light base-mounting fixture.

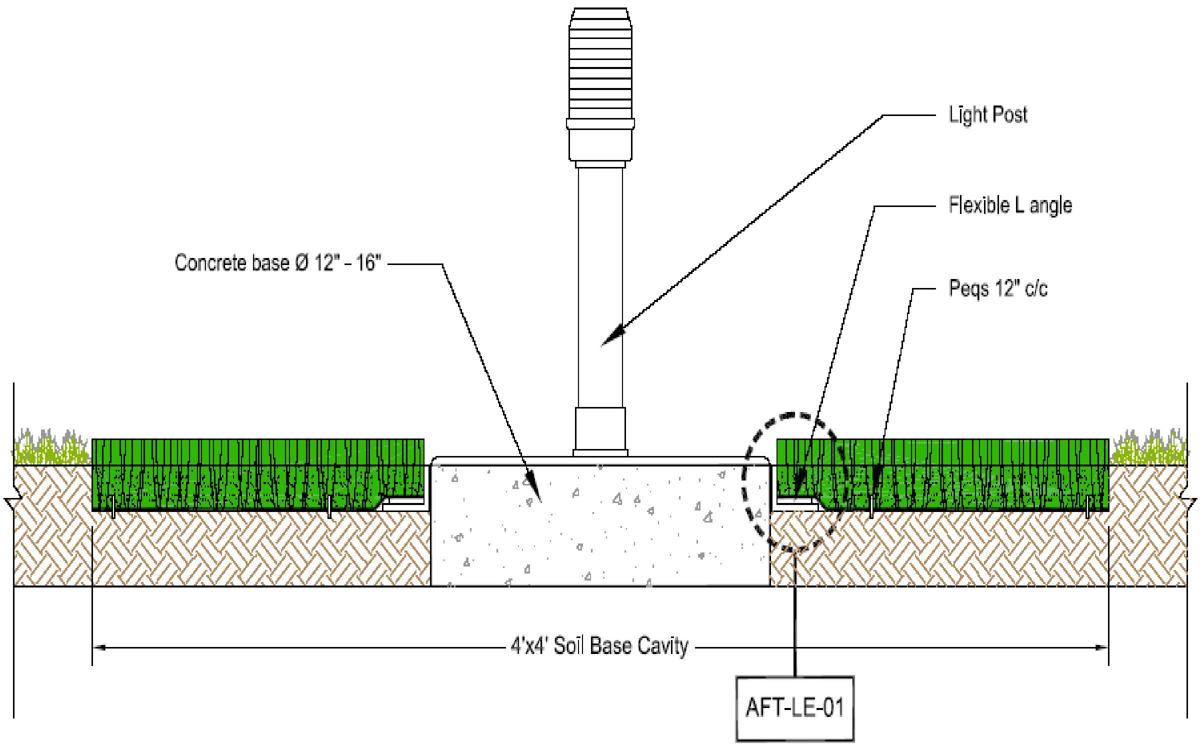



FIGURE 3-20. AIR FIELDTURF CROSS-SECTIONAL VIEW OF THE LIGHT CAN INSTALLATION

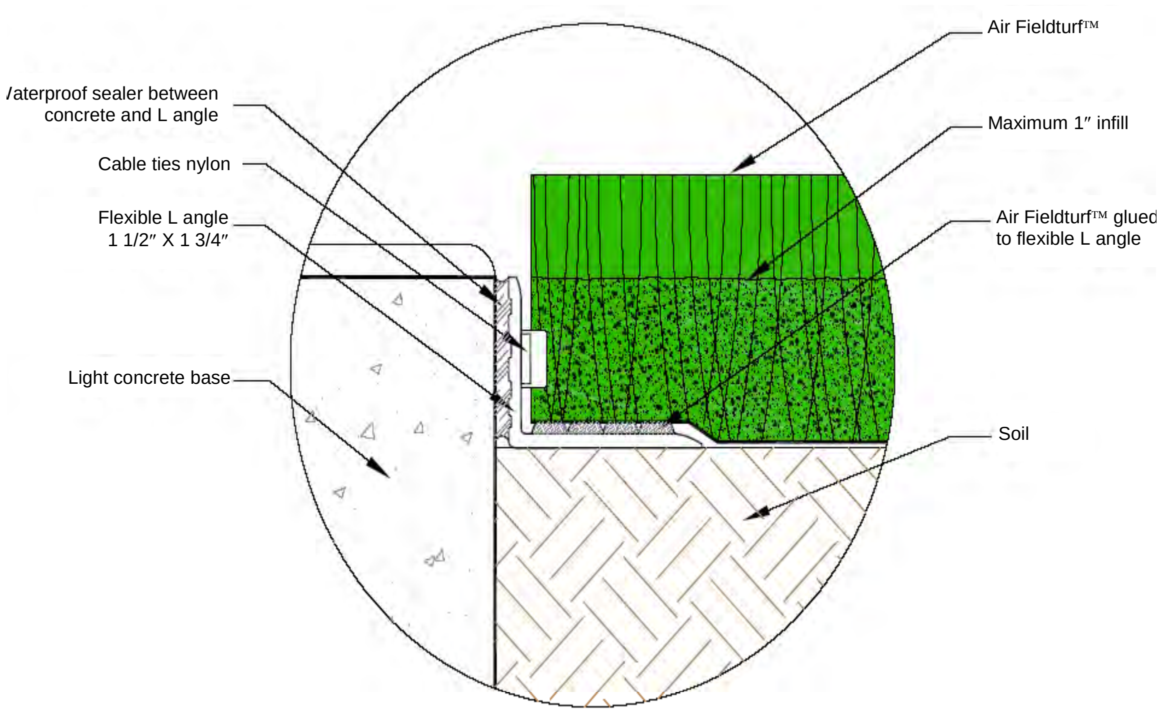



FIGURE 3-21. AIR FIELDTURF CLOSE-UP VIEW OF LIGHT CAN ATTACHMENT

3.1.3.2 Installation Description for Buried Edge Artificial Turf.

a. A trench was excavated to bury the edge of the turf (figure 3-22).

b. The trench is dug in either a V or U shape with a minimum depth of 18 inches and a minimum width of 12 inches.

c. Using standard sod cutter equipment, the existing grass was cut out to a depth of 1 1/2 inches.

d. The excavated area was cleaned of all debris and smoothed out (sand or top soil is sometimes added) prior to the placement of the turf.

e. A flexible L angle was attached to the light base-mounting fixture. Adhesive was placed on the horizontal edge of the fixture to form a seal (preventing growth from coming through), as shown in figures 3-23 and 3-24, or the turf is cut around the light base-mounting fixture and glued directly to the top of the light-mounting fixture, as shown in figure 3-25.

f. The turf was then pressed down around the perimeter of the light-mounting fixture in order to have the sealer or adhesive bond to the turf.

g. The back end of the turf was placed into the trench and filled with the excavated soil.

h. The artificial turf was then filled in with ballast sand, as shown in figure 3-26.


FIGURE 3-22. LIGHT CAN BEING TRENCHED FOR INSTALLATION OF ARTIFICIAL TURF


FIGURE 3-23. TRENCHED ARTIFICIAL TURF PLACED AROUND LIGHT CAN


FIGURE 3-24. TRENCHED ARTIFICIAL TURF PLACED AROUND SIGN


FIGURE 3-25. ARTIFICIAL TURF BEING ATTACHED TO A LIGHT-MOUNTING FIXTURE


FIGURE 3-26. TRENCHED ARTIFICIAL TURF INSTALLATION AROUND THE LIGHT CAN COMPLETED

Figures 3-27 and 3-28 show a cross-sectional view of the different types of trenching techniques used to bury the artificial turf.

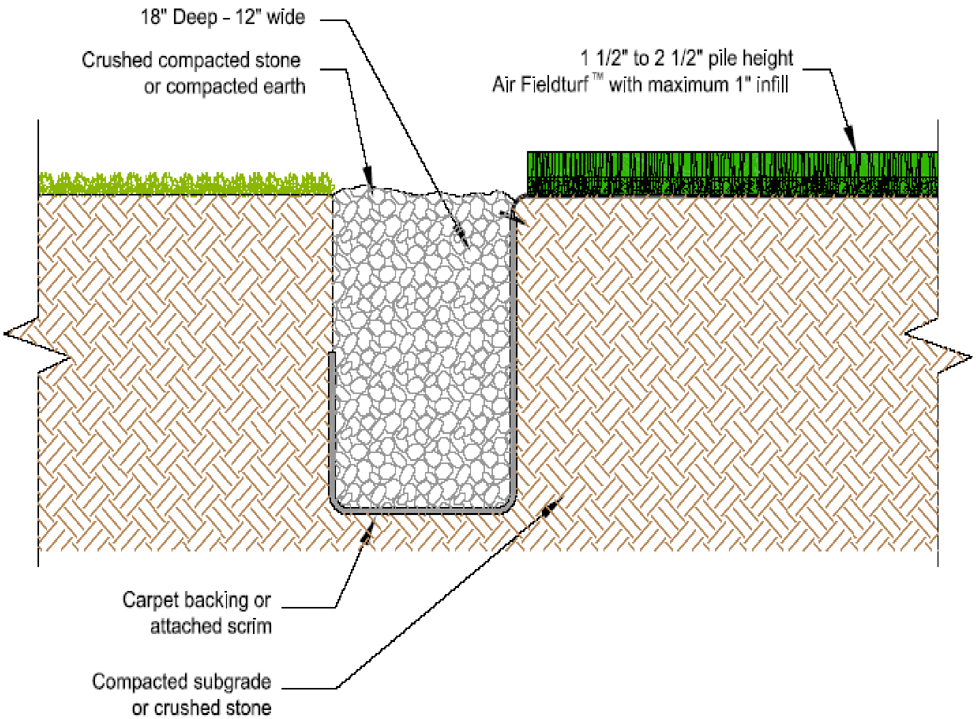



FIGURE 3-27. AIR FIELDTURF CROSS-SECTIONAL VIEW OF A U-SHAPED TRENCH INSTALLATION

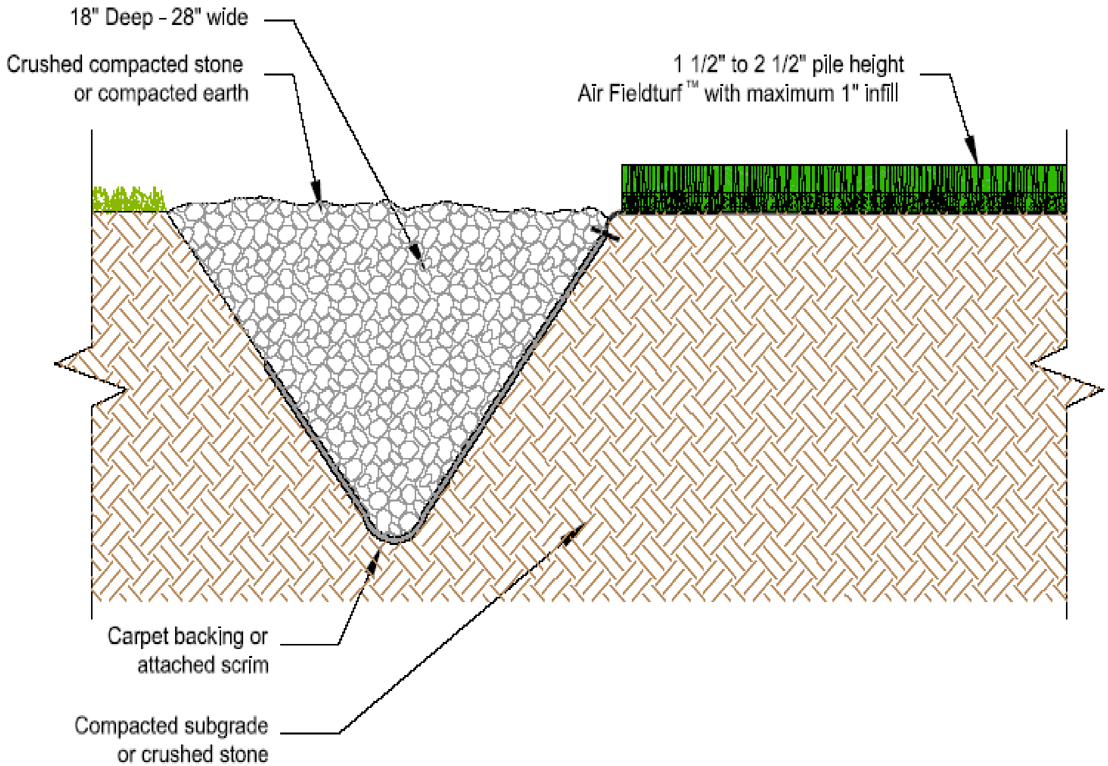



FIGURE 3-28. AIR FIELDTURF CROSS-SECTIONAL VIEW OF A V-SHAPED TRENCH INSTALLATION

## 3.2 AVTURF INSTALLATION METHOD.

Depending on the installation location of the artificial turf, the area was excavated to a depth of 9.5 to 11.5 inches. A geotextile weed barrier was placed on top of the excavated soil to prevent unintended natural grass growth. Depending on the location of the installation, a varied amount of aggregate road base (CA6), compacted between 90 and 100 percent maximum density, was used. The artificial turf adjoining concrete and asphalt was anchored into the ground with 1-inch galvanized staples into a 16-foot, 2- by 4-inch wood composite header buried into the base. Turf that adjoined grass was buried into the ground and secured with compacted soil back fill. Once the turf surface was secured, ballast sand was brushed into the surface to help aid in fluid and debris retention.

Damaged turf surfaces were replaced by cutting out a section of the turf surface larger than the damaged area, placing glue strips along the edges of the cutout, and rolling a new turf section with a heavy roller to anchor it to the glue strips. The repair process is the same if electrical work is needed on signs, lighting, or other equipment. The repair work can be done by the manufacturer or by trained airport staff.

# 4. TESTING.

To address the safety concerns and performance expectations of airside artificial turf installations, several different tests were performed. It should be noted that the majority of the tests performed to date were to quantify the artificial turf product and not to qualify the artificial turf. During the airport surveys, airport personnel were asked what concerns they had with an artificial turf installation. The majority of their concerns were related to

- resisting jet blast.
- demonstrating durability to weather conditions and fluids (fuel, deicing fluid).
- supporting the load of safety vehicles and operational deviations.
- being skid- and fire-resistant.
- allowing access to lighting and other equipment.

Both suppliers and installers of airside artificial turf had conducted a series of tests using independent testing laboratories for resistance to fire and contaminants such as deicing fluids, hydraulic fluids, and aviation fuels and oils. The supplier or installer tests are presented at the end of this section. Additionally, wind tunnel and fire tests have been conducted at the FAA William J. Hughes Technical Center. The test conditions and results of these tests are detailed in appendices C and D.

The current installations are active demonstration tests to address the airports' concerns and to evaluate maintenance and cost benefits. However, pre- and postdemonstration tests were performed at different sites as follows:

- ORD—Heavy load tests with ARFF vehicles and a B-757 and a burn test (performed in conjunction with MDW).

- MDW—Heavy load tests with ARFF vehicles and a B-757 and a burn test.

- BOS—Heavyweight tests with ARFF vehicles, jet blast tests with a B-757, and high-speed passes with ARFF vehicles and VAMMAS snow blower.

- HNL—High-speed passes with ARFF vehicles, burn tests, and oversaturation with water to show drainage capabilities.

- SFO—Jet blast tests with a B-777 and B-747.

## 4.1 FLAMMABILITY FIELD TESTS PERFORMED AT MDW.

These tests were conducted on October 12, 2000. Test boxes, 4 feet by 8 feet by 3 5/8 inches made of 2- by 4-inch frames and plywood-backed construction, contained a sample of turf on top of 1/2-inch of dry sand base over a 3/16-inch rock subbase. The turf sample had approximately 3/4-inch fiber exposed. Based on expected fuel spills, aviation grade Jet-A, vehicle-grade diesel, and vehicle-grade unleaded gasoline were used for the tests.

Two burns were conducted on each test sample. Approximately 2 to 3 gallons of fuel were poured over 35-50 percent of the sample surface. The tests were conducted outdoors, in full wind conditions.

The results were similar in all classes. Even with a 16-knot wind, the flame did not spread to the fibers that were not in contact with the fuel. The fibers melted away from the flame, thus limiting the spread of the flame.

## 4.2 LOAD-BEARING TESTS.

At BOS, heavy airport vehicles were tested in various ways to see how the artificial turf reacted. A static test using an ARFF vehicle weighing 66,000 lbs was parked on the turf and allowed to rest for 10-20 minutes. Once the vehicle was removed from the area, the turf was inspected for any rutting or problematic areas. After an extensive inspection, no ruts or other problems were reported.

To determine if the artificial turf would shift or be dislodged by a turning vehicle, an ARFF vehicle, shown in figure 4-1, was slowly driven on the turf surface while constantly turning. No damage was noted, and the same ARFF vehicle, shown in figure 4-2, was directed to gain speed on an adjacent taxiway then veer onto the turf surface and veer off. No movement of the turf or displacement of the anchoring system was noted. No problems with traction or maneuverability were noted by the vehicle operator.

FIGURE 4-1. AN ARFF VEHICLE CONSTANTLY TURNING WHEELS ON ARTIFICIAL TURF SURFACE (BOS)

FIGURE 4-2.  AN ARFF VEHICLE PERFORMING A HIGH-SPEED PASS (BOS)

A similar test was performed at HNL, with an ARFF vehicle traversing the artificial turf.  The difference from the tests performed at BOS was that the ARFF vehicle came to a complete stop on the turf.  No movement or dislodging of the artificial turf was observed.

Another load test that was performed by airport operations staff at MDW was to use the right main gear of a B-757 with full fuel tanks (see figure 4-3) to taxi across the edge of the artificial turf installation.  The aircraft was able to taxi across the entire surface without incident.  Minimal rutting occurred, but this was easily repaired by using a heavy roller to smooth out the surface.

FIGURE 4-3.  FULLY FUELED B-757 TAXIING ACROSS ARTIFICIAL TURF SURFACE (BOS)

## 4.3 JET BLAST TESTING AND CONCENTRATED AIR PRESSURE.

BOS used a United Airlines B-757, as shown in figure 4-4, to test the artificial turf's resistance to jet blast erosion. Additionally, United Airlines provided a B-777 and a B-747 to perform similar jet blast tests at SFO. The results of the jet blast tests are provided in the following sections.

FIGURE 4-4. BOEING 757 PERFORMING JET BLAST TEST ON ARTIFICIAL TURF (BOS)

### 4.3.1 United Airlines B-757 Tests.

For the B-757 tests, the aircraft was placed perpendicular to the runway at two different distances (35 and 45 ft) ahead of the turf. The aircraft was cycled at three different power levels. The first set of tests used just the left engine at idle at distances of 35 and 45 ft with no visible signs of sand migration or damage to the turf surface, then with both engines at idle at 35 and 45 ft with no visible signs of sand migration or damage to the turf surface. The second set of tests used just the left engine at 70% thrust (approximately 88 mph) at 35 and 45 ft, with no visible signs of sand migration or damage to the turf surface, then both engines at 70 percent thrust (approximately 176 mph) at both 35 and 45 ft with no visible signs of sand evacuation or damage to the turf surface. The final sets of tests were conducted under the same procedure using 80 percent thrust (approximately 100 and 200 mph respectively) and still no visible signs of sand migration or damage to the turf surface. The B-757 has a top wind speed of 250 mph at 40 ft behind the aircraft during takeoff (see figures 4-5 and 4-6); however, the tests were not continued because of personnel and aircraft safety.

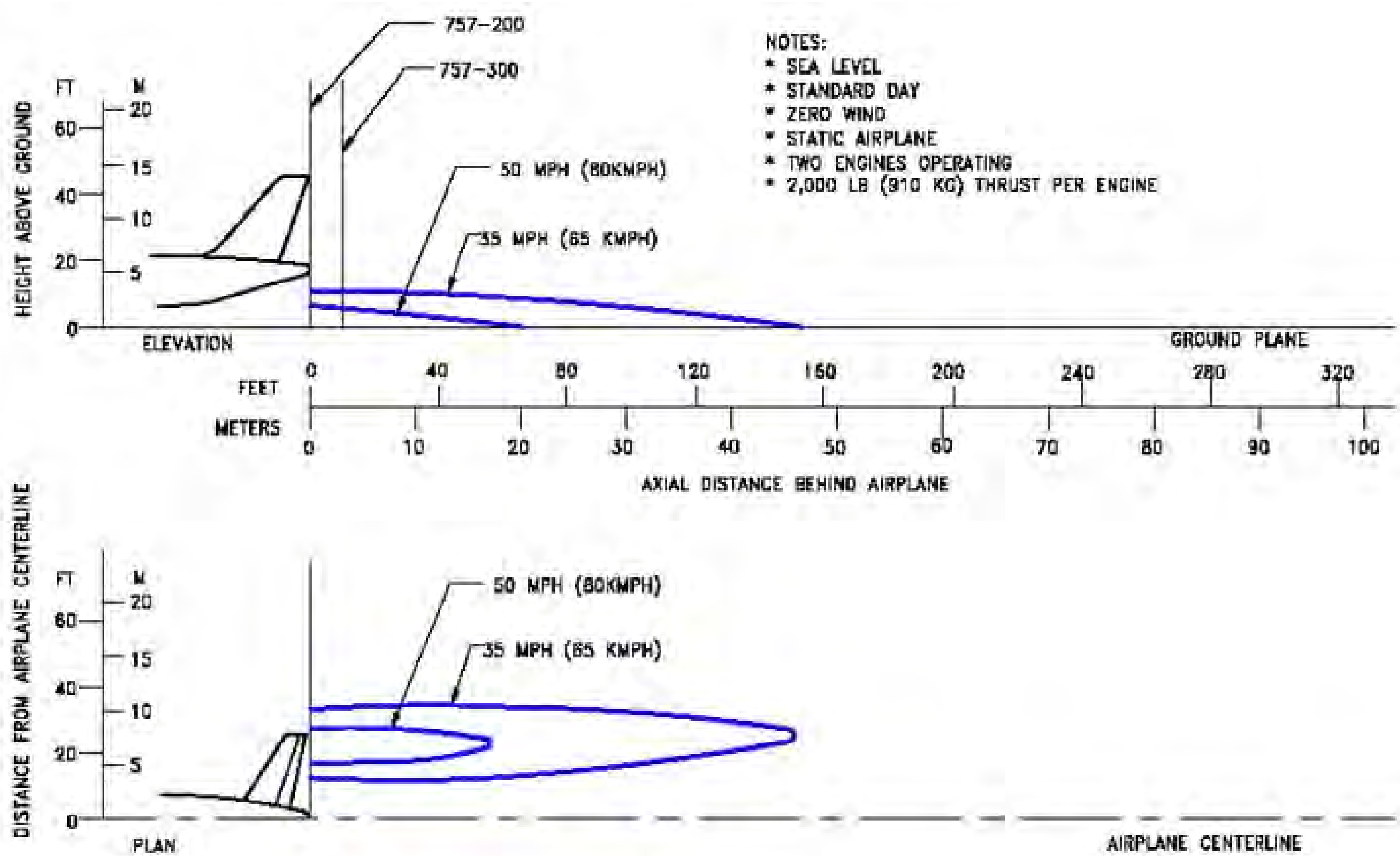



FIGURE 4-5. JET ENGINE EXHAUST VELOCITY FOR A B-757-200 AT IDLE THRUST

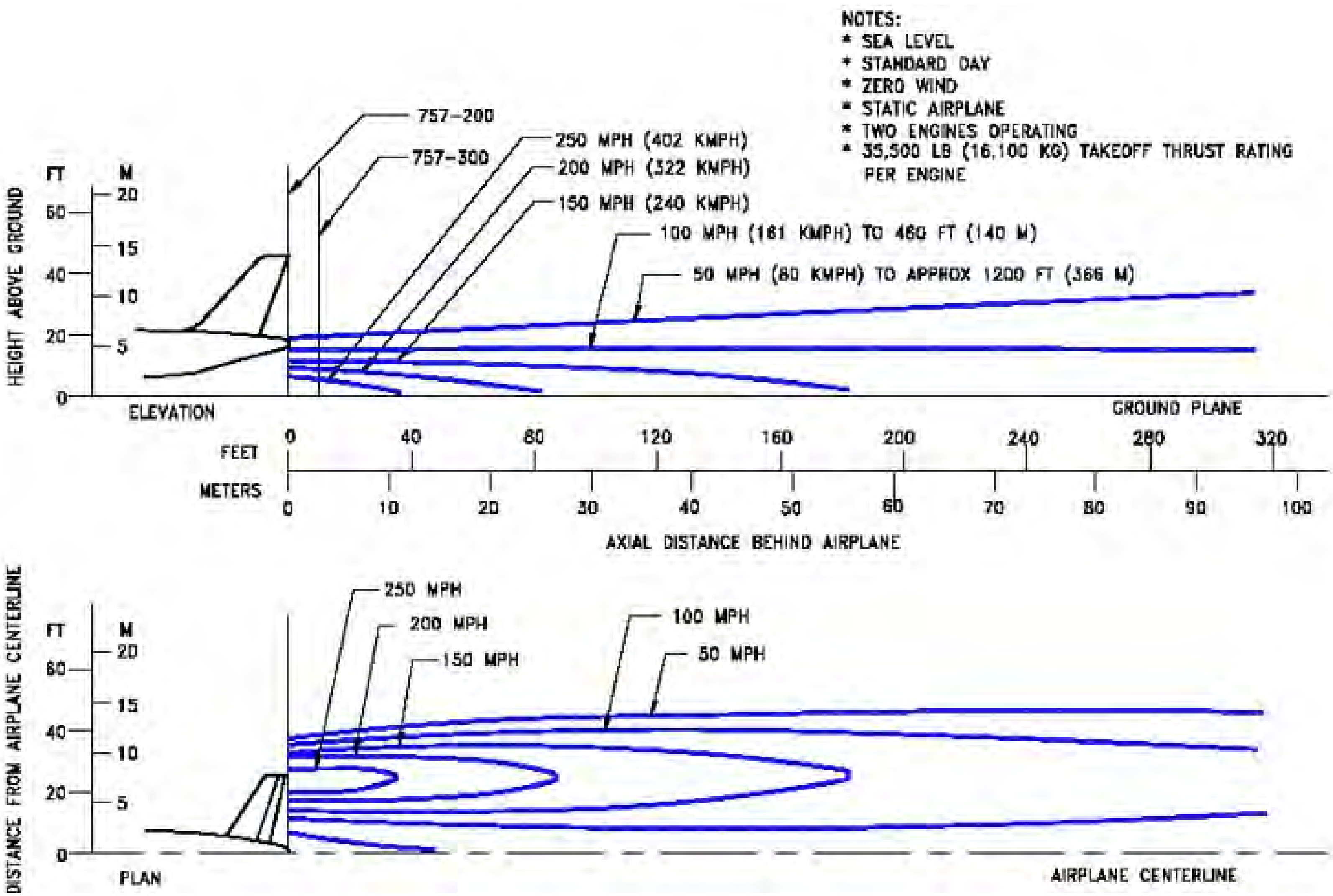



FIGURE 4-6. JET ENGINE EXHAUST VELOCITY FOR A B-757-200 AT TAKEOFF THRUST

4.3.2 United Airlines B-777 Tests.

For the B-777 tests (figure 4-7), the aircraft was positioned on the runway at a 45 degree angle to the turf at two different distances (approximately 35 and 45 feet). The tests were conducted with the left engine (figures 4-8 and 4-9) at idle (19 percent thrust) and then cycled every 30 seconds starting from breakaway (30 percent) thrust upward in 5 percent increments up to 50 percent thrust (50 percent thrust is the safest power setting that the United team would allow). The following lists the approximate wind speeds, in mph, behind the aircraft for 35 ft. According to Boeing's ACAP Manual, the wind speeds behind a B-777 are the same at 35 and 45 feet; therefore, only the 35-foot wind speed tests are shown.

| Engine thrust | 35 feet |
|---|---|
| Idle thrust 19% | 50 mph |
| Breakaway thrust 30% | 50 mph |
| Takeoff thrust 35% | 70 mph |
| 40% | 80 mph |
| 45% | 90 mph |
| 50% | 100 mph |

Throughout the duration of the static aircraft engine run-ups, there was no visible sand migration or turf displacement.

FIGURE 4-7. BOEING 777 JET BLAST TEST, VIEW 1 (SFO)

FIGURE 4-8.  BOEING 777 JET BLAST TEST, VIEW 2 (SFO)


FIGURE 4-9.  BOEING 777 TAXIING BY ARTIFICIAL TURF (JET BLAST TEST ACROSS ARTIFICIAL TURF SURFACE) (SFO)

After the static aircraft engine run-ups were completed, the B-777 taxied parallel to the artificial turf three times (each pass getting closer to the turf).  There was no visible sand movement or turf displacement.  The B-777 has a top wind speed of 200 mph at 50 ft behind the aircraft during takeoff (see figures 4-10, 4-11, and 4-12), but the tests were restricted for safety precautions.

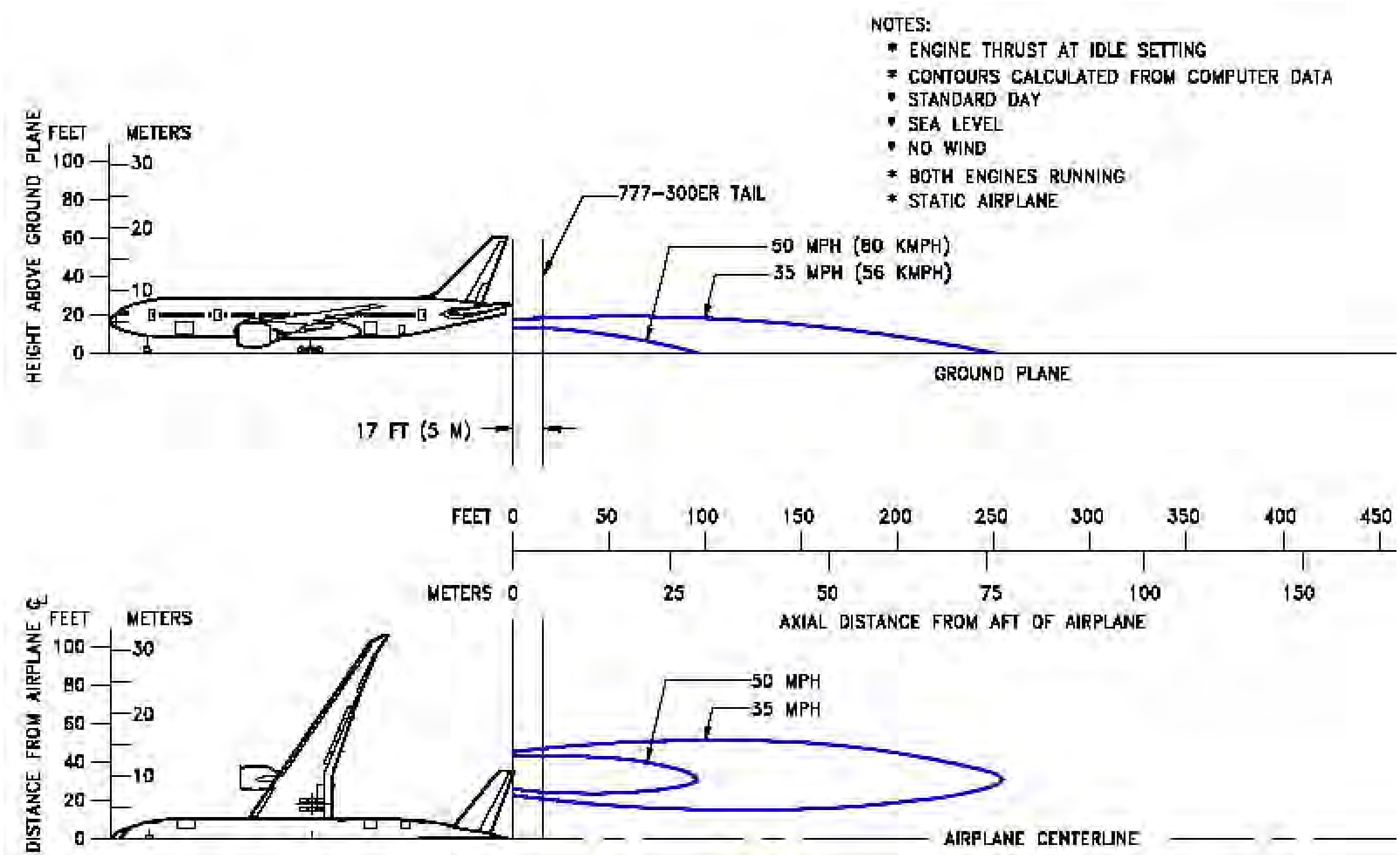



FIGURE 4-10. JET ENGINE EXHAUST VELOCITY FOR A B-777 AT IDLE THRUST

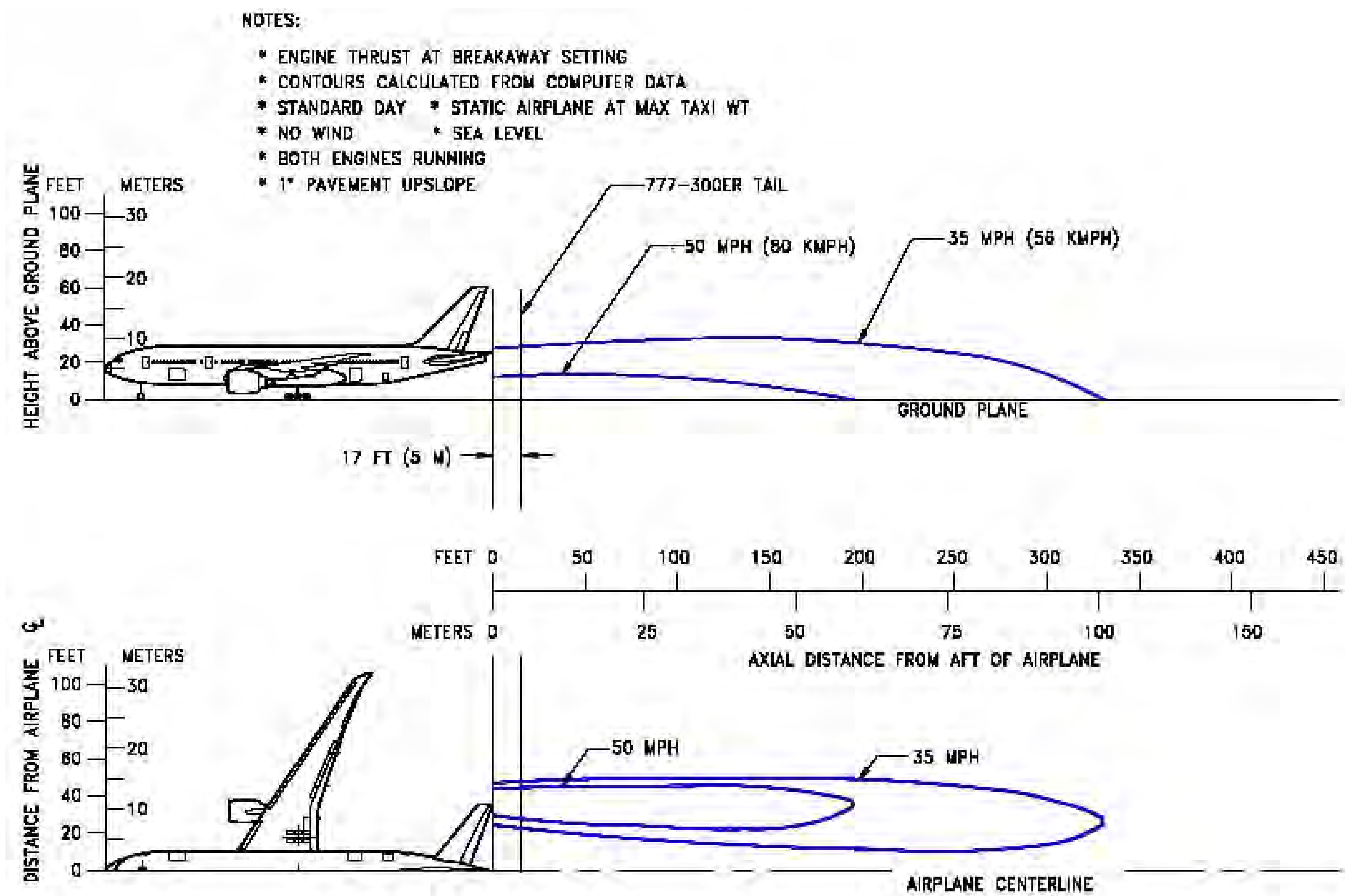



FIGURE 4-11. JET ENGINE EXHAUST VELOCITY FOR A B-777 AT BREAKAWAY THRUST

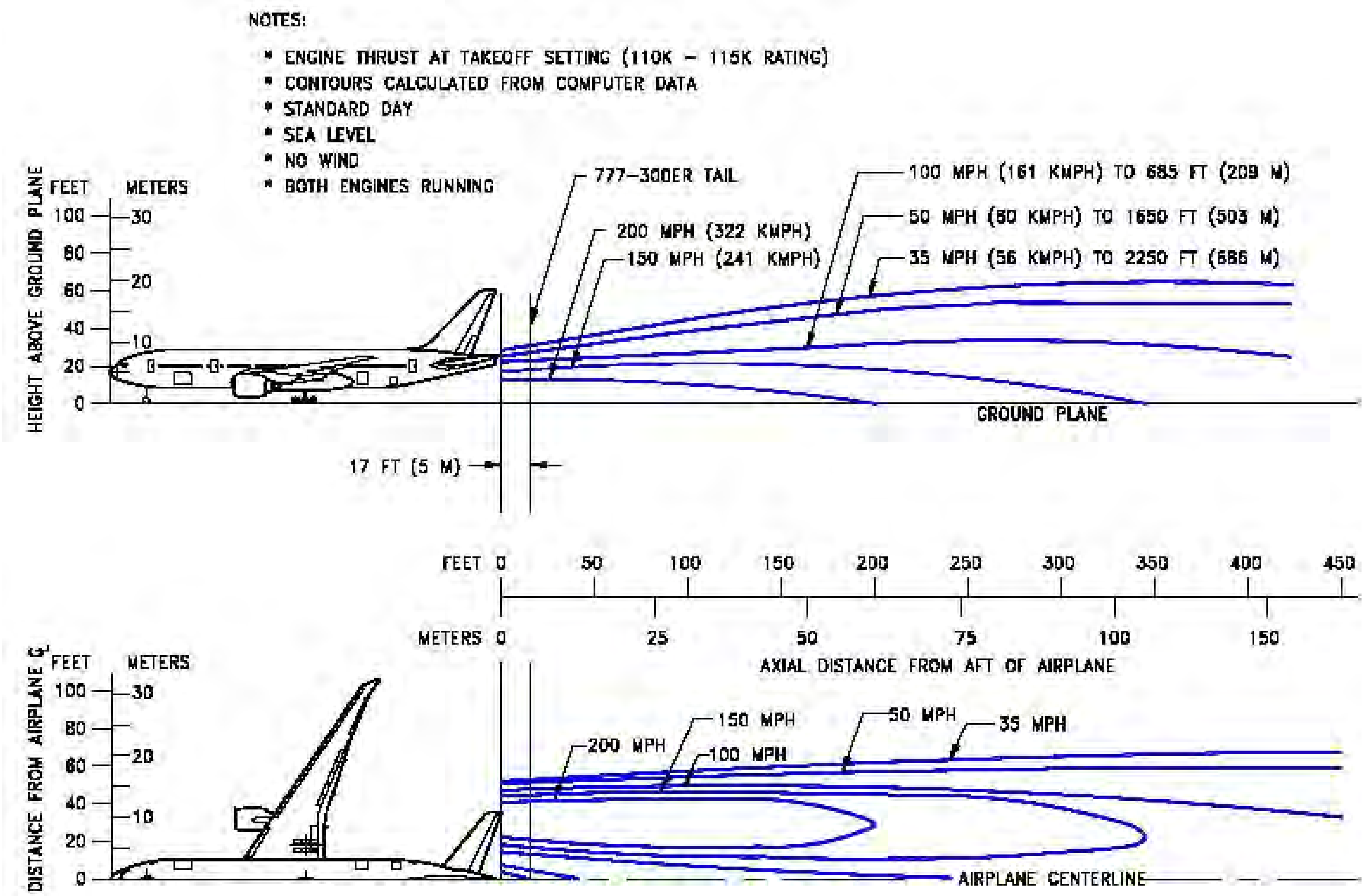



FIGURE 4-12. JET ENGINE EXHAUST VELOCITY FOR A B-777 AT TAKEOFF THRUST

4.3.3 United Airlines B-747 Tests.

For the B-747 tests, the aircraft was positioned on the runway at a 45 degree angle to the turf at two different distances (approximately 35 and 45 feet). The tests were conducted with the number 3 engine (see figures 4-13 and 4-14) at idle (19 percent thrust) and then cycled every 30 seconds starting from breakaway (30 percent) thrust upward in 5 percent increments up to 50 percent thrust (50 percent thrust is the safest power setting that the United team would allow). According to Boeing's ACAP Manual, the wind speeds behind a B-747 are the same at 35 and 45 feet; therefore, only the 35-foot wind speed tests are shown.


FIGURE 4-13. BOEING 747 JET BLAST TEST (STATIC AIRCRAFT), VIEW 1 (SFO)


FIGURE 4-14. BOEING 747 JET BLAST TEST (STATIC AIRCRAFT), VIEW 2 (SFO)

The following lists the approximate wind speeds, in mph, for only the number 3 engine, behind the aircraft for 35 feet:

| No. 3 engine thrust | 35 feet |
|---|---|
| Idle thrust 19% | 17 mph |
| Breakaway thrust 30% | 35 mph |
| Takeoff thrust 35% | 44 mph |
| 40% | 50 mph |
| 45% | 57 mph |
| 50% | 63 mph |
| 55% | 69 mph |
| 60% | 75 mph |
| 64% | 80 mph |

Throughout the duration of the static aircraft engine run-ups, there was no visible sign of sand or turf being displaced.

After the number 3 engine was run through the power cycles, both the number 3 and 4 engines were cycled using the same procedure as above but up to 64 percent thrust. The following lists the approximate wind speeds, in mph, for the number 3 and 4 engines behind the aircraft for 35 feet:

| Nos. 3-4 engine speed | 35 feet |
|---|---|
| Idle thrust 19% | 35 mph |
| Breakaway thrust 30% | 70 mph |
| Takeoff thrust 35% | 88 mph |
| 40% | 100 mph |
| 45% | 113 mph |
| 50% | 125 mph |
| 55% | 138 mph |
| 60% | 150 mph |
| 64% | 160 mph |

Throughout the duration of the static aircraft engine run-ups, there was no visible indication of sand or turf being displaced.

After the static aircraft engine run-ups were completed, the B-747 also taxied by the artificial turf three times (each pass getting closer to the turf). The entire time the aircraft taxied past the installation the outboard engine was directly over the artificial turf (see figures 4-15 and 4-16). The B-747 has a top wind speed of 250 mph at 25 ft behind the aircraft during takeoff (see figures 4-17, 4-18, and 4-19).

FIGURE 4-15. BOEING 747 TAXIING BY ARTIFICIAL TURF (JET BLAST TEST ACROSS ARTIFICIAL TURF SURFACE) (SFO)

FIGURE 4-16. BOEING 747 TAXIING FROM ARTIFICIAL TURF TO NATURAL GRASS (JET BLAST TEST ACROSS ARTIFICIAL TURF SURFACE) (SFO)

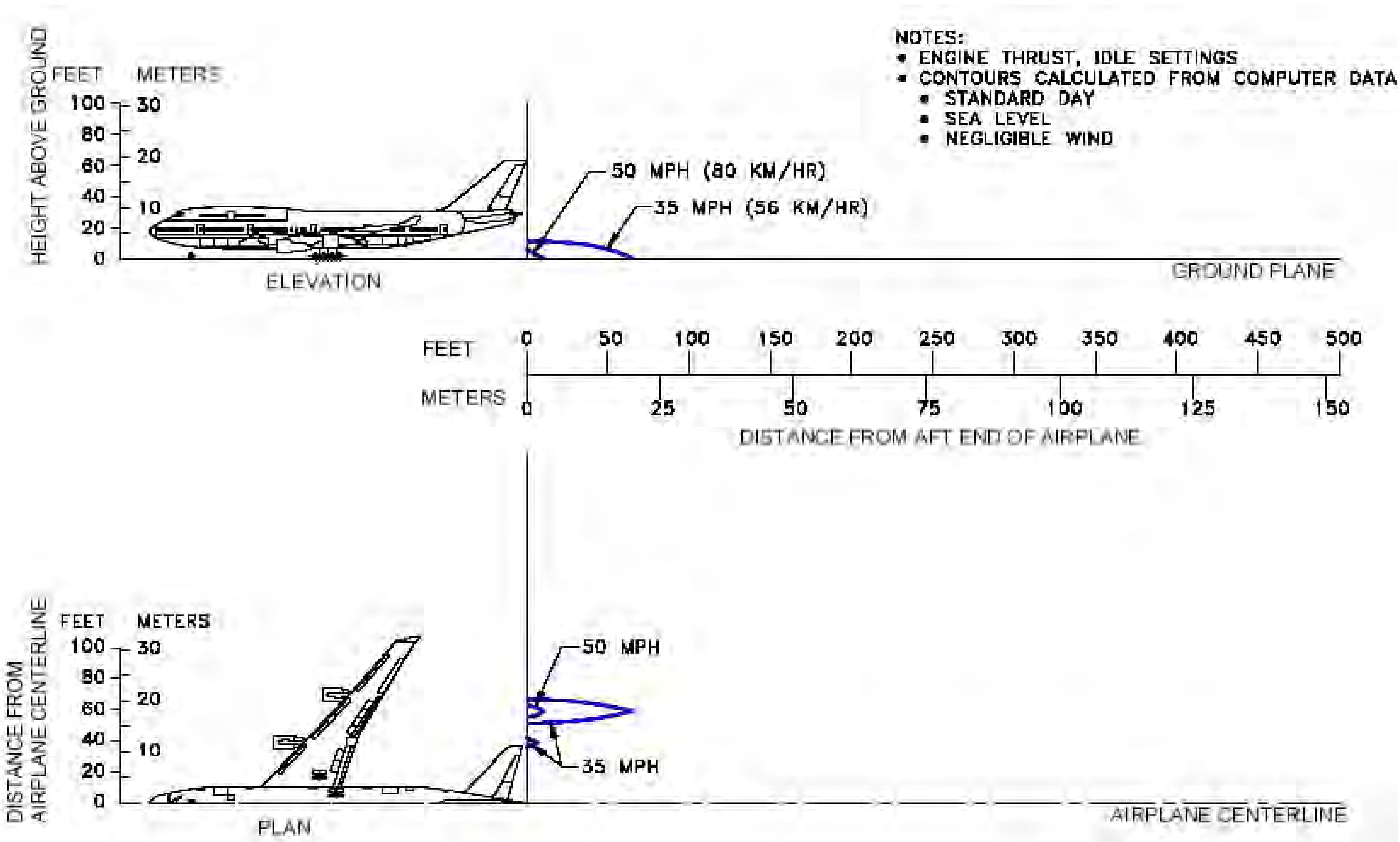



FIGURE 4-17. JET ENGINE EXHAUST VELOCITY FOR A B-747 AT IDLE THRUST

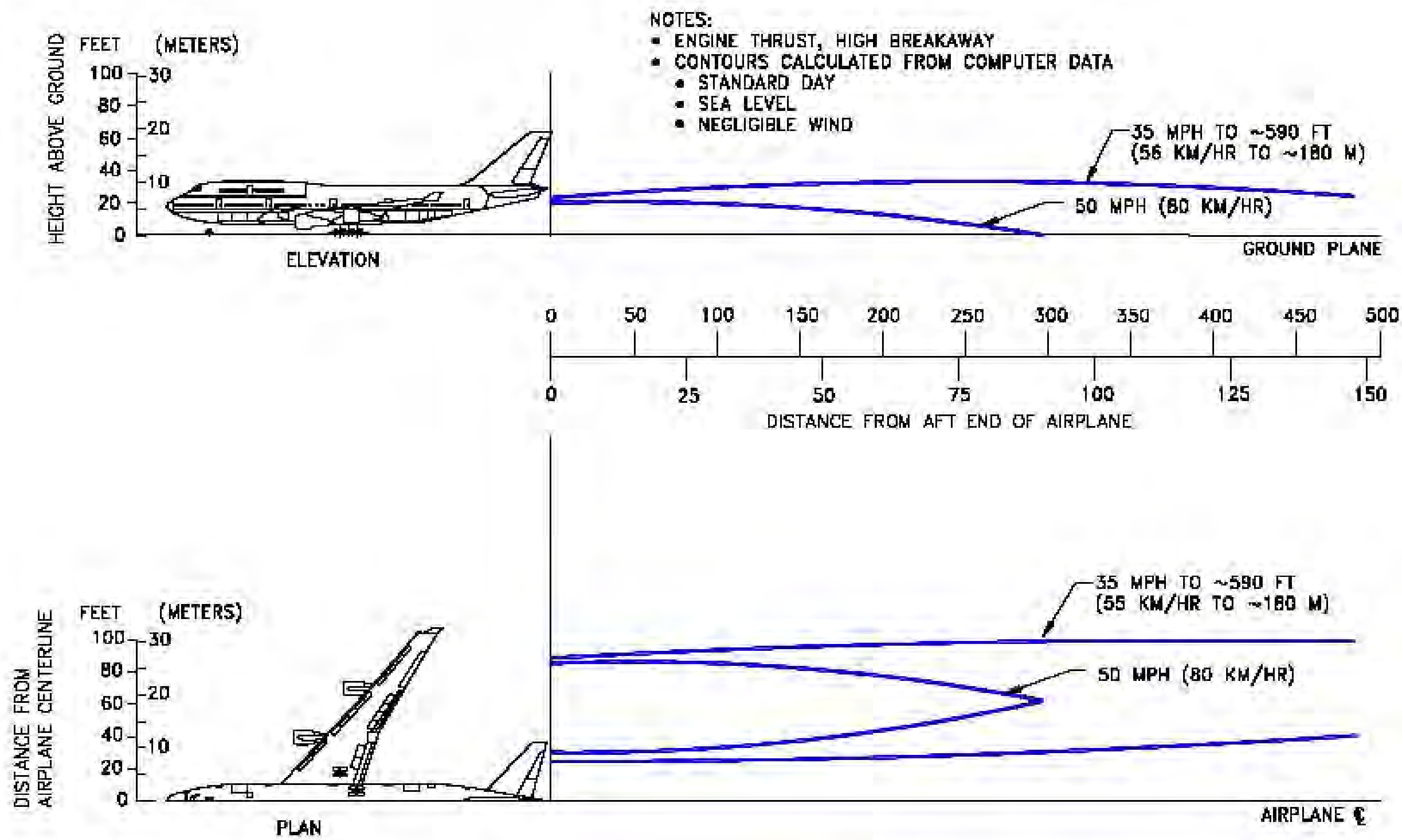



FIGURE 4-18. JET ENGINE EXHAUST VELOCITY FOR A B-747 AT BREAKAWAY THRUST

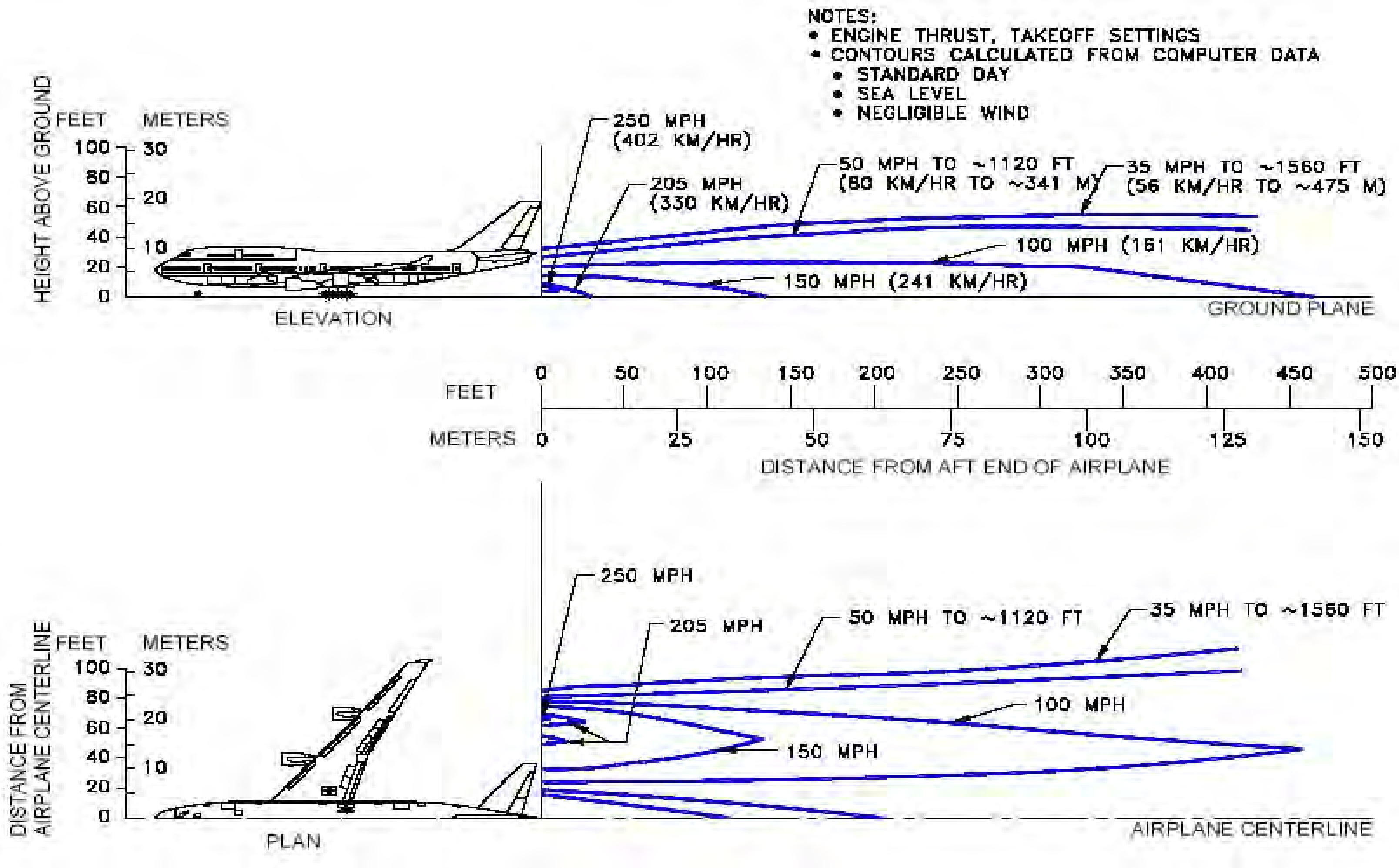



FIGURE 4-19. JET ENGINE EXHAUST VELOCITY FOR A B-747 AT TAKEOFF THRUST

## 4.4 CONCENTRATED AIR BLOWERS.

Concentrated air blowers are used to clean debris from runways and taxiways. One artificial turf installation was tested using a concentrated air blower with a multiangle nozzle, as shown in figure 4-20. The artificial turf was tested at multiple angles with different wind velocities; no sand or artificial turf displacement was seen.

FIGURE 4-20. CONCENTRATED AIR BLOWER USED ON EDGE ATTACHMENT OF ARTIFICIAL TURF (BOS)

The artificial turf installation was jet blast tested using a VAMMAS (see figure 4-21) snow blowing machine with a multiangle nozzle at BOS. The artificial turf was tested with the snow blowing machine positioned at multiple angles with different power settings; no sand or artificial turf displacement was seen.

FIGURE 4-21. VAMMAS SNOW BLOWER TEST OF ARTIFICIAL TURF (BOS)

## 4.5 BLAST PAD AREA.

To ensure that the artificial turf would not become dislodged or cause FOD damage with everyday airport usage, a test strip was installed at the blast area of a runway at MDW (see figure 4-22). The strip was successful and did not show any signs of movement or uplift.

FIGURE 4-22. ARTIFICIAL TURF INSTALLED AT MDW BLAST PAD LOCATION

To determine the uplift stability of the artificial turf in the event of an aircraft veering off, a demonstration was also performed at MDW. A B-757 was powered up with one engine aligned over the top of the artificial turf surface. The aircraft then came to full power and tookoff with no artificial turf movement or dislodging.

A test strip of the artificial turf was installed near a helipad at MDW. Airport operations personnel have witnessed helicopters taxi across the top of the surface at low altitudes with no adverse affects to the artificial turf from the rotowash.

## 4.6 CHEMICAL TEST.

A deicing fluid durability test on the artificial turf product was performed during the winter operations and snow clean up at MDW, as shown in figure 4-23. Snow was purposely piled on the surface and potassium acetate was poured on the snow to accelerate the melting process. No adverse effects to the artificial turf were witnessed, and the snow continued to melt at an accelerated rate without adding more deicing fluid.

(a)

(b)

FIGURE 4-23. SATURATING THE ARTIFICIAL TURF WITH POTASSIUM ACETATE (MDW)

## 4.7 SUPPLIER OR INSTALLER-PERFORMED FIRE TESTS.

### 4.7.1 AvTurf.

The following was provided by Commercial Testing Company Test #: 3214-4460-R

Test conducted using the ASTM fire test respond standard E 648-06 “Critical Radiant Flux of Floor – Covering Systems Using a Radiant Heat Energy Source.” It measures the critical radiant flux at flame-out of a horizontal-mounted, floor-covering system that duplicates or simulates accepted installation practices. The floor-covering system is exposed to a flaming ignition source in a graded radiant heat energy environment generated by a radiant panel inclined at a 30° angle to the sample. The panel generates heat distribution along the sample length ranging from a normal maximum of 1.0 $W/cm^2$ to a minimum of 0.1 $W/cm^2$. Tests on individual components are of limited value and are not valid for elevation of floor-covering systems.

Floor Covering:
Covering: AvTurf 42
Material: Aviation Safety Surface
Weight: 66.8 $oz/yd^2$

Flooring System:
Similar to airfield installation; turf filled with ballast sand to 3/4 inch from the tip of the turf (1 1/4-in.-deep turf)

| Test Results: | Test 1 | Test 2 | Test 3 |
|---|---|---|---|
| Maximum Burn Distance (cm): | 9.4 | 9.8 | 10.4 |
| Time to Flame Out (min): | 12.4 | 11.6 | 11.4 |
| Critical Radiant Flux: | >1.08 | >1.08 | 1.07 |

4.7.2 Air FieldTurf.

The following was provided by Bodycote Materials Testing Canada Inc.

The test method designated CAN/ULC-S102.2-M88, “Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings and Miscellaneous Materials,” is designed to determine the relative surface burning characteristics of materials under specific test conditions. Results are expressed in terms of flame spread classification (FSC) and smoke developed (SD).

4.7.2.1 Surface-Burning Characteristics of Air FieldTurf System.

The following was provided by the Standards Council of Canada

Summary of Test:

The tunnel was preheated to 85°C, as measured by the back-wall-embedded thermocouple located 7090 mm downstream of the burner ports, allowed to cool to 40°C, as measured by the back-wall-embedded thermocouple located 4000 mm from the burners. At this time, the tunnel lid was raised and the test sample was placed along the floor of the tunnel so as to form a continuous surface and then the lid is lowered. Upon ignition of the gas burners, the flame spread distance was observed and recorded every 15 seconds. Flame spread distance versus time was plotted ignoring any flame front recessions. Smoke developed was determined by comparing the area under the observation curve for the test sample to that of inorganic reinforced cement board and red oak, arbitrarily established as 0 and 100, respectively.

Test Results:

| | FSC | SD |
|---|---|---|
| Air FieldTurf System: | 0 | 5 |

Observations of Burning Characteristics:

Melting of the artificial grass pile was observed immediately upon exposure to the test flame. Brief ignitions of molten material located in the area of direct flame impingement occurs during the test; however, there was no propagation of flame beyond the zero point. Only a very slight increase in smoke developed was recorded during the 10-minute test period.

4.7.2.2 Surface Burning Characteristics of Air FieldTurf System With Accelerant System.

The following was provided by the Standards Council of Canada

Note: After insertion of the sample into the test chamber and just prior to testing, approximately 1 liter of Jet A-1 fuel was poured down the length of the test specimen to act as accelerant.

Summary of Test:

The tunnel was preheated to 85°C, as measured by the back-wall-embedded thermocouple located 7090 mm downstream of the burner ports, allowed to cool to 40°C, as measured by the back-wall-embedded thermocouple located 4000 mm from the burners. At this time, the tunnel lid was raised and the test sample was placed along the floor of the tunnel so as to form a continuous surface and then the lid was lowered. Upon ignition of the gas burners, the flame spread distance was observed and recorded every 15 seconds. Flame spread distance versus time was plotted ignoring any flame front recessions. Smoke developed was determined by comparing the area under the obscuration curve for the test sample to that of inorganic reinforced cement board and red oak, arbitrarily established as 0 and 100, respectively.

Test Results:

| | FSC | SD |
|---|---|---|
| Air FieldTurf System with Jet A-1 fuel: | 10 | 5 |

Observations of Burning Characteristics:

The sample began to ignite and propagate flame immediately upon exposure to the test flame. The flame front advanced briefly to a distance of 0.6 meters during the initial 30 seconds of the test and then reseeded to the baseline for the remainder of the test period. Melting of the artificial grass pile was observed upon exposure to the test flame and during the brief flame propagation. Only a very slight increase in smoke developed was recorded during the 10-minute test period.

## 4.8 SKID RESISTANCE TESTING.

No full-scale skid resistance tests were performed. Air FieldTurf, through Bodycote Materials Testing, conducted coefficient of friction tests. The tests were performed on dry and wet sand and pebble material in accordance with ASTM C1028-96, “Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.” The results are as shown in tables 4-1 and 4-2.

TABLE 4-1. DRY SAND COEFFICIENT OF FRICTION

| Specimen No. | Peak Load |
|---|---|
| 1 | 78.20 |
| 2 | 107.50 |
| 3 | 87.20 |
| 4 | 136.40 |
| Mean | **102.33** |
| Standard deviation | **25.81** |
| Static coefficient of friction | ≤ 0.684 |

TABLE 4-2. WET SAND COEFFICIENT OF FRICTION

| Specimen No. | Peak Load |
|---|---|
| 1 | 105.90 |
| 2 | 70.10 |
| 3 | 113.50 |
| 4 | 67.00 |
| Mean | **89.13** |
| Standard deviation | **23.99** |
| Static coefficient of friction | ≤ 0.602 |

## 4.9 CONTAMINATE TESTING.

To test the durability of the artificial turf that may come in contact with certain volatile airport materials, Air FieldTurf, through Bodycote Materials Testing, conducted chemical resistance tests on the artificial turf material and yarn material. The test on the artificial turf material was done in accordance with ASTM D4632-91, “Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.” The test on the yarn material was done in accordance with CAN/CGSB-4.2 No. 9.4-M91, “Textile Test Methods—Breaking Strength of Yarns—Single Strand Method.” The artificial turf was soaked in the following chemicals for 2 weeks and then to check for durability:

- Propylene Glycol
- Jet A
- Ice-O-Later
- No-Gel
- Potassium Acetate
- Glycol Type 1 – Orange
- Aviation Hydraulic Fluid
- Urea
- 100 LL Fuel
- Diesel
- Glycol Type 4 – Green

The grab tensile test was conducted on the Air FieldTurf material and the green yarn material after 2 weeks of exposure to various fluids. In comparison to the baseline tensile test, the material was not affected except for the hydraulic fluid. When exposed to the hydraulic fluid for 14 days, the backing material deteriorated.

## 5. SUMMARY.

This study to investigate the considerations and concerns associated with airside applications of artificial turf was conducted using input from the artificial turf manufacturers and by administering and discussing questionnaire surveys via site visits to airports. These site visits were scheduled with some airports that already had installed artificial turf plots and during the installation of artificial turf plots at other airports.

To address the safety concerns and performance expectations of airside artificial turf installations, several tests were done. The majority of the tests performed to date were to quantify and qualify the artificial turf product. During the airport surveys, airport personnel were asked what concerns they had with an artificial turf installation. The results of the surveys and discussions with airport personnel indicated that the main reasons for considering artificial turf are for safety, soil erosion mitigation, and foreign object debris reduction. Additional and secondary considerations for the use of artificial turf were found to be abatement of turf management (i.e., low maintenance), jet blast erosion, wildlife control, and visual enhancements.

The majority of airport concerns for accepting the artificial turf applications concentrated on:

- Jet blast resistance
- Environmental and contaminant (fuel, deicing fluid) resistance
- Safety vehicle load support
- Skid and fire resistance
- Access for lighting and equipment maintenance

Although this investigation of artificial turf use at airports was limited by the lack of tests, standards, and long-term testing data, the following results were reached:

- The two main reasons for the use of artificial turf installations were to mitigate soil erosion and to reduce foreign object debris issues.

- Secondary considerations for the use of artificial turf were found to be abatement of turf management and low maintenance, jet blast erosion, wildlife mitigation, and visual enhancements.

- There were no reported disadvantages over natural turf other than a higher installation cost. However, there was limited historical data, and many questions relating to the performance, safety, and side effects arising from its use remain unanswered.

- Tests were conducted by the Federal Aviation Administration Airport and Aircraft Safety Research and Development Airport Technology Branch at the William J. Hughes Technical Center to investigate performance expectations and safety concerns demonstrated equal or better performance than natural turf. These tests, however, were for the most part nonstandard and qualitative.

- Sufficient data was not available to report on specific cost-effective issues, but all airports indicated that the product was cost-effective compared to alternative solutions to their specific problems.

# 6. RECOMMENDATIONS.

If artificial turf is more widely used at airports, the following recommendations are made:

a. Identify, review, specify, and develop product specifications tests
b. Identify, review, specify, and develop field acceptance tests
c. Monitor the long-term performance of existing and future artificial turf installations
d. Collect additional long-term data to establish the cost-effectiveness of artificial turf

# APPENDIX A—ARTIFICIAL TURF INSTALLATION SITES AT AIRPORTS

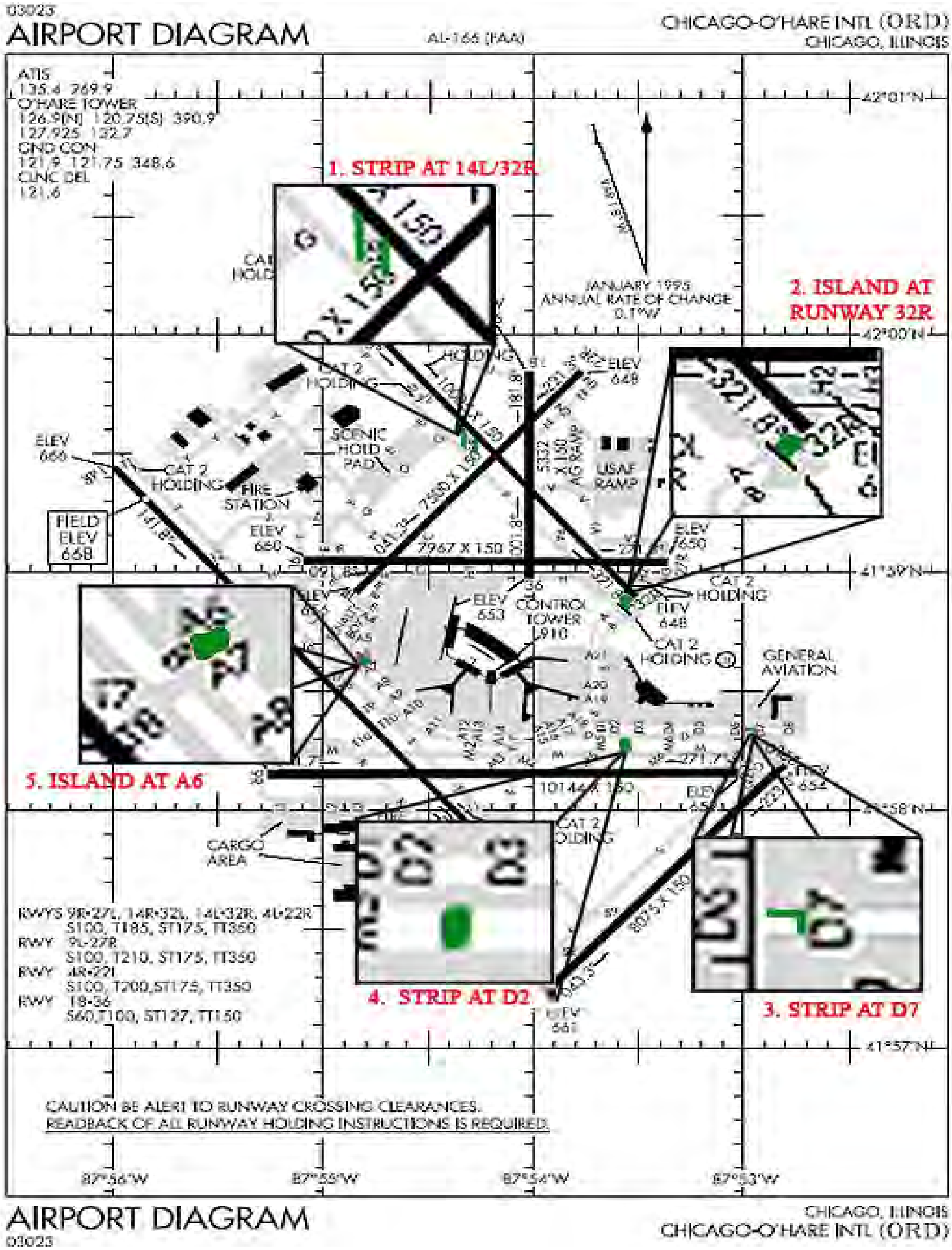



FIGURE A-1.  O'HARE INTERNATIONAL AIRPORT INSTALLATION SITES

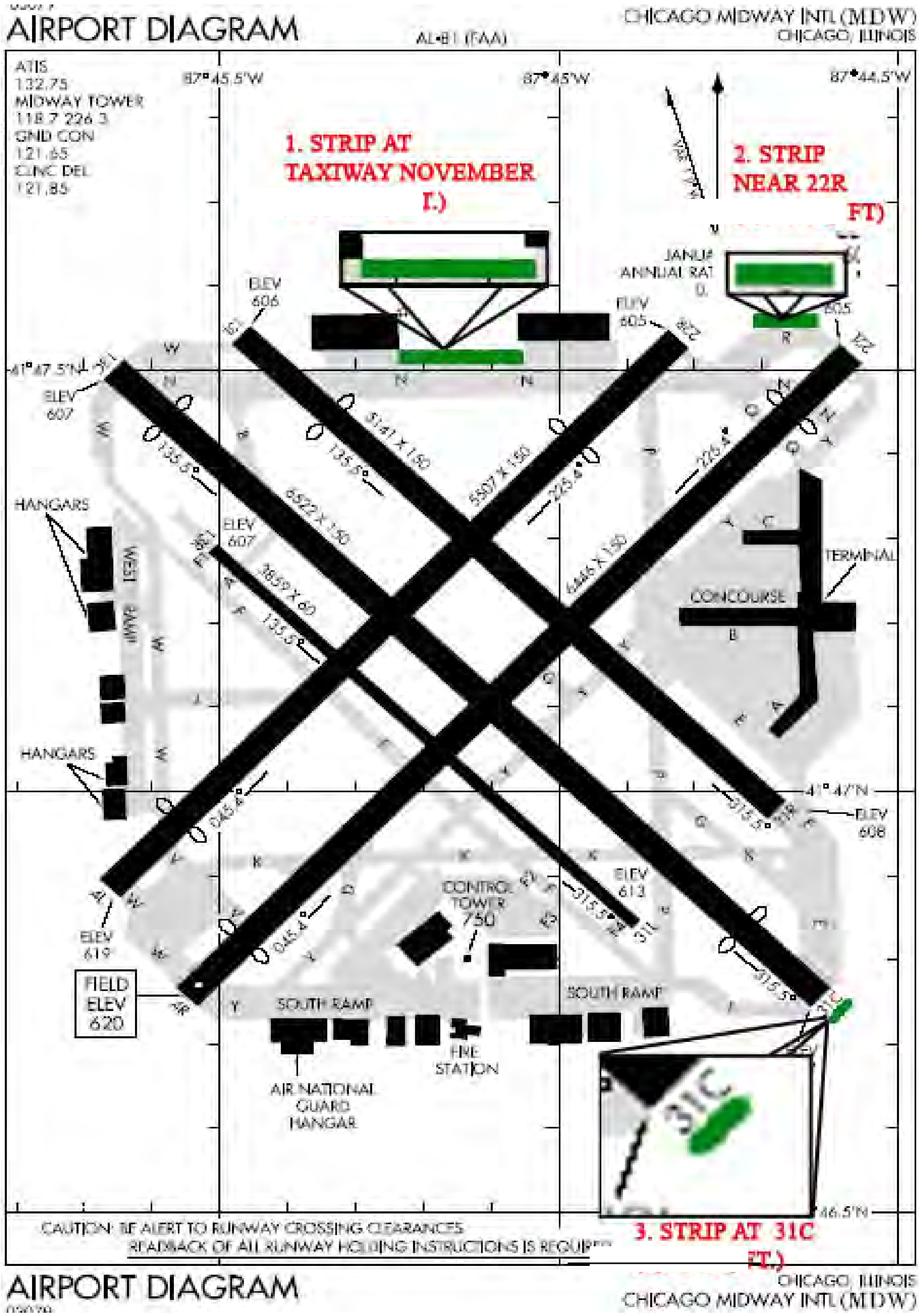



FIGURE A-2. MIDWAY INTERNATIONAL AIRPORT INSTALLATION SITES

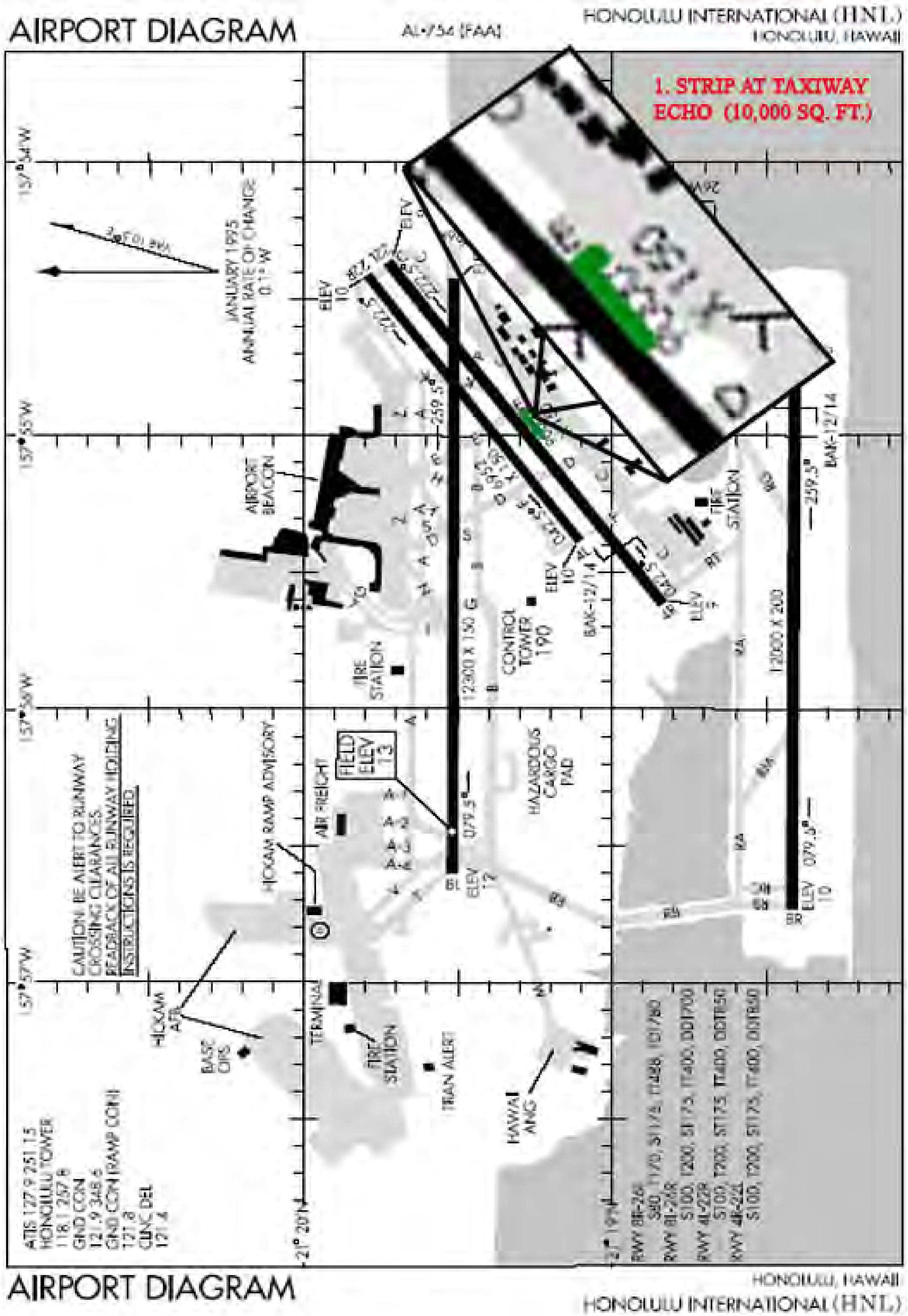



FIGURE A-3. HONOLULU INTERNATIONAL AIRPORT INSTALLATION SITE

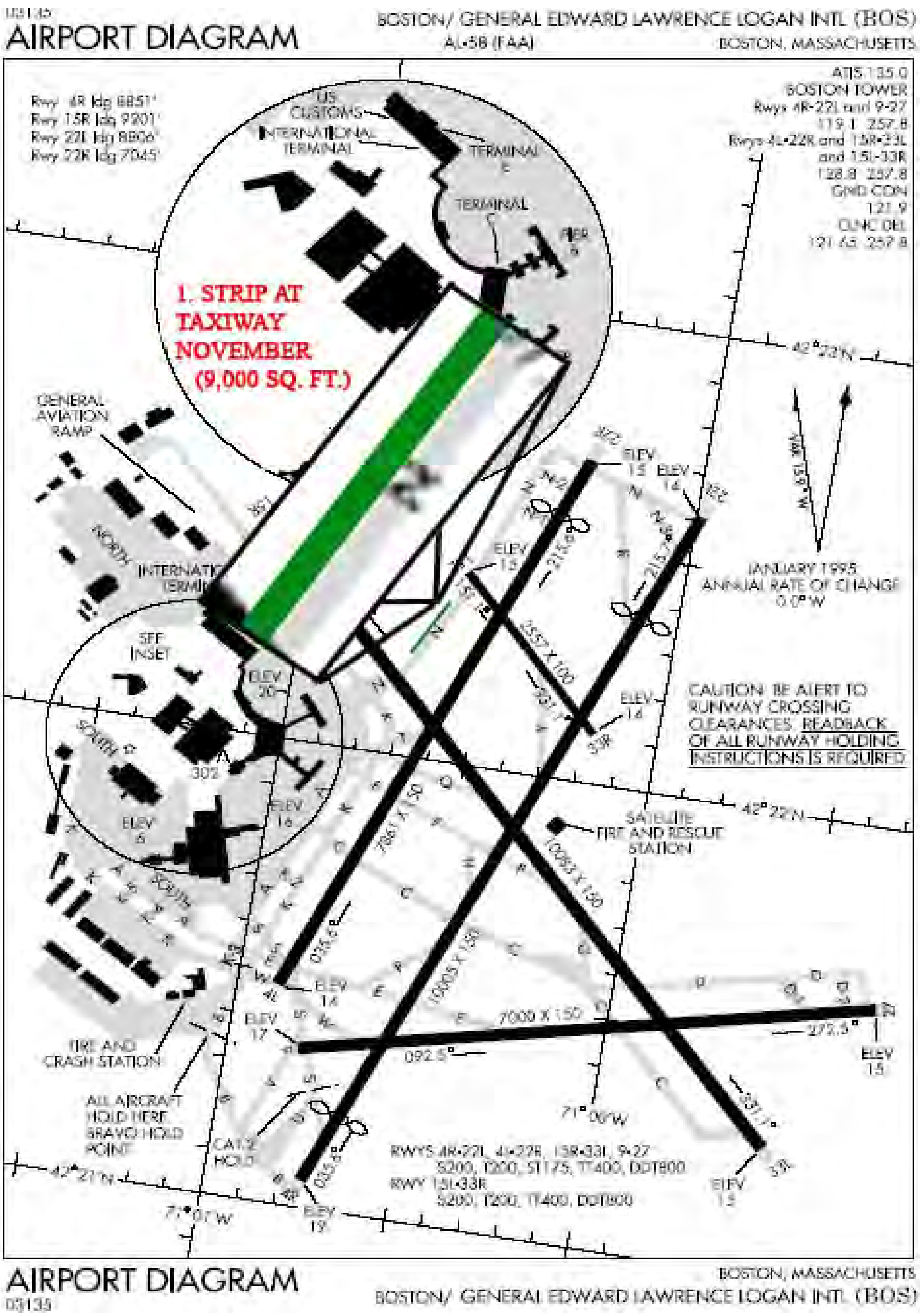



FIGURE A-4.  BOSTON LOGAN INTERNATIONAL AIRPORT INSTALLATION SITE

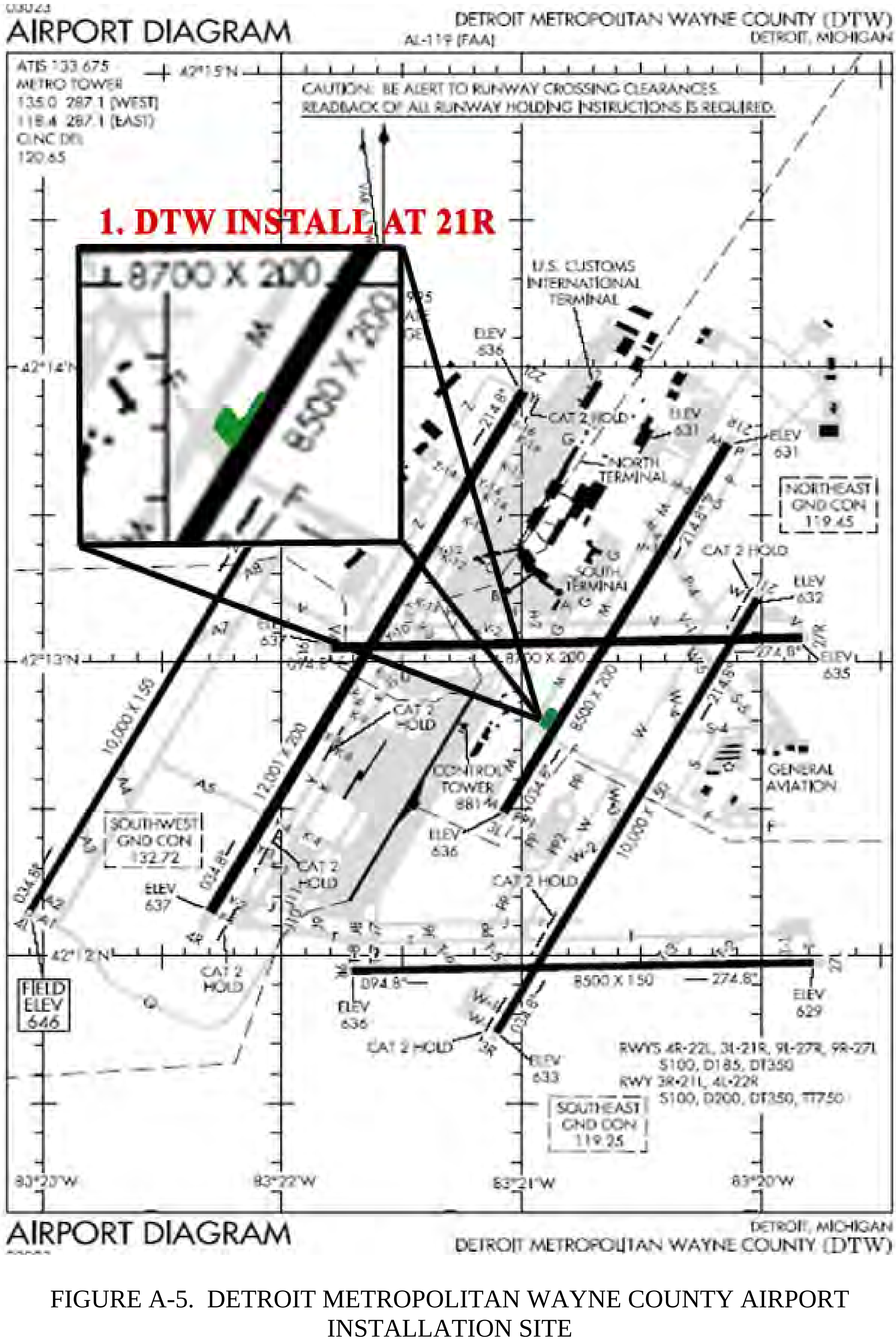



FIGURE A-5. DETROIT METROPOLITAN WAYNE COUNTY AIRPORT INSTALLATION SITE

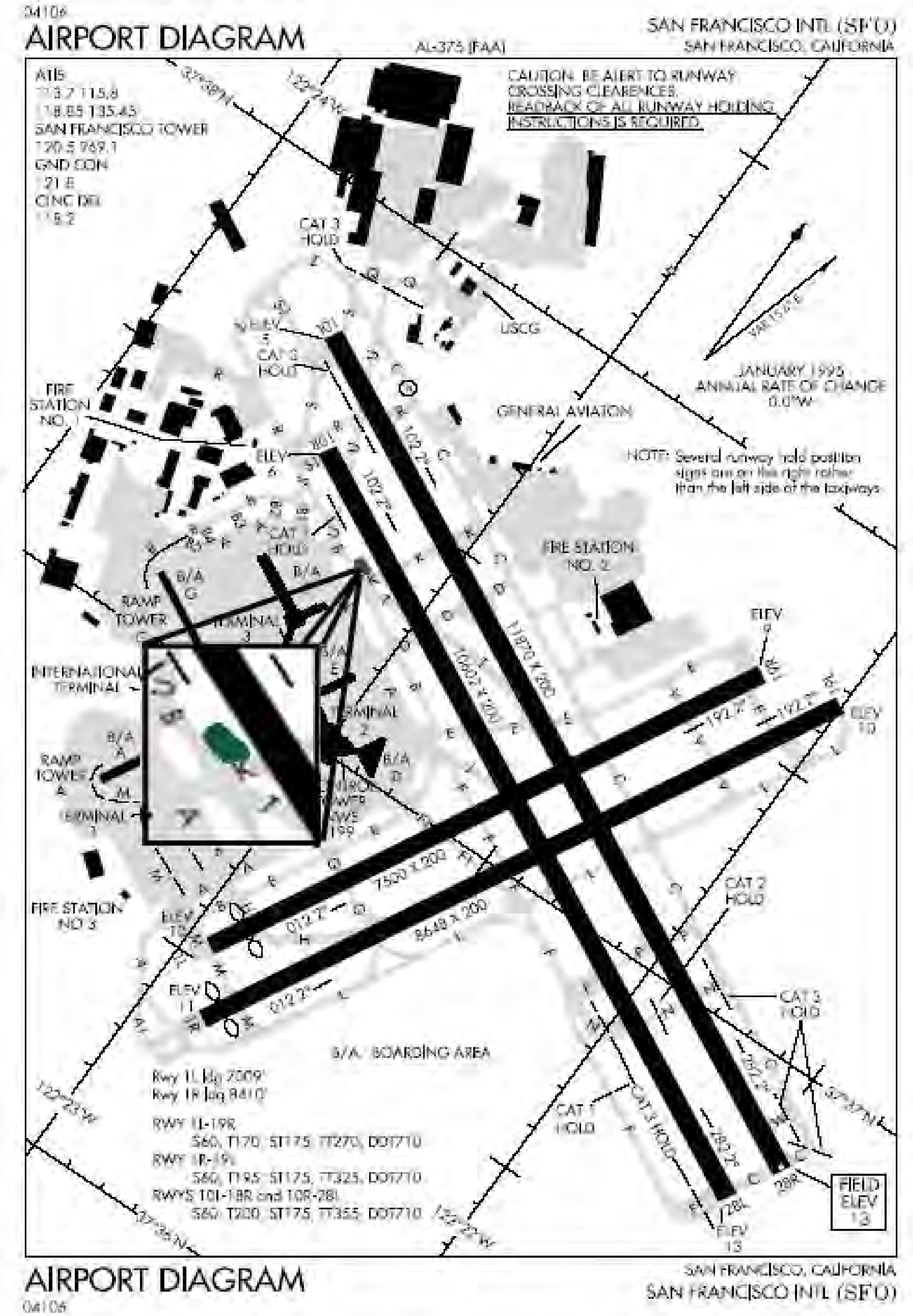



FIGURE A-6. SAN FRANCISCO INTERNATIONAL AIRPORT INSTALLATION SITE

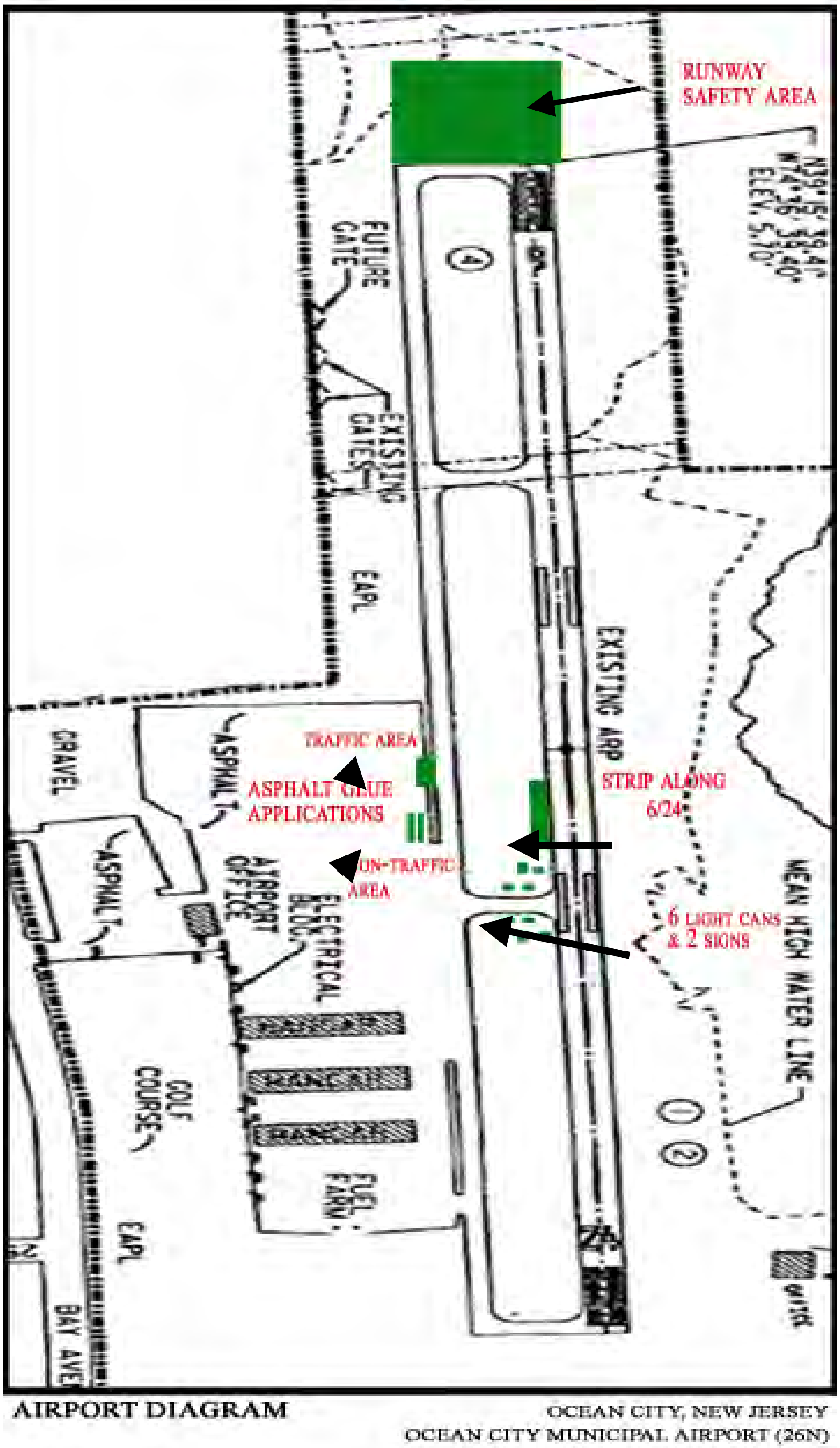


FIGURE A-7. OCEAN CITY MUNICIPAL AIRPORT INSTALLATION SITE

# APPENDIX B—ARTIFICIAL TURF SURVEY QUESTIONNAIRE AND RESULTS

## **GENERAL**

Did you investigate the use of an artificial turf product to possibly solve a specific problem? If so, what was the specific problem?

Who came to whom; did the turf manufacturer contact you or did you seek an alternative for your previous surface?

What factors/problems with the current condition prompted you to <u>consider</u> artificial turf as a grass/turf replacement?

- ❑ Abatement of Turf Management (i.e. grass cutters, pesticides, etc.)
- ❑ Low Maintenance Needs
- ❑ Soil Erosion
- ❑ Poor Drainage
- ❑ Wildlife Issues
- ❑ Visual Enhancement
- ❑ Safety
- ❑ Other(s)

What factors <u>convinced you to install</u> the artificial turf product?

- ❑ Abatement of Turf Management (i.e. grass cutters, pesticides, etc.)
- ❑ Low Maintenance
- ❑ Erosion Control
- ❑ Drainage Control
- ❑ Wildlife Control
- ❑ Visual Enhancements
- ❑ Safety
- ❑ Reduction of FOD
- ❑ Cost Control
- ❑ Durability
- ❑ Warranty
- ❑ Other(s)

Rank these factors from most important to least important for considering installing artificial turf:

- ❑ Abatement of Turf Management (i.e. grass cutters, pesticides, etc.)
- ❑ Low Maintenance
- ❑ Erosion Control
- ❑ Drainage Control
- ❑ Wildlife Control
- ❑ Visual Enhancements
- ❑ Safety
- ❑ Reduction of FOD
- ❑ Cost Control
- ❑ Jet Blast
- ❑ Expected Service Life
- ❑ Warranty
- ❑ Other(s)

What concerns did you have with installing a product like this?

- ❑ Durability (traffic, weather, fuel, deicing fluid resistance)
- ❑ Safety (skid resistance, fire resistance)
- ❑ Jet blast (resistance)
- ❑ Access to lighting/equipment

Were any tests/demonstrations performed to relieve your concerns?

Did you establish any “acceptance” criteria?

Have any concerns been raised (new or otherwise) since the artificial turf has been installed?

At this point, are you satisfied with the artificial turf installation?  If not in your opinion what could be improved upon?

Do you feel that this product should be installed throughout the airport wherever grass exists or just as strips along the edges of taxiways/runway?

## AMPLIFYING QUESTIONS FOR SPECIFIC FACTORS:

## INSTALLATION

What had to be done to the existing surface to prepare the area for installation of the artificial turf product?

How long did the installation process take?

Were there any disruptions to daily operations while the artificial turf was being installed?

Are damaged areas repairable/replaceable by you?

If there are existing signs in the ground how did they effect installation?

Is it easy to access existing signs/lighting cabling?

Is it easy to install new signs/lighting?

Are there any areas around taxiways/runways where this turf should not be installed?

## TESTING/ACCEPTANCE

Were any of the following tests performed at your location? Please describe?

❑ FIRE

❑ CONTAMINANTS
- Fuel spills
- Deicing fluid spills

❑ JET BLAST (also propwash and rotowash)

❑ SKID RESISTANCE

Actual friction measurement or different type of vehicle?

WERE ANY OF THE ABOVE TESTS USED FOR YOUR ACCEPTANCE CRITERIA?

## VISUAL ENHANCEMENT

Do you feel that the installation has visually enhanced the airport?

In talking with pilots, do they feel that the turf visual enhances the airport from the air?

Does this turf standout in dark lighting/night time or is it the same as grass?

Does airport lighting reflect any differently off of the turf than off grass? What about sunlight?

## FOREIGN OBJECT DAMAGE

Has any of the turf been damaged and caused a possible problem?

Are you concerned about the dangers of FOD if the artificial turf surface fails?

## EMERGENCIES

Has there been an instance when an aircraft has deviated from the runway/taxiway and driven on the turf?

Have emergency vehicles been able to drive over the turf with out any problems?

How did the turf perform?

## WEATHER

Does rapid temperature change effect stability or durability of the turf?

Does water "stand" on the surface or is it quickly absorbed in to the subgrade?

Do ice and other cold weather elements easily gather and rest on the surface? If so, how easily/difficult are they to remove?

Does constant hot weather affect the turf in any way?

## MAINTENANCE / DURABILITY

What is typically done to the turf on any given day/month/year to maintain the turf installation?

Have you noticed any type of discoloration since the turf was first installed?

Do you feel that you have to maintain the turf more than the grass installation or less than the grass?

Do weeds and other pollinating seeds grow on or around the turf?

If the turf rips/tears, what must be done to repair the surface? How easy/difficult is it to repair such a defect?

How often does the turf have to be replaced under normal usage?

## WILDLIFE

Have you witnessed an increase, decrease and /or change in the type of wildlife around the artificial turf area?

In your opinion does the artificial turf have an effect on wildlife?

Has any studies been conducted to see if the turf cut down on the amount of wildlife resting on the surface?

## MISCELLANEOUS

Did the manufacturer present you with financial figures for this product? (i.e.: Return on Investment, Risk Reward ratio, etc).

In your opinion, do you feel that this product will pay for itself over the course of its use at the airport?

In your opinion do you feel that the artificial turf is cost effective in comparison to what problems it was intended to solve?

## RECOMMENTATIONS/ACCEPTANCE

Based on your experience, what guidance and acceptance criteria would you recommend for future installations?

Who is the local FAA representative that authorized the installation of the artificial turf?

## ARTIFICIAL TURF SURVEY RESULTS

NOTE: Although there were seven airports surveyed only six airports provided feedback about the artificial turf, thus the rankings placed on the artificial turf are weighed against those responses.

**DID YOU INVESTIGATE THE USE OF AN ARTIFICIAL TURF PRODUCT TO POSSIBLY SOLVE A SPECIFIC PROBLEM? IF SO, WHAT WAS THE SPECIFIC PROBLEM?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Drainage | X | X | X | X | X | | X |
| Low Maintenance Needs | X | X | X | X | X | X | X |
| Soil Erosion | X | X | X | X | X | | X |
| Soil Stability | X | X | X | | | | |
| Safety | X | X | X | | X | X | |
| Reduction of FOD | | | | | X | X | |
| Wildlife Deterrent | X | X | X | | | | |
| Abatement of Turf Management | X | X | X | X | X | X | X |
| Visual Enhancement | | | X | | | | X |

Note: Sorted by importance weighting

**WHO CAME TO WHOM; DID THE TURF MANUFACTURER CONTACT YOU OR DID YOU SEEK AN ALTERNATIVE FOR YOUR PREVIOUS SURFACE?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Went to Manufacturer | | | X | X | | | X |
| Manufacturer came to airport | X | X | | | X | X | |

**WHAT FACTORS/PROBLEMS WITH THE CURRENT CONDITION PROMPTED YOU TO <u>CONSIDER</u> ARTIFICIAL TURF AS A NATURAL GRASS REPLACEMENT?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Erosion Control | X | X | X | X | X | | X |
| Drainage Control | X | X | X | X | X | | X |
| Low Maintenance | X | X | X | X | X | X | X |
| Abatement of turf management | X | X | X | X | X | X | X |
| Safety | X | X | X | X | X | X | |
| Soil Stability | X | X | X | X | | | X |
| Reduction of FOD | | X | X | | X | X | |
| Wildlife Control | X | X | X | X | | | |
| Cost Control | | X | X | X | X | | |
| Expected Service Life | X | X | X | X | | | |
| Visual Enhancement | | X | X | | | | X |
| Warranty | | X | | | | | |
| Durability | X | | | | X | | |
| Other | | | | | X | | |

Note: sorted by importance weighting

**WHAT FACTORS <u>CONVINCED YOU TO INSTALL</u> THE ARTIFICIAL TURF PRODUCT?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Drainage Control | X | X | X | X | | | X |
| Low Maintenance | X | X | X | | X | | X |
| Erosion Control | X | X | X | X | X | X | X |
| Soil Stability | X | X | X | | X | | X |
| Safety | X | X | X | | X | X | |
| Reduction of FOD | X | X | X | | X | X | |
| Wildlife Control | X | X | X | | | X | |
| Abatement of turf management | X | X | X | | | | X |
| Cost Control | X | | X | | X | | |
| Expected Service Life | X | | X | | | | |
| Visual Enhancement | | | X | | | | X |
| Warranty | | | X | | | X | |
| Cost Control | | | X | | X | X | |
| Other | | | Ruts | Winter Sand | Offered by manufacturer | | |

Note: sorted by importance weighting

**RANK THESE FACTORS FROM MOST IMPORTANT TO LEAST IMPORTANT FOR CONSIDERING INSTALLING ARTIFICIAL TURF**

(Ranked 1-(most important) thru 13-(least important)

| (Ranked 1-(most important) thru 13-(least important) | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** | **SUM** |
|---|---|---|---|---|---|---|---|---|
| Abatement of turf management | 1 | 8 | 6 | 8 | 3 | 4 | 4 | 34 |
| Low Maintenance | 1 | 2 | 5 | 5 | 4 | 5 | 6 | 28 |
| Erosion Control | 1 | 3 | 8 | 2 | 5 | 6 | 1 | 26 |
| Drainage Control | 1 | 6 | 2 | 4 | 6 | 9 | 3 | 31 |
| Wildlife Control | 1 | 7 | 3 | 7 | 8 | 7 | | 33 |
| Visual Enhancement | 1 | 9 | 12 | 11 | 9 | 11 | 5 | 58 |
| Safety | 1 | 10 | 1 | 9 | 1 | 2 | 2 | 26 |
| Reduction of FOD | 1 | 5 | 5 | 12 | 2 | 1 | | 26 |
| Cost Control | 1 | 11 | 7 | 10 | 7 | 8 | | 44 |
| Jet Blast | 1 | 4 | 3 | 3 | 11 | 10 | | 32 |
| Expected Service Life | 1 | 12 | 10 | 5 | 10 | 12 | | 50 |
| Warranty | 1 | 13 | 11 | 13 | 12 | 3 | | 53 |
| Other | | 1 (Ease of installation) | | 1 (Sand Cleanup) | | | | |

Note: Sum equals importance weighting

**WHAT CONCERNS DID YOU HAVE WITH INSTALLING A PRODUCT LIKE THIS?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Jet blast (resistance) | X | X | X | X | X | X | |
| Durability (traffic, weather, fuel, deicing fluid resistance) | X | | X | X | X | X | X |
| Safety (skid resistance, fire resistance) | X | | X | X | X | X | |
| Access to lighting/equipment | X | | X | | | | X |

**WERE ANY TESTS/DEMONSTRATIONS PERFORMED TO RELIEVE YOUR CONCERNS?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Load Bearing Test | X | X | X | X | X | | |
| High Powered Blower | X | X | | X | | | |
| Jet Blast | | | | X | | X | |

**DID YOU ESTABLISH ANY "ACCEPTANCE" CRITERIA?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X (used part 139) | X (used part 139) | | | | X | |
| No | | | X | X | X | | |

**HAVE ANY CONCERNS BEEN RAISED (NEW OR OTHERWISE) SINCE THE ARTIFICIAL TURF HAS BEEN INSTALLED?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | | X (Weed Control) | | | | | |
| No | X | | X | X | X | X | X |

**AT THIS POINT, ARE YOU SATISFIED WITH THE ARTIFICIAL TURF INSTALLATION?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | X | X | X |
| No | | | | | | | |

**DO YOU FEEL THAT THIS PRODUCT SHOULD BE INSTALLED THROUGHOUT THE AIRPORT WHEREVER GRASS EXISTS OR JUST AS STRIPS ALONG THE EDGES OF TAXIWAYS/RUNWAY?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Throughout airport | X | | | | | | |
| Strips in safety areas | | X | X | X | X | X | X |

## AMPLIFYING QUESTIONS FOR SPECIFIC FACTORS:

## INSTALLATION

**WHAT HAD TO BE DONE TO THE EXISTING SURFACE TO PREPARE THE AREA FOR INSTALLATION OF THE ARTIFICIAL TURF PRODUCT?**

| Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|
| 1. Take soil out 5"-6" down<br>2. Install AG-6<br>3. Install headers & anchors<br>4. Install turf surface | 1. Excavate 6-8" of soil<br>2. Install CA-6<br>3. Install headers & anchors<br>4. Install turf surface | 1. 10" excavation of soil<br>2. Geotextile material<br>3. Composite header<br>4. Install 22-AA road aggregate 9" | Installed 9" of p209 | 1.Area had to be graded<br>2. Trench dug to lay 4x4 wood<br>3. Lay turf | 1. Removal of native soil to allow for compatible resulting grade.<br>2. Backfill with sub-base and compaction.<br>3. Header installed around perimeter. | 1.Area had to be graded<br>2. Trench dug to lay header<br>3. Lay turf |

**HOW LONG DID THE TURF INSTALLATION PROCESS TAKE?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Length | 3 nights | 2 nights | 12 hours | 3 nights | 2 days | 1 night | 3 days |

**WERE THERE ANY DISRUPTIONS TO DAILY OPERATIONS WHILE THE ARTIFICIAL TURF WAS BEING INSTALLED?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | X (runway closure) | | X | X (taxiway closures) | |
| No | X | X | | X | | | X (Airport was closed) |

**ARE DAMAGED AREAS REPAIRABLE/REPLACEABLE BY YOU?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | | | X |
| No | | | | | X | X | |

**IF THERE ARE EXISTING SIGNS IN THE GROUND HOW DID THEY EFFECT INSTALLATION?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Major | | | | | | | |
| Minimal | | | | X | | | |
| N/A | X | X | X | | X | X | X |

**IS IT EASY TO ACCESS EXISTING SIGNS/LIGHTING CABLING?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | | X | X | |
| No | | | | | | | |
| N/A | | | | X | | | X |

**IS IT EASY TO INSTALL NEW SIGNS/LIGHTING?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | | | X | | |
| No | | | | | | | |
| N/A | | | X | X | | X | X |

**ARE THERE ANY AREAS AROUND TAXIWAYS/RUNWAYS WHERE THIS TURF SHOULD NOT BE INSTALLED?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| No | X | X | X | X | X | X | X |

## TESTING/ACCEPTANCE

**WERE ANY OF THE FOLLOWING TESTS PERFORMED AT YOUR LOCATION? PLEASE DESCRIBE?**

❑ FIRE

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X | X | | | X | | |
| No | | | X | X | | X | X |

❑ CONTAMINANTS

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X | | | | X | | |
| No | | X | X | X | | X | X |

❑ JET BLAST (also propwash and rotowash)

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X | | | X | | X | |
| No | | X | X | | X | | X |

❑ SKID RESISTANCE

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | | | | | X | X | |
| No | X | X | X | X | | | X |

**WERE ANY OF THE ABOVE TESTS USED FOR YOUR ACCEPTANCE CRITERIA?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | | | X (Used test results from ORD & MDW) | | | X | |
| No | | | | | X | | |
| None established | X | X | | X | | | X |

## VISUAL ENHANCEMENT

**DO YOU FEEL THAT THE INSTALLATION HAS VISUALLY ENHANCED THE AIRPORT?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | X | X | X |
| No | | | | | | | |

**IN TALKING WITH PILOTS, DO THEY FEEL THAT THE TURF VISUAL ENHANCES THE AIRPORT FROM THE AIR?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | X | | X |
| No | | | | | | X | |

**DOES THIS TURF STANDOUT IN DARK LIGHTING/NIGHT TIME OR IS IT THE SAME AS GRASS?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Same | X | X | X | | X | X | X |
| Standout | | | | X | | | |

**DOES AIRPORT LIGHTING REFLECT ANY DIFFERENTLY OFF OF THE TURF THAN OFF GRASS?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| No | X | X | X | X | X | X | X |

**WHAT ABOUT SUNLIGHT?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| No | X | X | X | X | X | X | X |

## FOREIGN OBJECT DAMAGE

**HAS ANY OF THE TURF BEEN DAMAGED AND CAUSED A POSSIBLE PROBLEM?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | X (no problem) | | | | |
| No | X | X | | X | X | X | X |

**ARE YOU CONCERNED ABOUT THE DANGERS OF FOD IF THE ARTIFICIAL TURF SURFACE FAILS?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | X | X | X |
| No | X | X | X | X | | | |

# EMERGENCIES

**HAS THERE BEEN AN INSTANCE WHEN AN AIRCRAFT HAS DEVIATED FROM THE RUNWAY/TAXIWAY AND DRIVEN ON THE TURF?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X (on purpose) | | | | | | |
| No | | X | X | X | X | X | X |

**HAVE EMERGENCY VEHICLES BEEN ABLE TO DRIVE OVER THE TURF WITH OUT ANY PROBLEMS?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | X | X | |
| No | | | | | | | Not tested |

**HOW DID THE TURF PERFORM?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Positive performance | X | X | X | X | X | X | |
| Negative performance | | | | | | | N/A |

## WEATHER

**DOES RAPID TEMPERATURE CHANGE EFFECT STABILITY OR DURABILITY OF THE TURF?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | N/A |
| No | X | X | X | X | X | X | |

**DOES WATER "STAND" ON THE SURFACE OR IS IT QUICKLY ABSORBED IN TO THE SUBGRADE?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Absorbed | X | X | X | X | X | X | X |
| Not Absorbed | | | | | | | |

**DO ICE AND OTHER COLD WEATHER ELEMENTS EASILY GATHER AND REST ON THE SURFACE? IF SO, HOW EASILY/DIFFICULT ARE THEY TO REMOVE?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| No | X | X | X | | X | | |
| Unknown | | | | X | | X | X |

## DOES CONSTANT HOT WEATHER AFFECT THE TURF IN ANY WAY?

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| No | X | X | X | X | X | X | X |

## MAINTENANCE / DURABILITY

**WHAT IS TYPICALLY DONE TO THE TURF ON ANY GIVEN DAY/MONTH/YEAR TO MAINTAIN THE TURF INSTALLATION?**

| Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|
| Trash picked up, brushing yearly | Bi annual brushing to lift fibers | Sweep turf every 6 months | Nothing so far | Nothing so far | None as of yet | Nothing so far |

**HAVE YOU NOTICED ANY TYPE OF DISCOLORATION SINCE THE TURF WAS FIRST INSTALLED?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| No | X | X | X | X | X | X | X |

**DO YOU FEEL THAT YOU HAVE TO MAINTAIN THE TURF MORE THAN THE GRASS INSTALLATION OR LESS THAN THE GRASS?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| More | | | | | | | |
| Less | X | X | X | X | X | X | X |

**DO WEEDS AND OTHER POLLINATING SEEDS GROW ON OR AROUND THE TURF?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X (some) | X | | X | | |
| No | | | | X | | X | X |

**IF THE TURF RIPS/TEARS, WHAT MUST BE DONE TO REPAIR THE SURFACE? HOW EASY/DIFFICULT IS IT TO REPAIR SUCH A DEFECT?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Easy | | | X (Hot Glued turf down) | | | X | |
| Difficult | | | | | | | |
| N/A | X | X | | X | X | | X |

**HOW OFTEN DOES THE TURF HAVE TO BE REPLACED UNDER NORMAL USAGE?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | | | | | | | |
| N/A | X | X | X | X | X | X | X |

## WILDLIFE

**HAVE YOU WITNESSED AN INCREASE, DECREASE AND /OR CHANGE IN THE TYPE OF WILDLIFE AROUND THE ARTIFICIAL TURF AREA?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Increase | | | | | | | |
| Decrease | X | X | X | | | X | |
| Unknown | | | | X | X | | X |

**IN YOUR OPINION DOES THE ARTIFICIAL TURF HAVE AN EFFECT ON WILDLIFE?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | | X | | No food source | | X (Reduces presence) | |
| No | X | | (Not noted) | | X | | Not Noted |

**HAS ANY STUDIES BEEN CONDUCTED TO SEE IF THE TURF CUT DOWN ON THE AMOUNT OF WILDLIFE RESTING ON THE SURFACE?**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X (USDA) | X | | | | | |
| No | | | X | X | X | X | X |

## MISCELLANEOUS

**DID THE MANUFACTURER PRESENT YOU WITH FINANCIAL FIGURES FOR THIS PRODUCT? (I.E.: RETURN ON INVESTMENT, RISK REWARD RATIO, ETC).**

| | **Chicago Midway (MDW)** | **Chicago O'Hare (ORD)** | **Detroit Metro (DTW)** | **Boston Logan (BOS)** | **Honolulu (HNL)** | **San Francisco (SFO)** | **Ocean City (26N)** |
|---|---|---|---|---|---|---|---|
| Yes | X | | X | | | X | |
| No | | X | | X | X | | X |

**IN YOUR OPINION, DO YOU FEEL THAT THIS PRODUCT WILL PAY FOR ITSELF OVER THE COURSE OF ITS USE AT THE AIRPORT?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | X | X | X |
| No | | | | | | | |

**IN YOUR OPINION DO YOU FEEL THAT THE ARTIFICIAL TURF IS COST EFFECTIVE IN COMPARISON TO WHAT PROBLEMS IT WAS INTENDED TO SOLVE?**

| | Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|---|
| Yes | X | X | X | X | X | X | X |
| No | | | | | | | |

## RECOMMENTATIONS/ACCEPTANCE

**BASED ON YOUR EXPERIENCE, WHAT GUIDANCE AND ACCEPTANCE CRITERIA WOULD YOU RECOMMEND FOR FUTURE INSTALLATIONS?**

| Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|
| Follow Part 139 | | | | | Warranty of all installations for at least one year. Unsatisfactory performance resulting in product removal - costs should be borne by the manufacturer during warranty period. | |

**WHO IS THE LOCAL FAA REPRESENTATIVE THAT AUTHORIZED THE INSTALLATION OF THE ARTIFICIAL TURF?**

| Chicago Midway (MDW) | Chicago O'Hare (ORD) | Detroit Metro (DTW) | Boston Logan (BOS) | Honolulu (HNL) | San Francisco (SFO) | Ocean City (26N) |
|---|---|---|---|---|---|---|
| Tracey Halpin | Tracey Halpin | John Lott | Ben Castellano | Mack Humphrey | Gretchen Catron | N/A |

## APPENDIX C—FEDERAL AVIATION ADMINISTRATION WILLIAM J. HUGHES TECHNICAL CENTER WIND TUNNEL TESTING

### C.1 WIND TUNNEL TESTING.

At the Federal Aviation Administration (FAA) William J. Hughes Technical Center wind tunnel tests (figure C-1) were performed on the various fiber lengths of artificial turf to determine how high winds and jet blasts might affect the ballast sand infill. These tests were meant to simulate the effects over 1 month of jet blast and high winds to determine how often the ballast sand must be replaced during normal operations. It should be noted that the testing being performed was to quantify the artificial turf and not to qualify the turf.

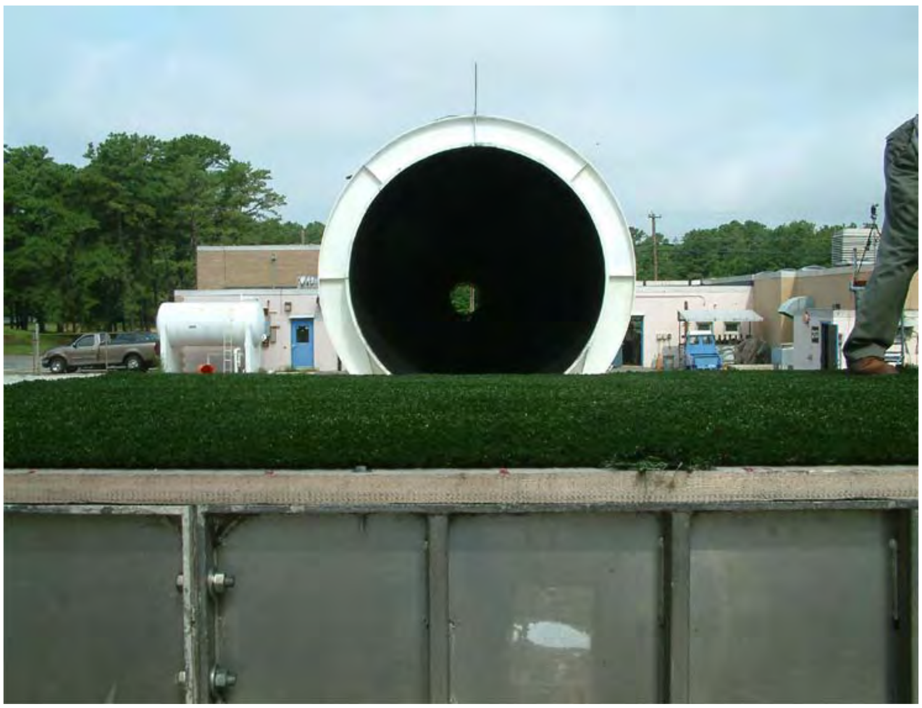


FIGURE C-1. TEST PLOT INSTALLED AT THE FAA WILLIAM J. HUGHES TECHNICAL CENTER WIND TUNNEL

Each manufacturer has a unique honeycomb shape cut to their fiber that acts like a net to trap the sand inside the artificial turf. How the ballast sand remains in the artificial turf comes from how each individual fiber is cut. With a jet blast or heavy winds, the fiber folds over the top of the sand and traps the sand within the honeycomb pattern. The purpose of the wind tunnel test was to determine how the composition of each manufacturer's turf holds up in relation to simulated aircraft traffic at an airport for 1 month. Of the two manufacturers that participated in the tests, only one manufacturer had multiple configurations. AvTurf tested one fiber length; a 2-inch fiber with a sand infill. Air FieldTurf brought along four different fiber lengths (2.5″, 2.0″, 1.5″, and 1.0″) as well as two types of infill (sand and pebble).

The artificial turf was installed on a test plot area consisting of a 12- by 12-ft raised platform that allowed for a modified installation of the artificial turf product. The test plot installation of the artificial turf did not mimic an actual airport installation.

## C.2 BACKGROUND.

During September 2000, estimated exposure times equivalent to conditions measured on the Runway 22 overrun area at LaGuardia Airport (LGA) were established for the platform located behind the FAA William J. Hughes Technical Center wind tunnel[*]. These estimates established the amount of time at various power settings to be equivalent to 1 month's exposure at LGA with the traffic mix depicted in table C-1. Ultimately, the power setting profiles contained in table C-2 were established to estimate LGA conditions at 40 and 75 feet from the overrun area.

TABLE C-1. TRAFFIC MIX FOR 1 MONTH AT LGA

| Aircraft Category | Takeoffs | Landings | Maximum Takeoff Speed (mph) |
|---|---|---|---|
| B-727 | 66 | 32 | 200 |
| B-737 | 108 | 34 | 250 |
| B-757 | 54 | 7 | 250 |
| B-767 | 8 | 3 | 250 |
| C19 | 11 | 9 | 136 |
| C20 | 60 | 22 | |
| DC-9 | 102 | 31 | 200 |
| F100 | 23 | 16 | |
| Other | 27 | 21 | - |
| Regional Jet | 67 | 26 | - |
| Turboprop | 100 | 55 | - |

Note: The reader should take into account that the aircraft mix for LGA traffic did not include heavy large aircraft like the Boeing 747 and 777 or the Airbus 340 and 380.

[*] Geoffrey J. Frank, "Summary of Measured Data and Recommendations for Testing on Platform Behind FAA Wind Tunnel," 28 September 2000.

TABLE C-2. RECOMMENDED PROFILES FOR SIMULATING LGA CONDITIONS

| Average at 40 feet | | Average at 75 feet | |
|---|---|---|---|
| 12 repetitions for 1 month | | 12 repetitions for 1 month | |
| Time (sec) | Power (%) | Time (sec) | Power (%) |
| 0 | 85 | 0 | 85 |
| 240 | 85 | 180 | 85 |
| 250 | 90 | 190 | 90 |
| 375 | 90 | 280 | 90 |
| 380 | 85 | 290 | 85 |
| 565 | 85 | 470 | 85 |
| 580 | 100 | 485 | 100 |
| 595 | 100 | 495 | 100 |
| 600 | 85 | 510 | 85 |

The testing process used at the FAA William J. Hughes Technical Center wind tunnel mimicked the profiles that simulated LGA conditions. The tests consisted of various thrust settings and durations of thrust that equate to being 40 or 75 feet from a runway. The tests were performed over 8- to 10-minute intervals. Once one test run was completed (12 cycles), measurements were taken to determine migration of sand, as shown in figure C-2, in relation to the baseline measurement depth of the sand. Both manufacturers tested their products at the wind tunnel on the following dates:

- Test 1—AvTurf, 2.0-inch fiber: 4 months at 75 ft and 3 months at 40 ft, 08/12/03
- Test 2a—Air FieldTurf, 2.5-inch fiber: 1 month at 75 ft and 1 month at 40 ft, 10/07/03
- Test 2b—Air FieldTurf, 2.5-inch fiber: 1 month at 75 ft and 1 month at 40 ft, 10/08/03
- Test 3—Air FieldTurf, 2.0-inch fiber: 1 month at 75 ft and 1 month at 40 ft, 10/09/03
- Test 4—Air FieldTurf, 1.0-inch fiber: 1 month at 75 ft and 1 month at 40 ft, 12/03/03
- Test 5—Air FieldTurf, 1.5-inch fiber: 1 month at 75 ft and 1 month at 40 ft, 02/04/04
- Test 6—Air FieldTurf, 2.0-inch fiber, glued (no infill): 4 cycles at 40 ft, 03/09/04
- Test 7—Air FieldTurf, 2.0-inch fiber, glued (with infill): 1 month at 40 ft, 03/10/04
- Test 8—Air FieldTurf, 1.5-inch fiber, 4 cycles at 40 ft, 03/11/04

FIGURE C-2. MEASURING SAND MOVEMENT AFTER TEST RUN

The tests were conducted using the wind tunnel power setting profiles for 40 and 75 ft on the different artificial turf as discussed in sections C.3 through C.11.

## C.3 TEST 1—AVTURF 2.0-INCH FIBER.

The artificial turf was installed on the test plot with a header system and the standard ballast sand infill. Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths (figure C-3). A total of 12 rows and 11 columns were marked. Figure C-4 is a cross-sectional view of the AvTurf installation used in the wind tunnel tests.

FIGURE C-3. MEASURING SAND MOVEMENT

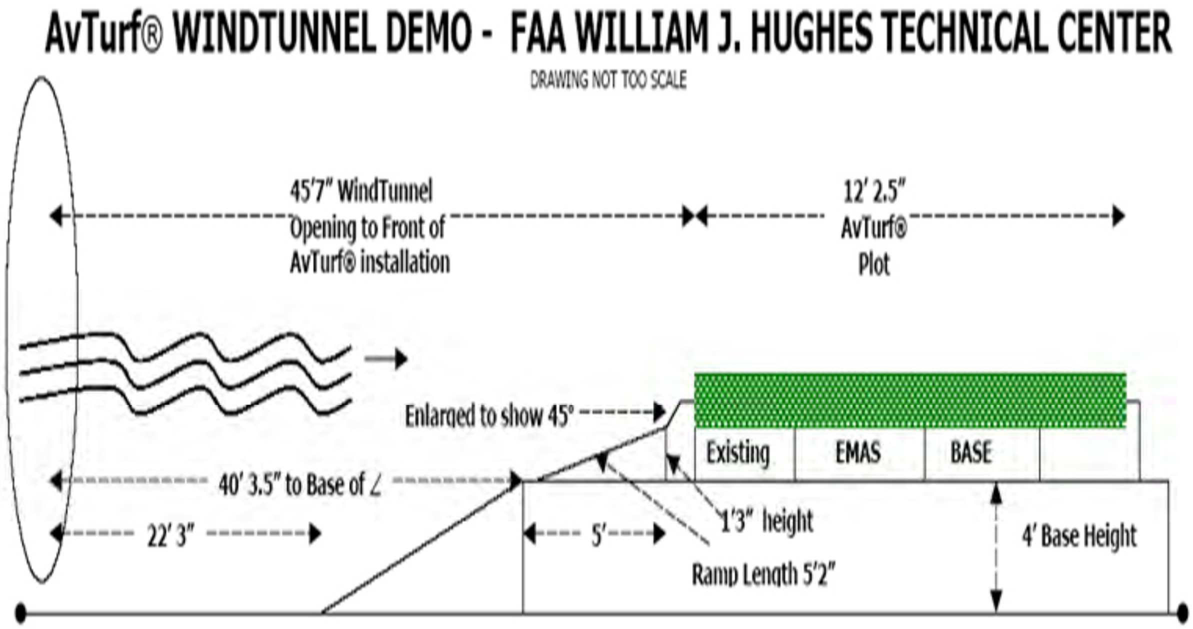



FIGURE C-4. AVTURF ENGINEERING DRAWING FROM WIND TUNNEL TEST

C.3.1 TEST 1 RESULTS.

- Baseline (figure C-5). The baseline depth of the ballast sand measured from 0.50 to 1.45 inches.

- Run 1—1 Month at 75 ft (figure C-6). Once the test was completed, measurements were taken. The depth of the ballast sand measured from 0.50 inch (front) to 1.75 inch (rear). Moderate sand movement was noted. It was determined that the 2.0-inch fiber was successful for 1 month at 75 ft.

- Run 2—1 Month at 75 ft (figure C-7). After the first test was conducted and measurements were taken, another 1-month test was conducted at 75 ft. There was no sand added to the artificial turf test plot. Once the test was completed, measurements were taken. The sand depth measured from 0.25 inch (front rows) to 1.35 inches (rear rows). Moderate sand migration was noted. It was determined that the 2.0-inch fiber was successful for a second month at 75 ft.

- Run 3—1 Month at 75 ft (figure C-8). After the second test was conducted and measurements were taken, another 1-month test was conducted at 75 ft. There was no sand added to the artificial turf test plot. Once the test was completed, measurements were taken. The sand depth measured from 0.00 inch (front rows) to 1.25 inches (rear rows). Extensive sand migration away from the front edge of the installation was observed.

- Run 4—1 Month at 75 ft (figure C-9). After the third test was conducted and measurements were taken, another 1-month test was conducted at 75 ft. There was no sand added to the artificial turf test plot. Once the test was completed, measurements were taken. The sand depth measured from 0.05 inch (front rows) to 1.25 inches (rear rows). Extensive sand migration away from the front edge of the installation was again observed. Along the front middle portion of the installation, a cone shape zone developed that contained no sand. The peak of this cone was at row 2.

- Run 5—1 Month at 40 ft (figure C-10). After the fourth test was conducted and measurements were taken, run 5 was initiated with a 40-ft jet blast simulation. There was no sand added to the artificial turf test plot. At this point, the sand depth measured from 0.00 inch (front rows) to 1.25 inches (rear rows). The ballast sand continued to migrate extensively away from the front middle portion of the installation, enlarging the cone shape. The cone with no sand reached up to row 3 with its peak being at column 9.

- Run 6—1 Month at 40 ft (figure C-11). After the fifth test was conducted and measurements were taken, another 1-month test was conducted at 40 ft. There was no sand added to the artificial turf test plot. At this point, the sand depth measured from 0.00 inch (front rows) to 1.25 inches (rear rows). The ballast sand continued to migrate extensively away from the front middle portion of the installation, enlarging the cone shape. The cone with no sand reached up to row 4 with its peak being at columns 8 and 9.
- Run 7—1 Month at 40 ft (figure C-12). After the sixth test was conducted and measurements were taken, another 1-month test was conducted at 40 ft. There was no sand added to the artificial turf test plot. At this point, the sand depth measured from 0.00 inch (front rows) to 1.25 inches (rear rows). The ballast sand continued to migrate extensively away from the front middle portion of the installation, enlarging the cone shape. The cone with no sand reached up to row 5 with its peak being at columns 8 and 9.

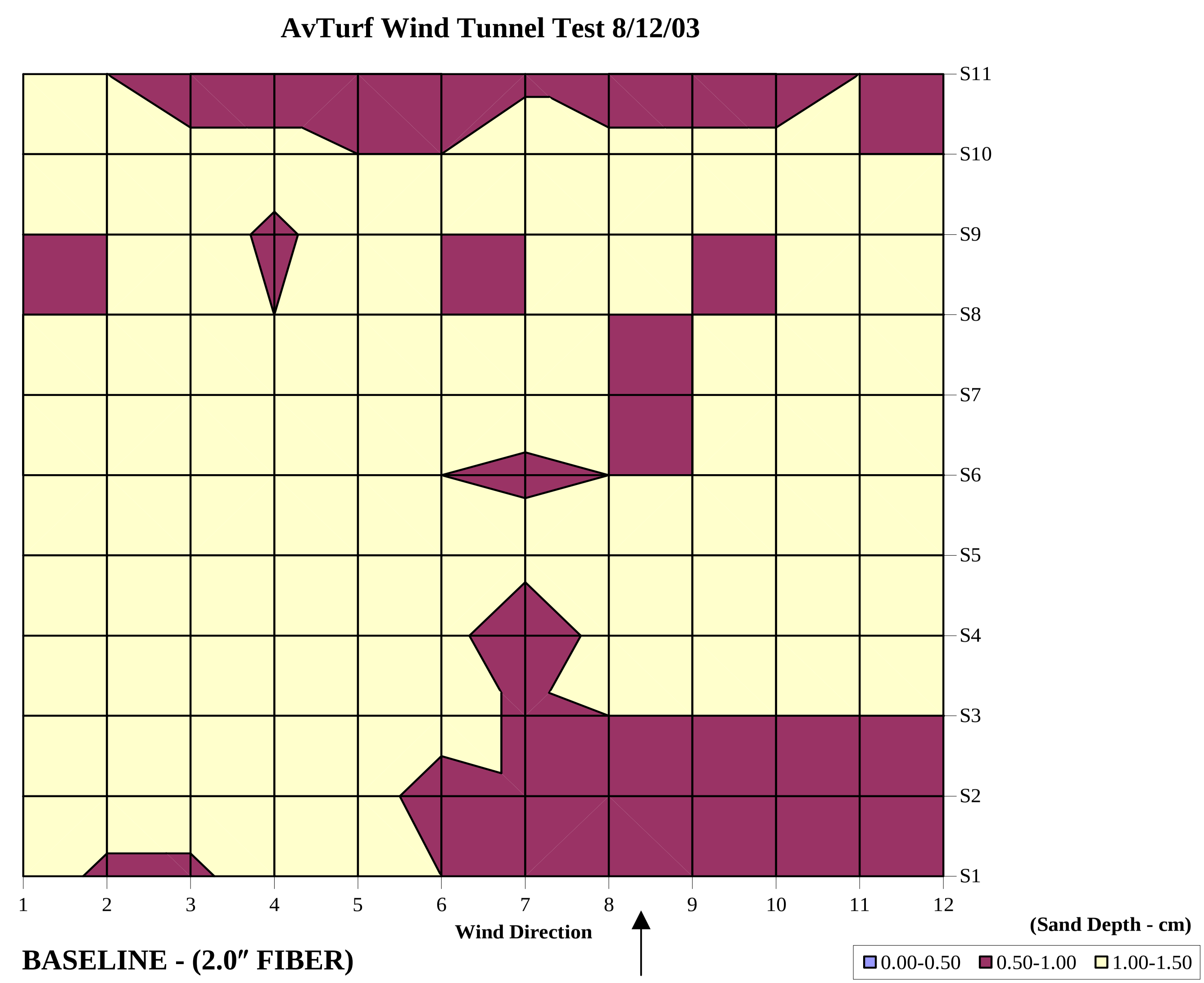
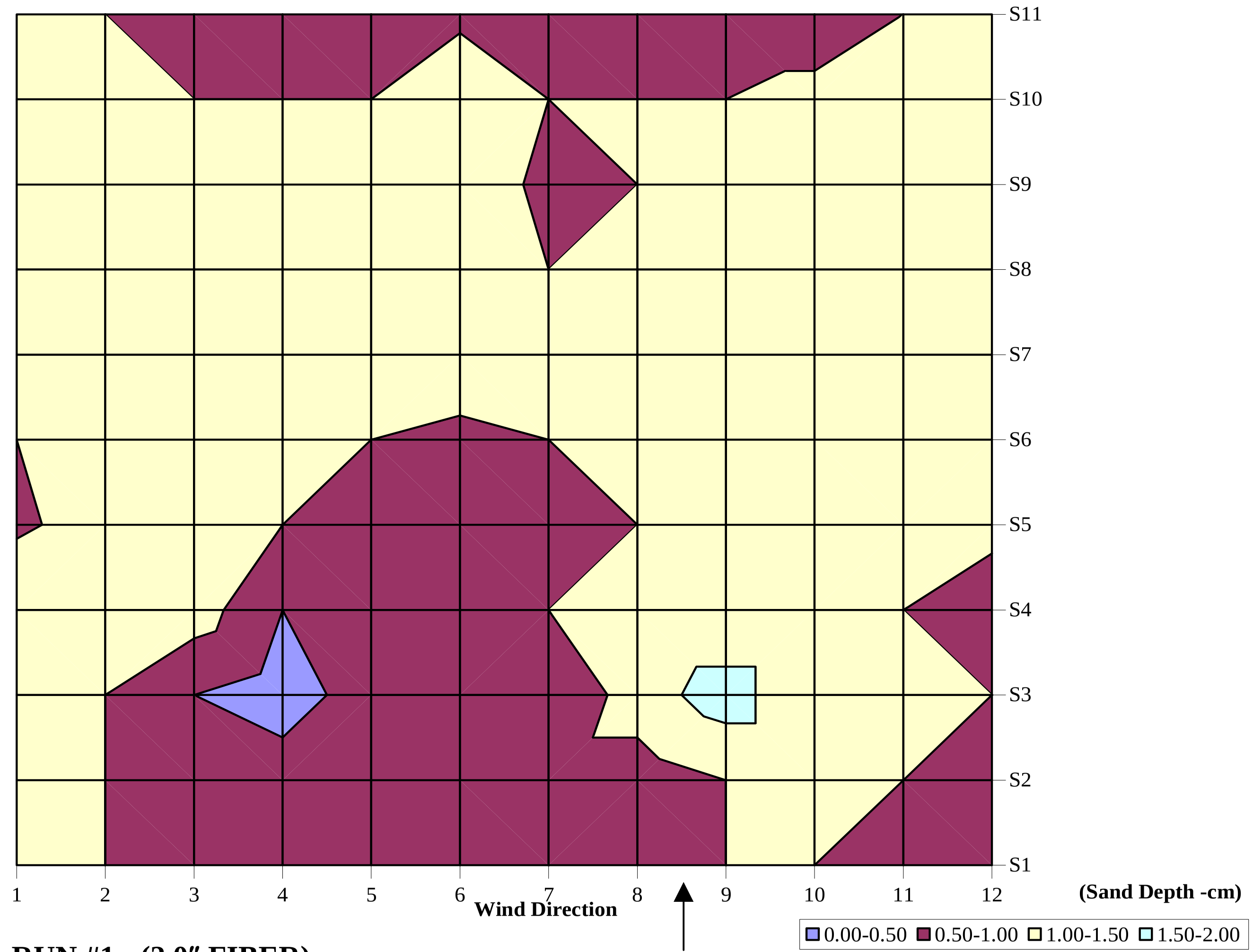


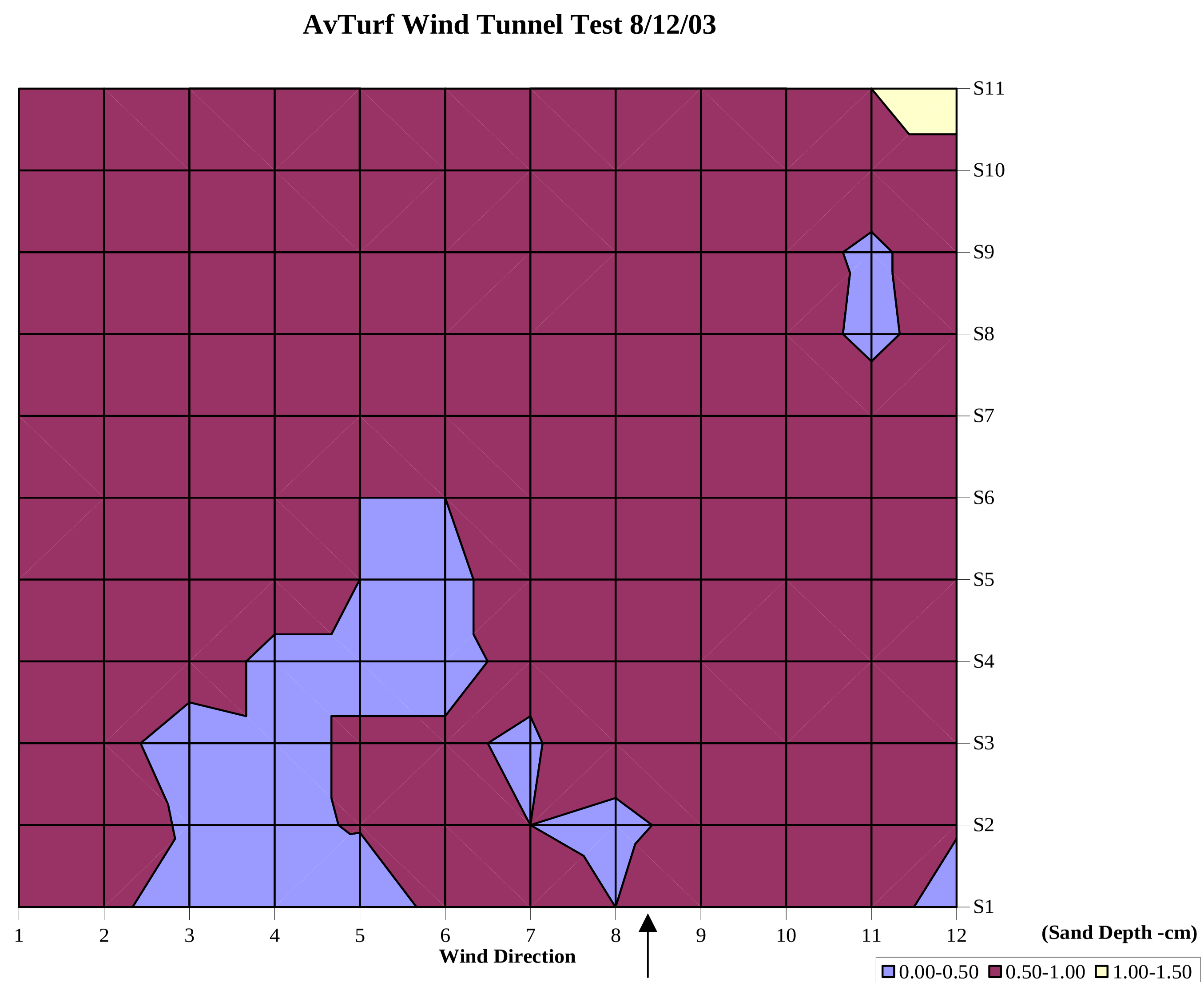

FIGURE C-5. BASELINE—1 MONTH AT 75 FEET

**AvTurf Wind Tunnel Test 8/12/03**




**RUN #1 - (2.0″ FIBER)**

FIGURE C-6. RUN 1—1 MONTH AT 75 FEET




**RUN #2 - (2.0″ FIBER)**

FIGURE C-7. RUN 2—1 MONTH AT 75 FEET

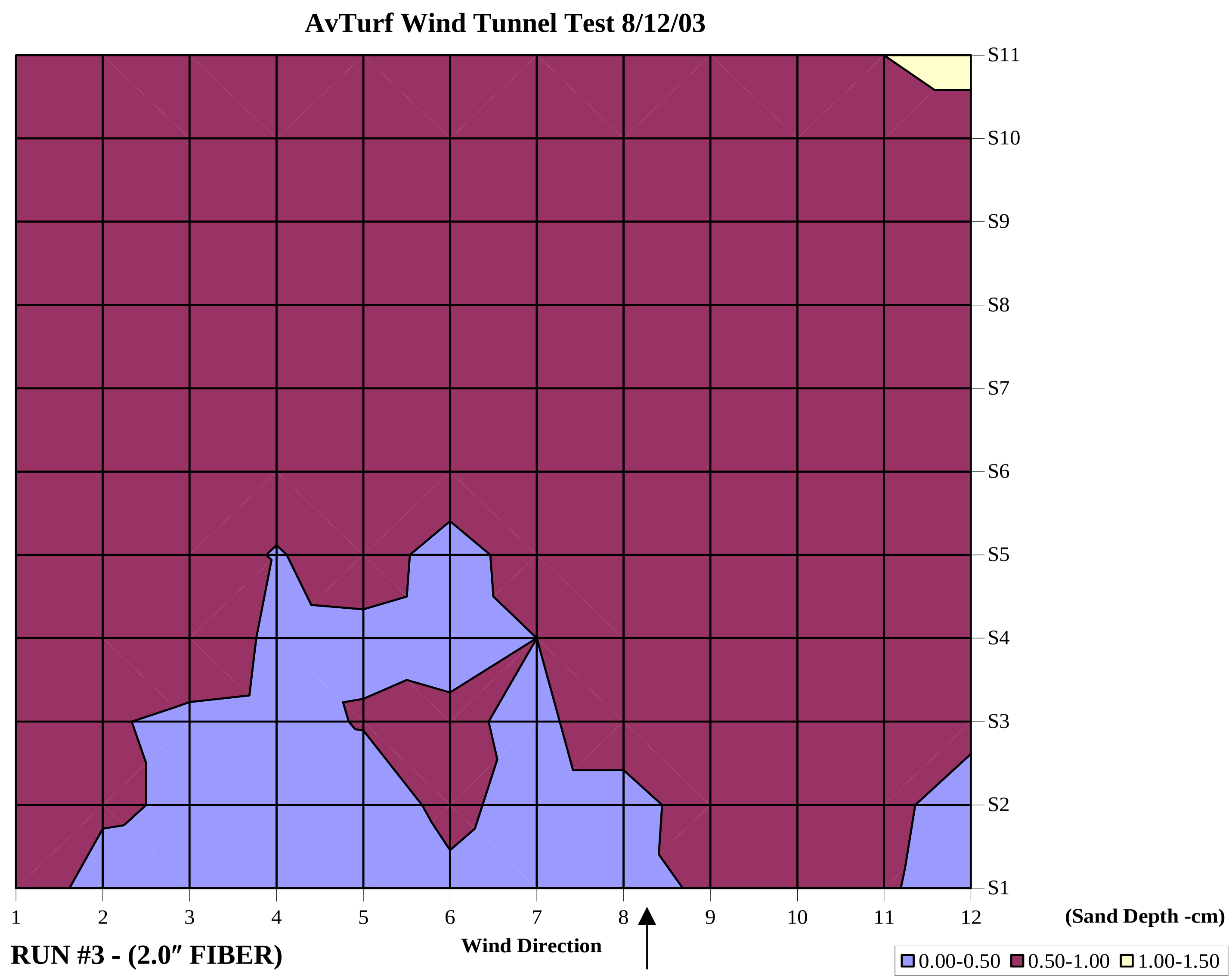
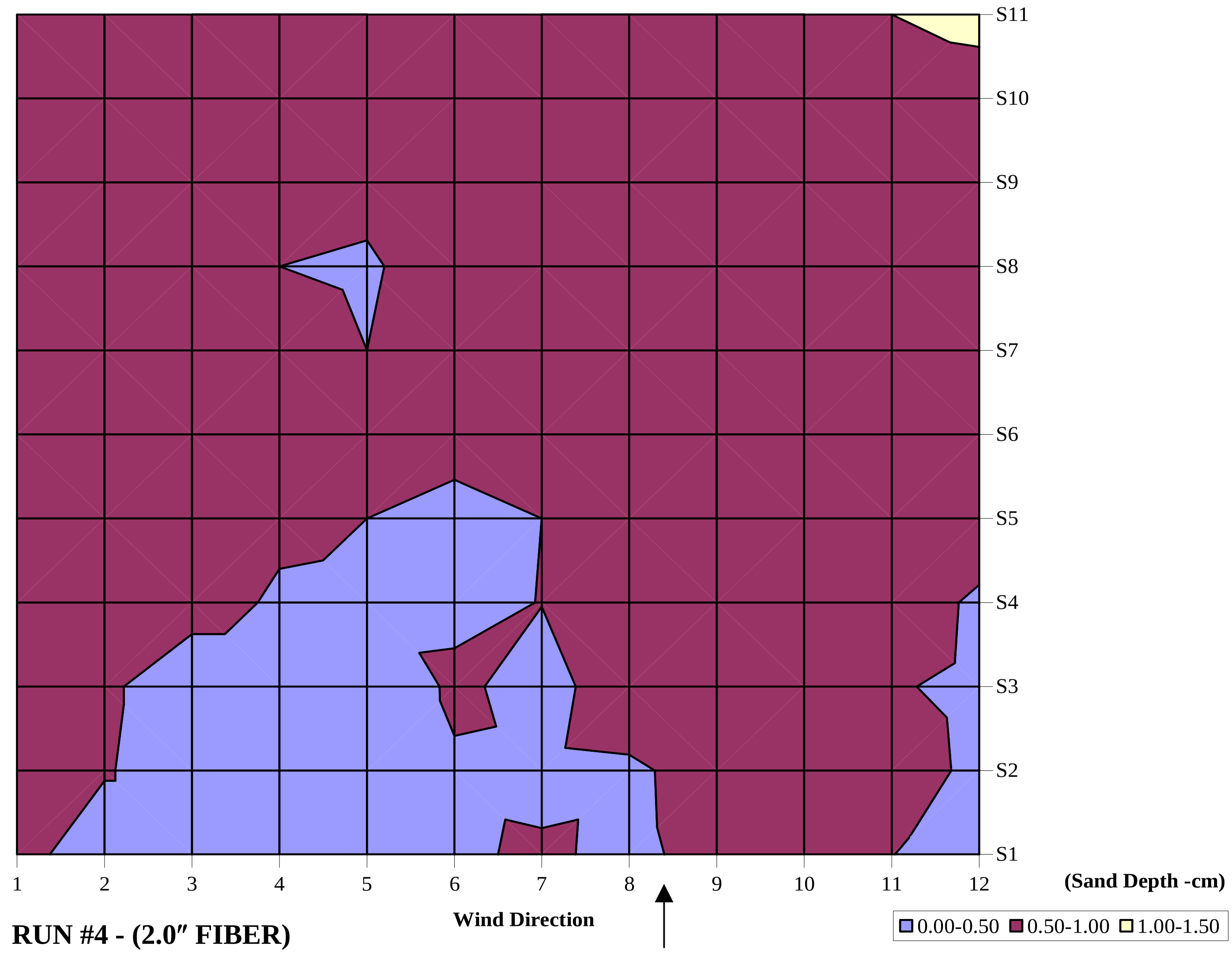



FIGURE C-8. RUN 3—1 MONTH AT 75 FEET

## AvTurf Wind Tunnel Test 8/12/03




**RUN #4 - (2.0″ FIBER)**

FIGURE C-9. RUN 4—1 MONTH AT 75 FEET

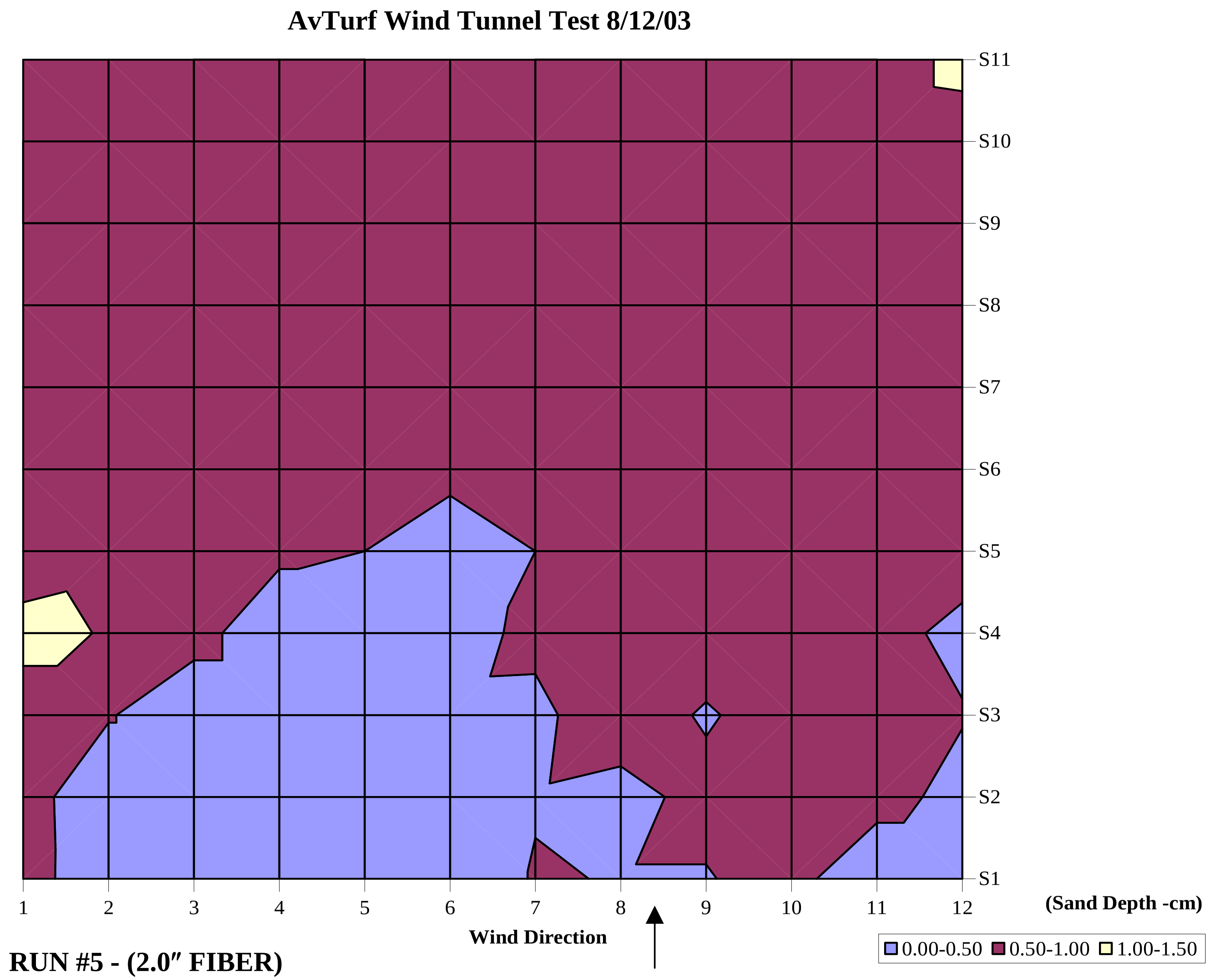



FIGURE C-10. RUN 5—1 MONTH AT 40 FEET

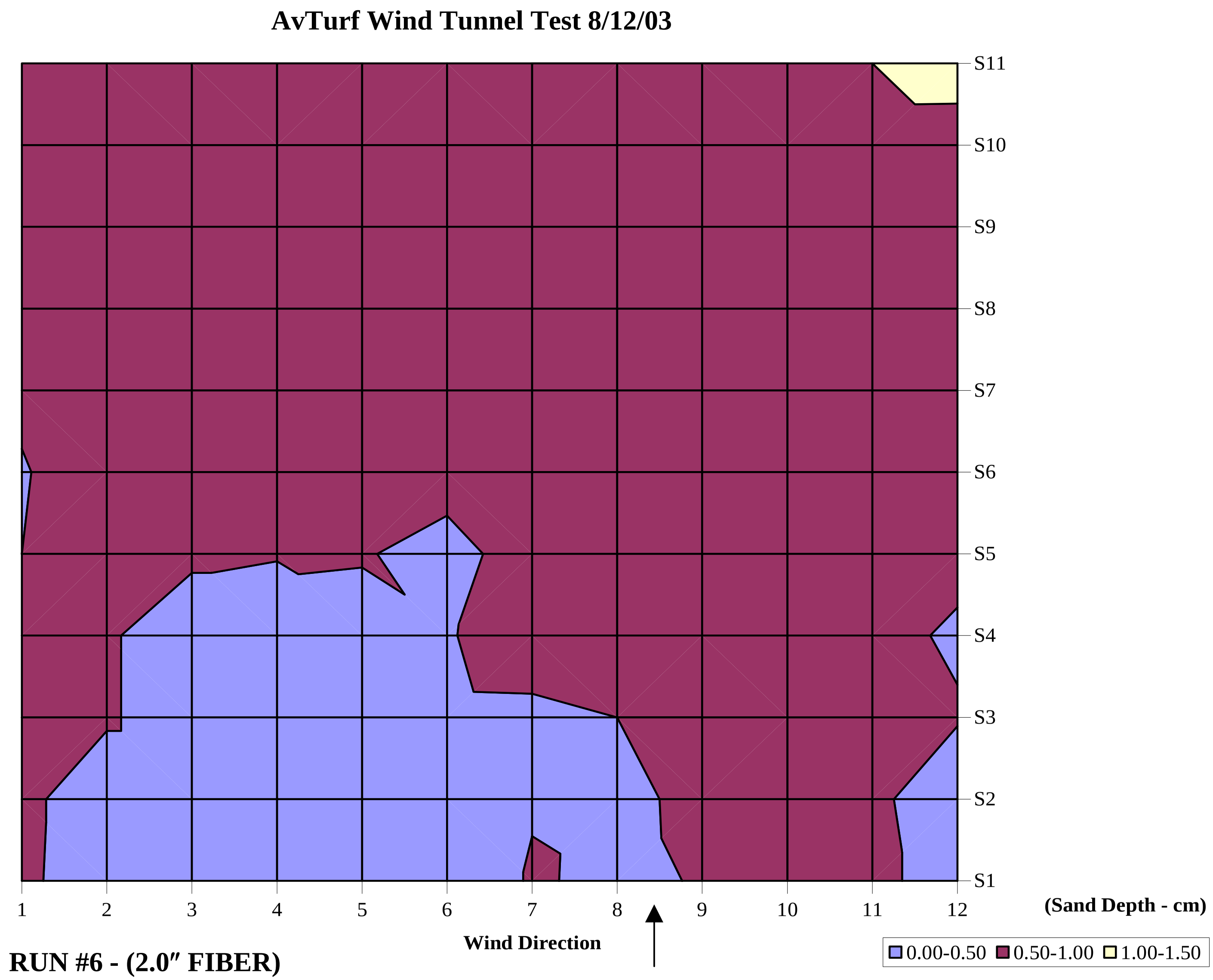



FIGURE C-11. RUN 6—1 MONTH AT 40 FEET

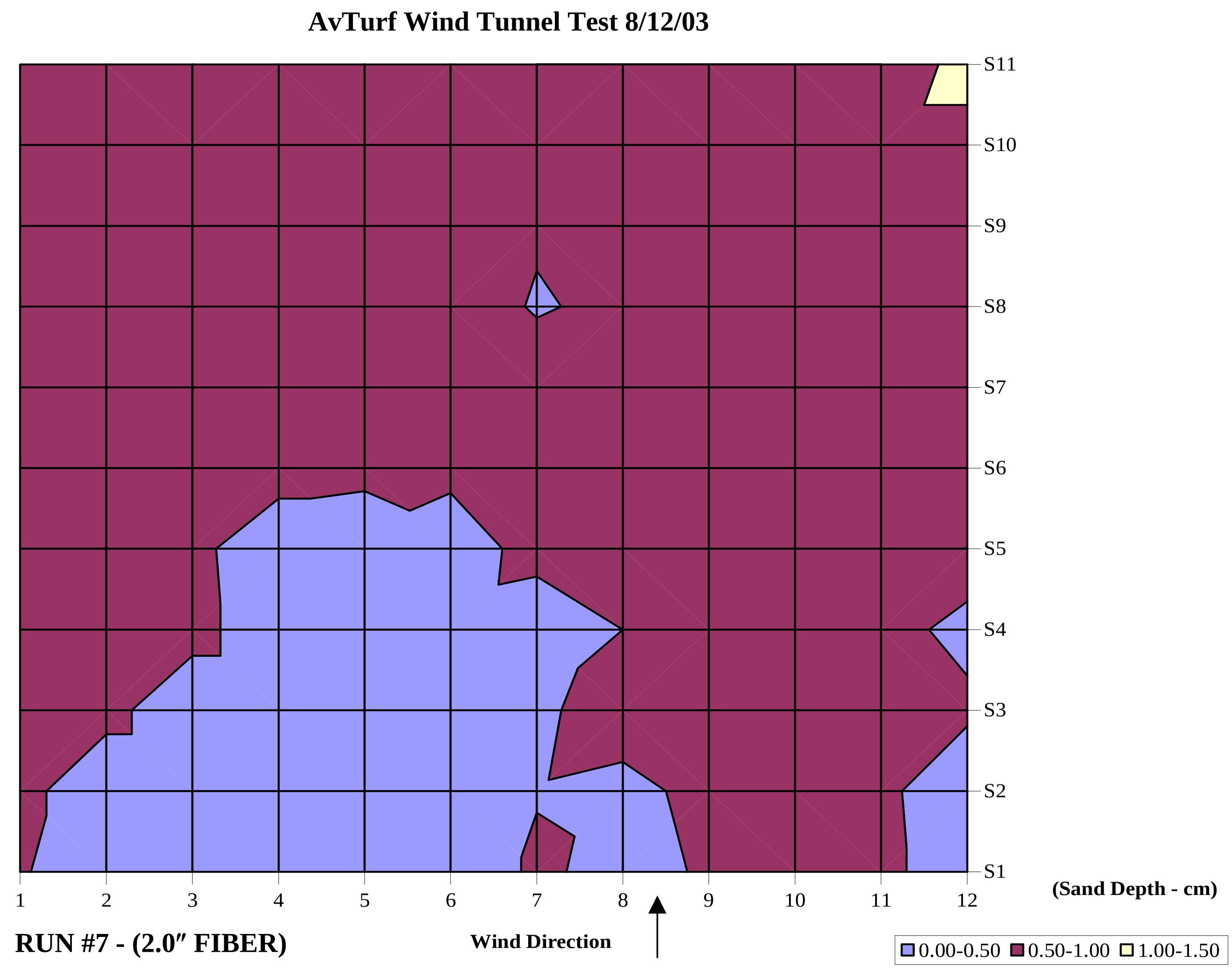



FIGURE C-12.  RUN 7—1 MONTH AT 40 FEET

## C.3.2 CONCLUSION.

It was determined that the AvTurf artificial turf product would experience heavy sand migration or removal (figures C-13 and C-14) from the artificial turf fibers between the fourth and fifth month at an airport that experienced aircraft traffic similar to LGA. It was noted that the artificial turf resonated up and down with no ballast sand. A possible explanation for the evacuation of the ballast sand is that the honeycomb fiber pattern is too wide and does not adequately trap the ballast sand.

FIGURE C-13. MEASURING CONE OUTLINE

FIGURE C-14. CONE SHAPE FROM MIGRATION OF SAND

## C.4 TEST 2A—AIR FIELDTURF 2.5-INCH FIBER.

### C.4.1 DESCRIPTION.

Figure C-15 shows the artificial turf used in this set of tests. The turf was divided in half perpendicularly with two different types of ballast sand. The left side of the platform contained pebble type infill about 0.25 inch in diameter. The right side of the platform contained the normal ballast sand used on previous tests. Both the pebbles and the sand infill came to the front edge of the test plot, parallel to the wind direction; a transition from pebble and sand is down the center of the test plot.

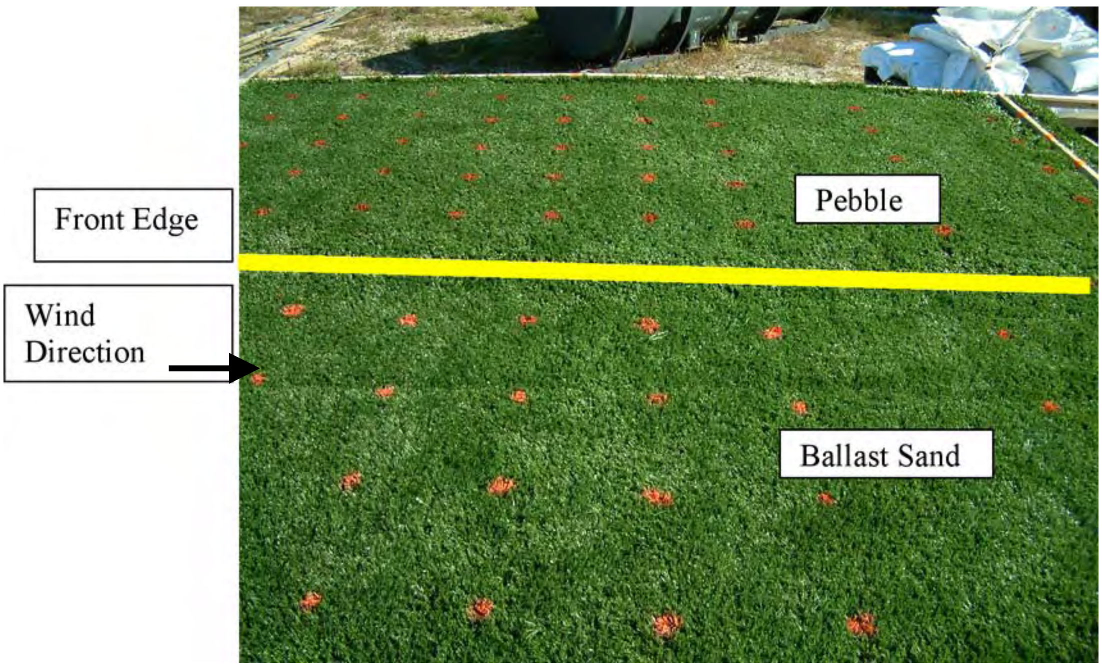



FIGURE C-15. TEST 2a—2.5-INCH FIBER TEST PLOT

Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths. A total of 7 rows and 11 columns were marked. The sixth column was the splitting point between the ballast sand infill and the pebble infill.

### C.4.2 RESULTS.

It was determined that the front edge of the artificial turf was not installed correctly (figure C-16). The systems front header was exposed and was weakened due to the wind speed (figure C-17). Since the test location did not mimic an actual installation, Air FieldTurf made a modification to the plot, and tests were resumed the following day.

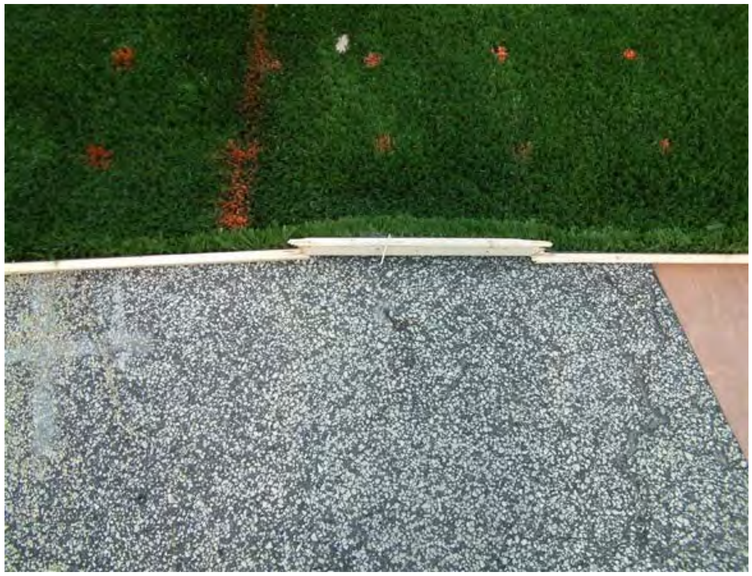


FIGURE C-16.  TEST 2a—2.5-INCH FIBER HEADER

FIGURE C-17.  TEST 2a—2.5-INCH FIBER TEST PLOT

## C.5  TEST 2b—AIR FIELDTURF 2.5-INCH FIBER

### C.5.1  DESCRIPTION.

The artificial turf used in this set of tests was divided in half perpendicularly with two different types of ballast sand (figure C-18).  The left side of the platform contained pebble type ballast (figure C-19), about 0.25 inch in diameter.  The pebble infill was used only for experimentation purposes.  Air FieldTurf wanted to see if the pebble ballast would remain in the turf.  Their intent was to use the pebble in noncritical areas, where there would be no chance of engine ingestion.

The right side of the platform contained the normal ballast sand used on previous tests (figure C-20). Figure C-21 shows a cross-sectional view of the 2.5-inch fiber test plot installation at the FAA William J. Hughes Technical Center wind tunnel.

FIGURE C-18. TEST 2b—2.5-INCH FIBER TEST PLOT (SECOND INSTALLATION)

FIGURE C-19. PEBBLE INFILL SIDE OF TEST PLOT

FIGURE C-20. BALLAST SAND INFILL SIDE OF TEST PLOT

Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths. A total of 7 rows and 11 columns were marked. The sixth column was the splitting point between the ballast sand infill and the pebble infill.

C.5.2 RESULTS.

- Baseline (figure C-22). The baseline depth of the pebble infill measured from 0.40 to 0.9 inch. The baseline depth of the ballast sand measured from 0.80 to 1.40 inches. The column that divided the sand and pebble measured from 0.5 to 1.0 inch.

- Run 1—1 Month at 75 feet (figure C-23). Once the test was completed, measurements were taken at the plot points on both sides. The depth of the pebble measured from 0.40 to 0.90 inch. The depth of the ballast sand measured from 0.90 to 1.45 inches. The column that divided the sand and pebble measured from 0.50 to 0.95 inch. Very minimal sand and pebble movement was noted. It was determined that the 2.5-inch fiber was successful at 75 ft.

- Run 2—1 Month at 40 feet (figure C-24). After the 75 ft test was conducted and measurements were taken, a 1-month test was conducted at 40 ft. There was no sand or pebble added to the artificial turf test plot. Once the test was completed, measurements were taken at the plot points on both sides. The depth of the pebble measured from 0.40 to 0.85 inch. The depth of the ballast sand measured from 0.8 to 1.45 inches. Very minimal sand and pebble movement was noted. It was determined that the 2.5-inch fiber was successful at 40 ft.

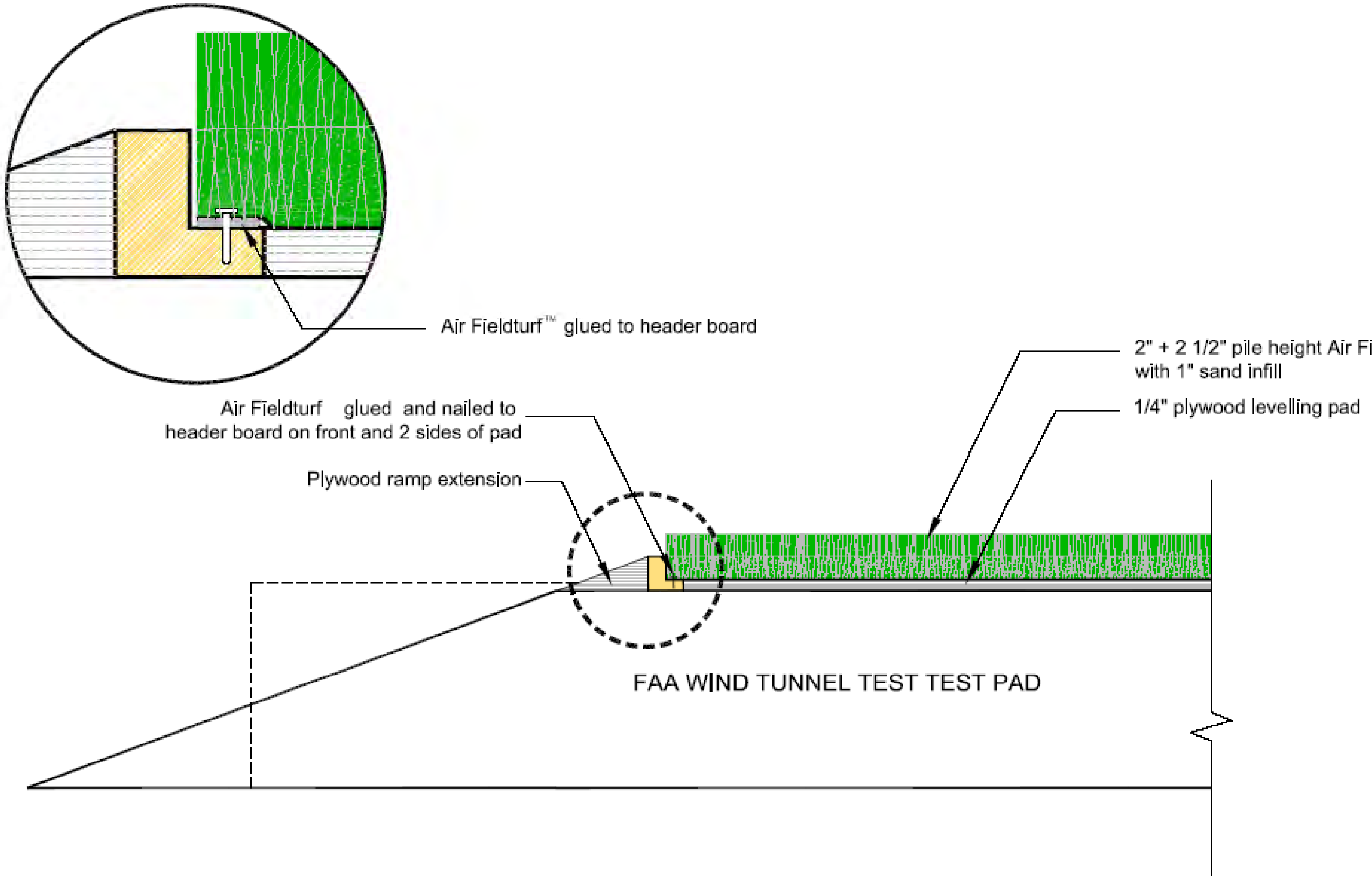



FIGURE C-21. AIR FIELDTURF ENGINEERING DRAWING FROM WIND TUNNEL, 2.5-INCH FIBER

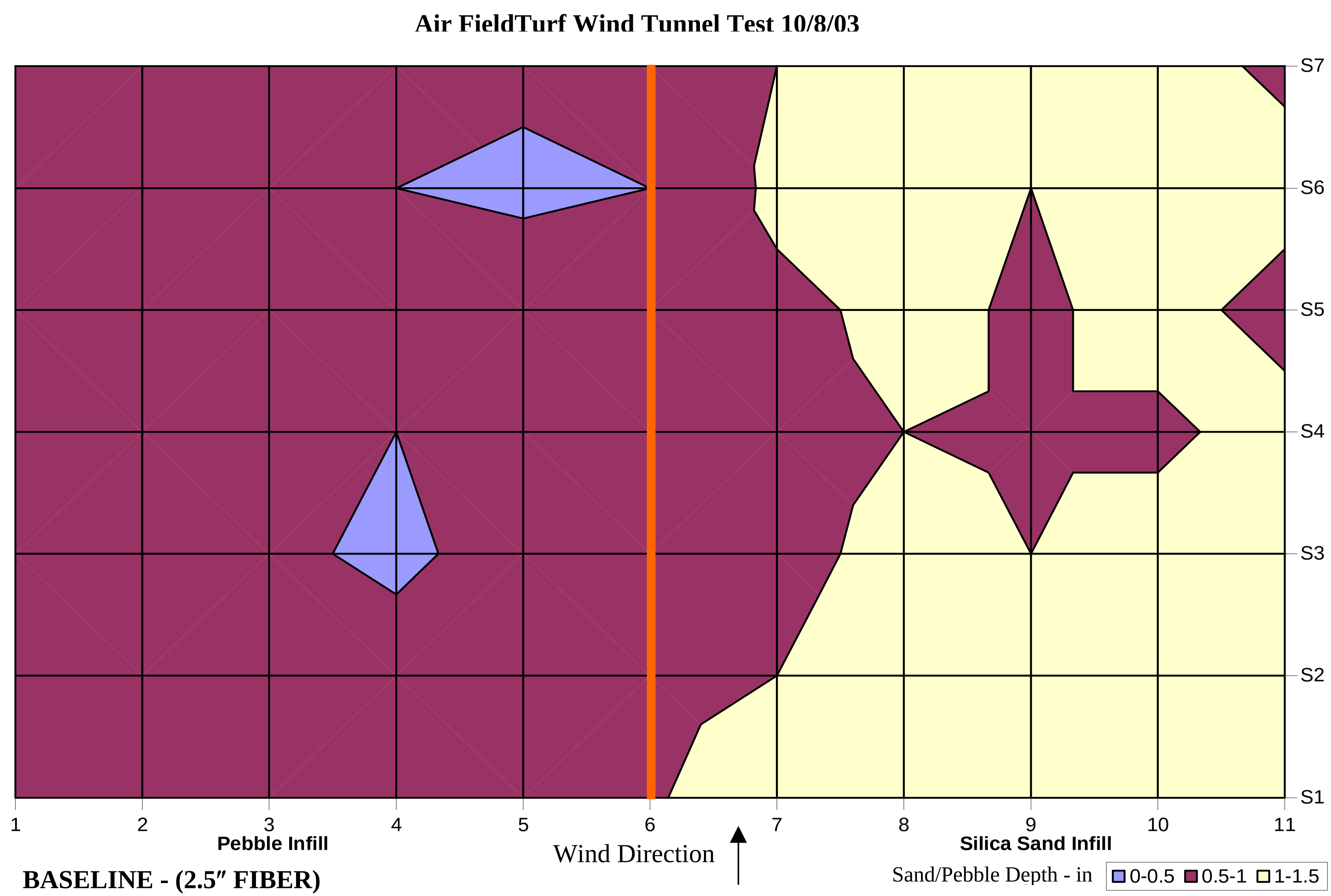
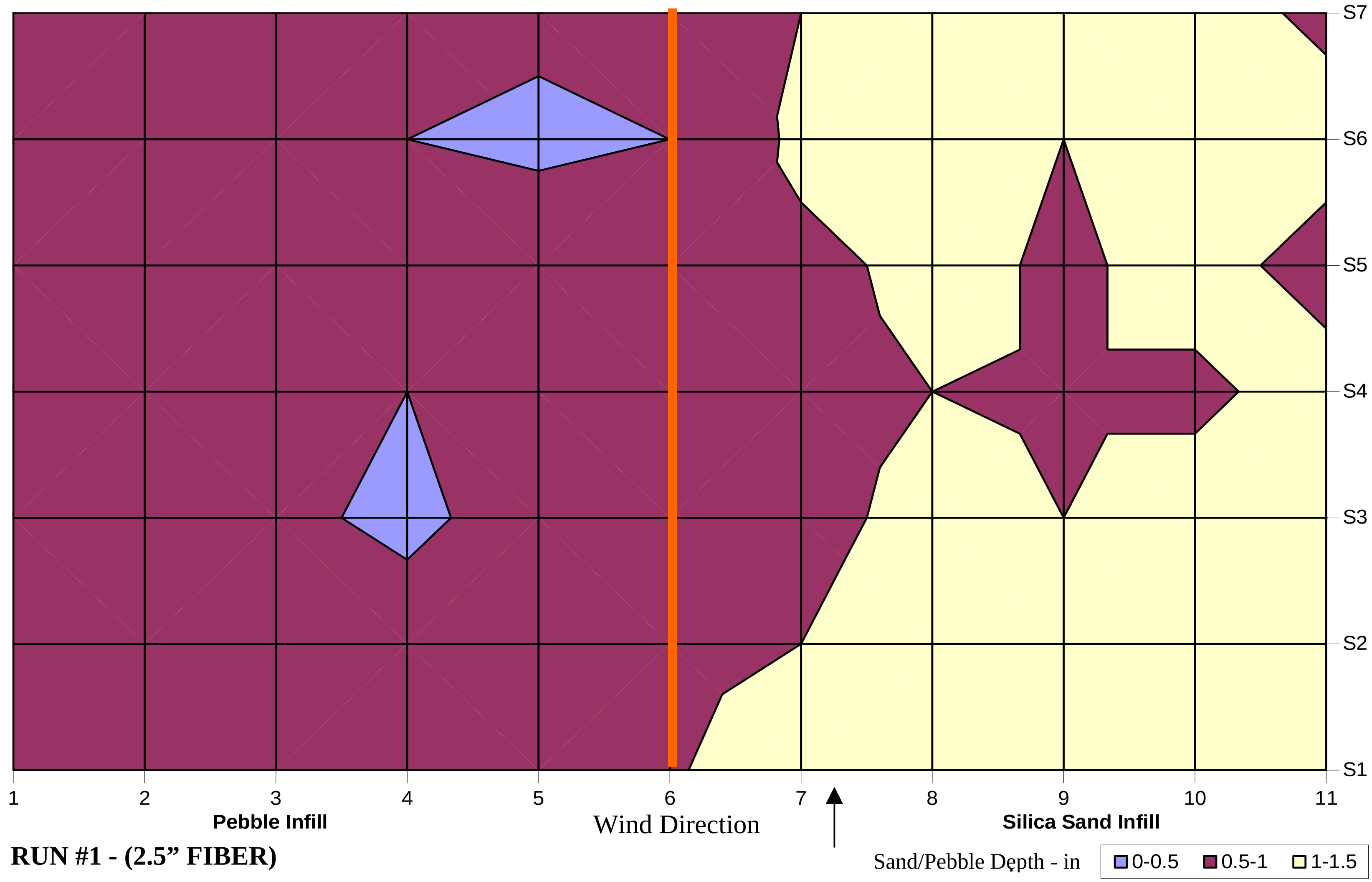



FIGURE C-22. TEST 2b—BASELINE LAYOUT

Air FieldTurf Wind Tunnel Test 10/8/03




RUN #1 - (2.5" FIBER)

FIGURE C-23. TEST 2b—RUN 1, 1 MONTH AT 75 FEET

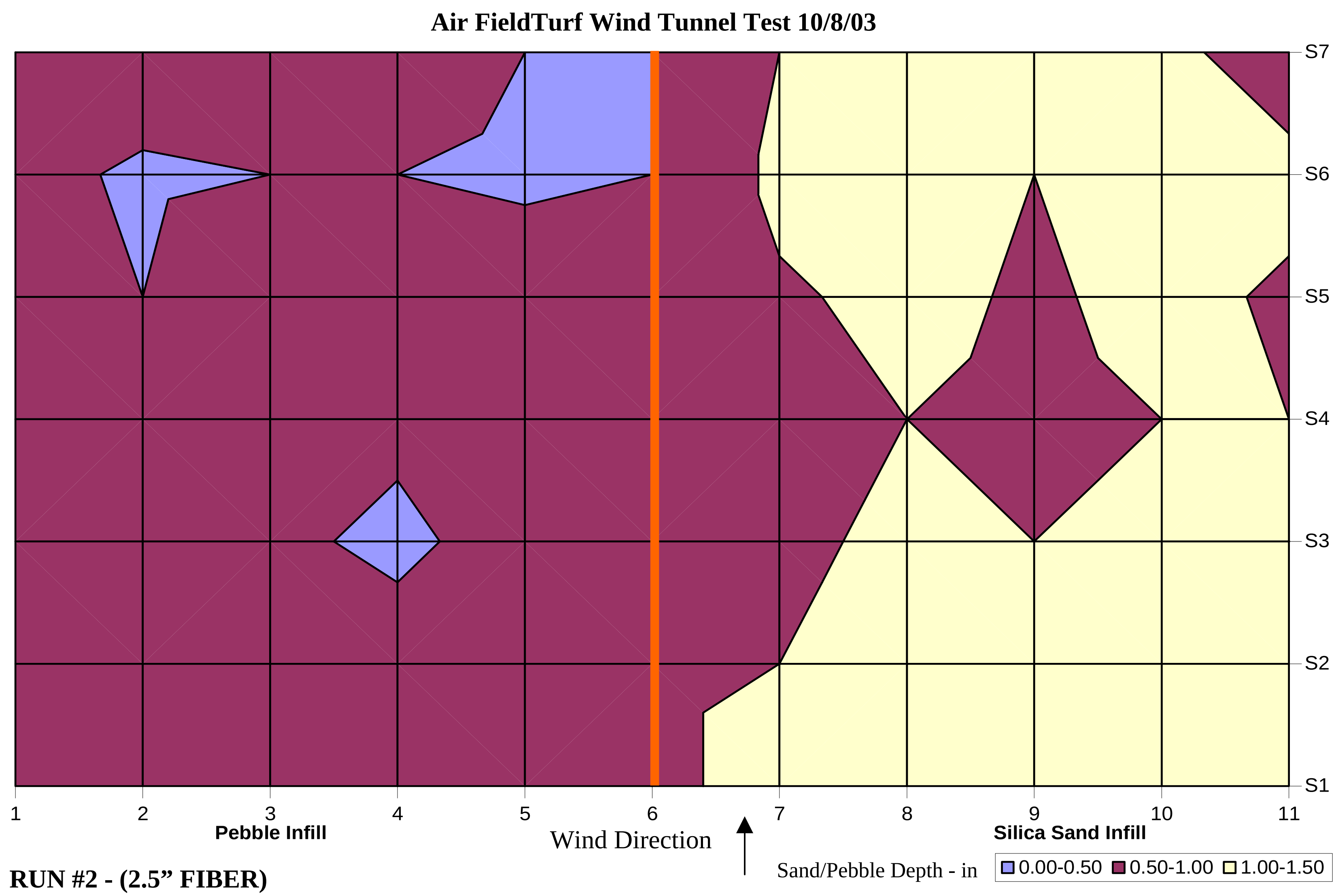



FIGURE C-24. TEST 2b—RUN 2, 1 MONTH AT 40 FEET

C.6 TEST 3—AIR FIELDTURF 2.0-INCH FIBER.

C.6.1 DESCRIPTION.

The artificial turf used in this set of tests was divided in half perpendicularly with two different types of ballast sand (figure C-25). The left side of the platform contained a pebble type infill, about 0.25 inch in diameter. The right side of the platform contained the normal ballast sand used on previous tests.

FIGURE C-25. TEST 3—2.0-INCH FIBER TEST PLOT

Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths. A total of 7 rows and 11 columns were marked. The sixth column was the splitting point between the ballast sand infill and the pebble infill. Figure C-26 shows a cross-sectional view of the 2.0-inch fiber test plot installation at the wind tunnel.

C.6.2 RESULTS.

- Baseline (figure C-27). The baseline sand depth of the pebble measured from 0.70 to 1.10 inches. The baseline depth of the ballast sand measured from 0.70 to 1.20 inches.

- Run 1—1 Month at 75 ft (figure C-28). Once the test was completed, measurements were taken at the plot points on both sides. The depth of the pebble measured from 0.55 to 1.00 inch. The depth of the ballast sand measured from 0.70 to 1.10 inches. The column that divided the sand and pebble measured from 0.65 to 1.0 inch. Very minimal sand and pebble movement was noted. It was determined that the 2.0-inch fiber was successful at 75 ft.

- Run 2—1 Month at 40 ft (figure C-29). After the 75-ft test was conducted and measurements were taken, a 1-month test was conducted at 40 ft. There was no sand or pebble added to the artificial turf test plot. Once the test was completed, measurements were taken at the plot points on both sides. The depth of the pebble measured from 0.70 to 1.20 inches. The depth of the ballast sand measured from 0.65 to 1.10 inches. Very minimal sand and pebble movement was noted. It was determined that the 2.0-inch fiber was successful at 40 ft.

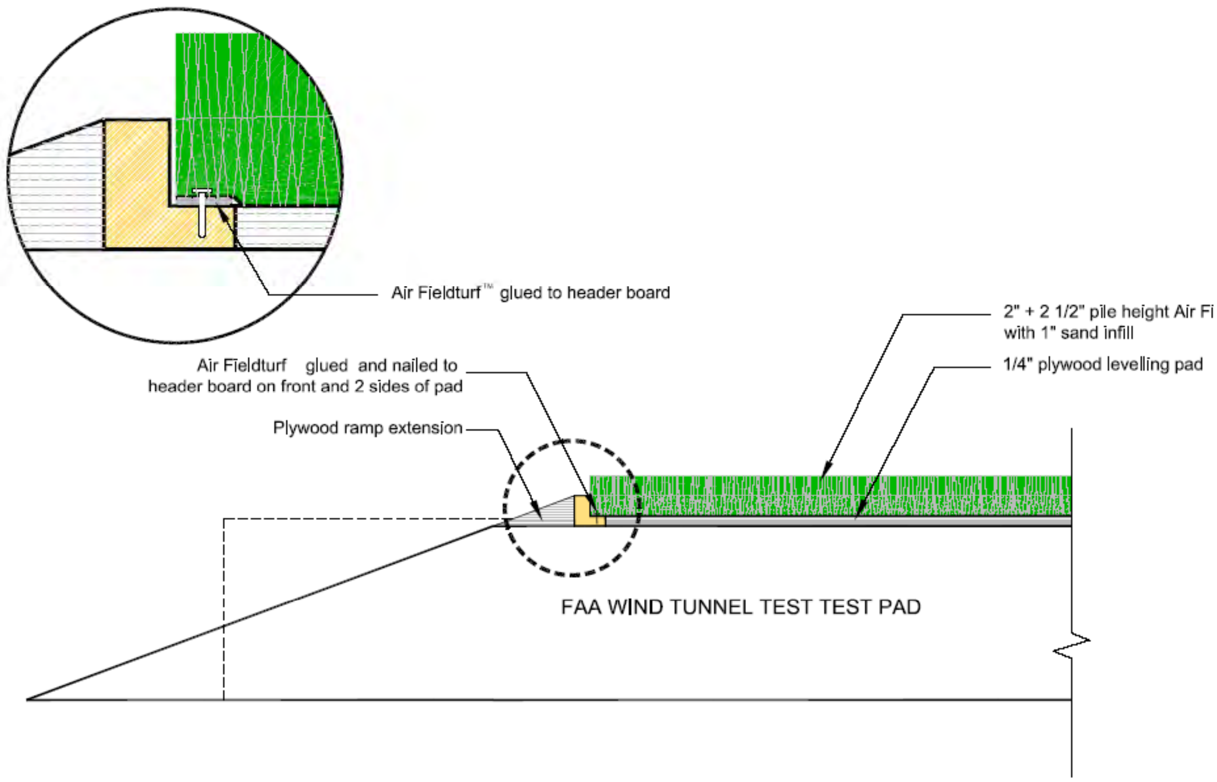



FIGURE C-26. AIR FIELDTURF ENGINEERING DRAWING FROM WIND TUNNEL 2.0-INCH FIBER

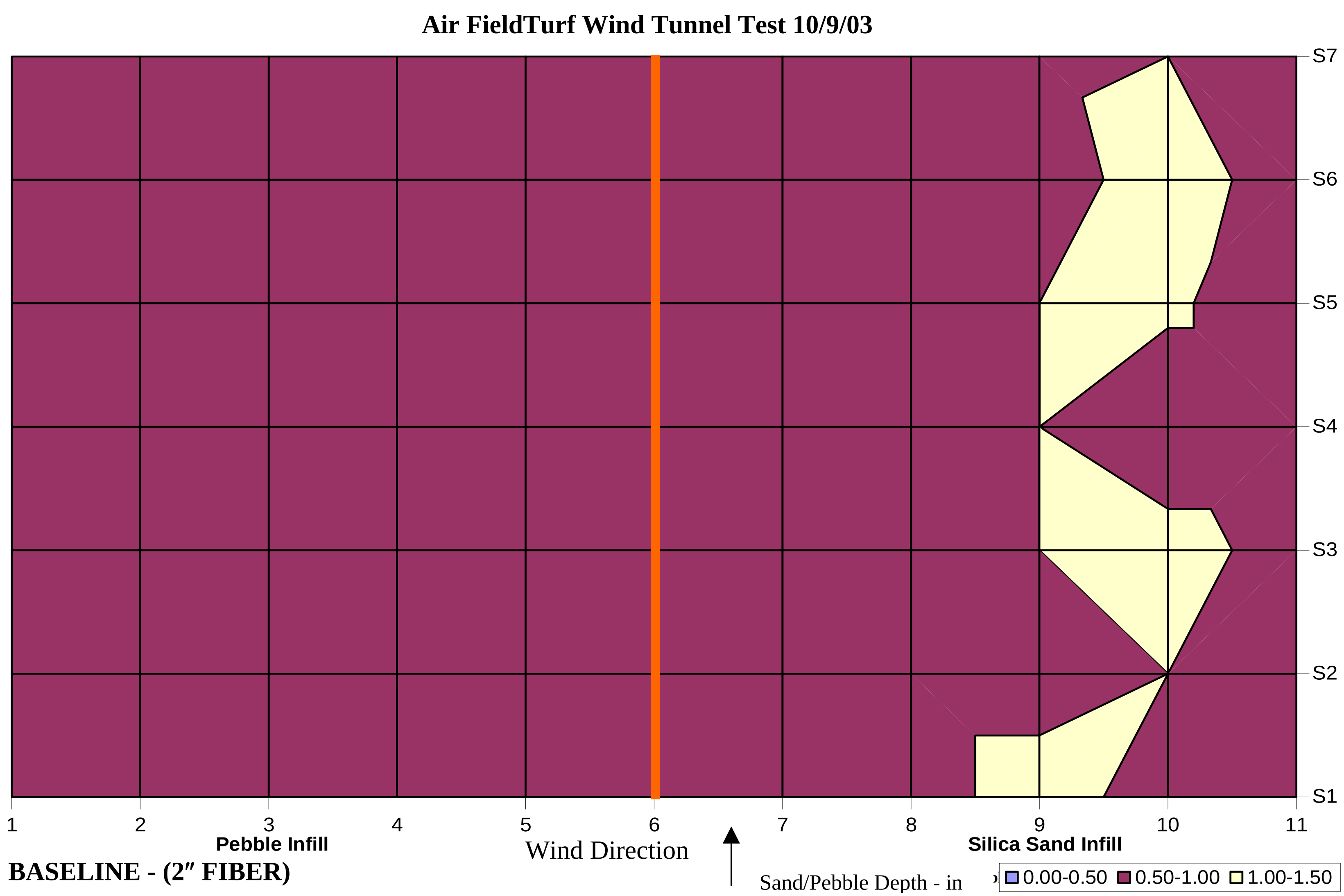



FIGURE C-27. TEST 3—BASELINE LAYOUT

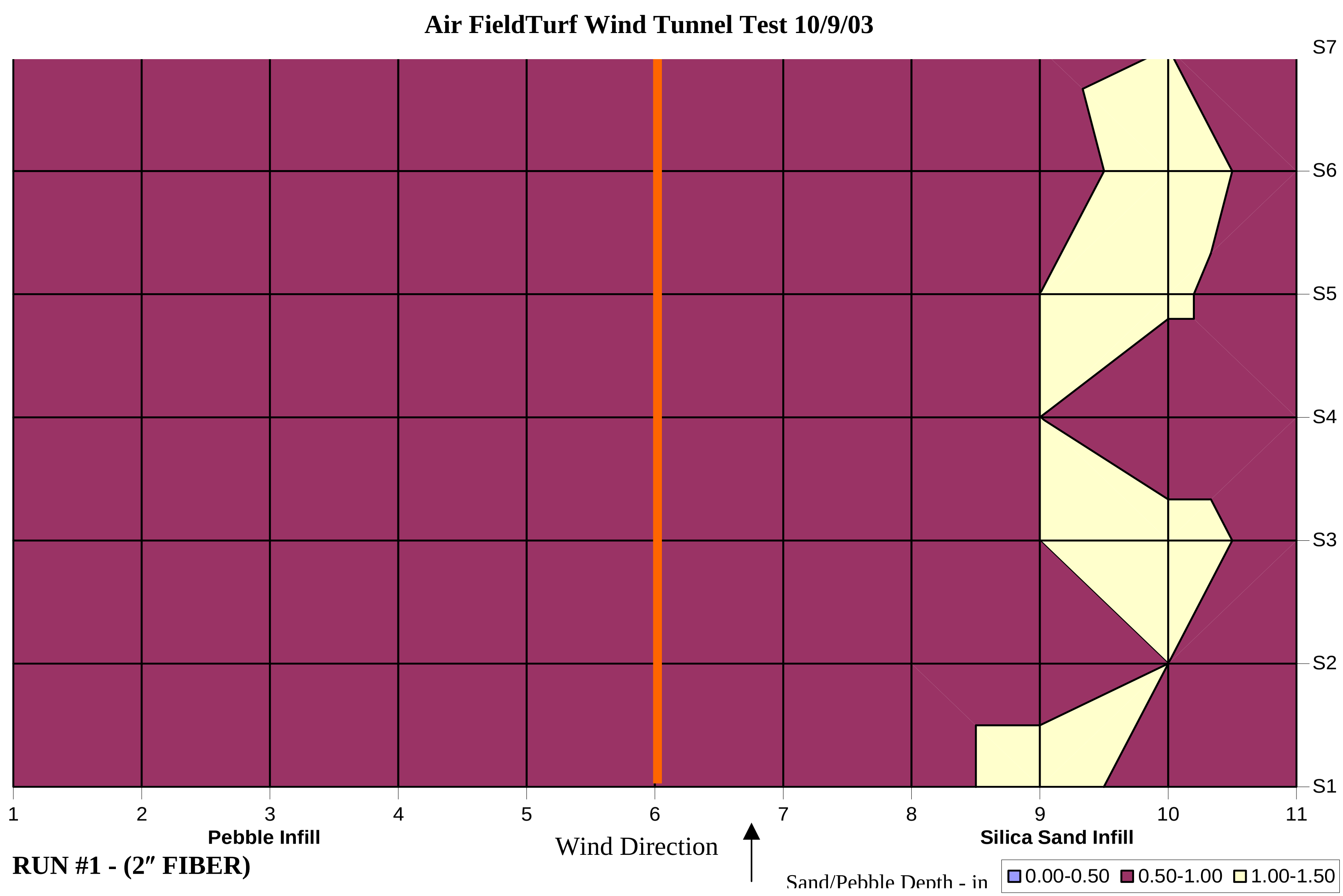
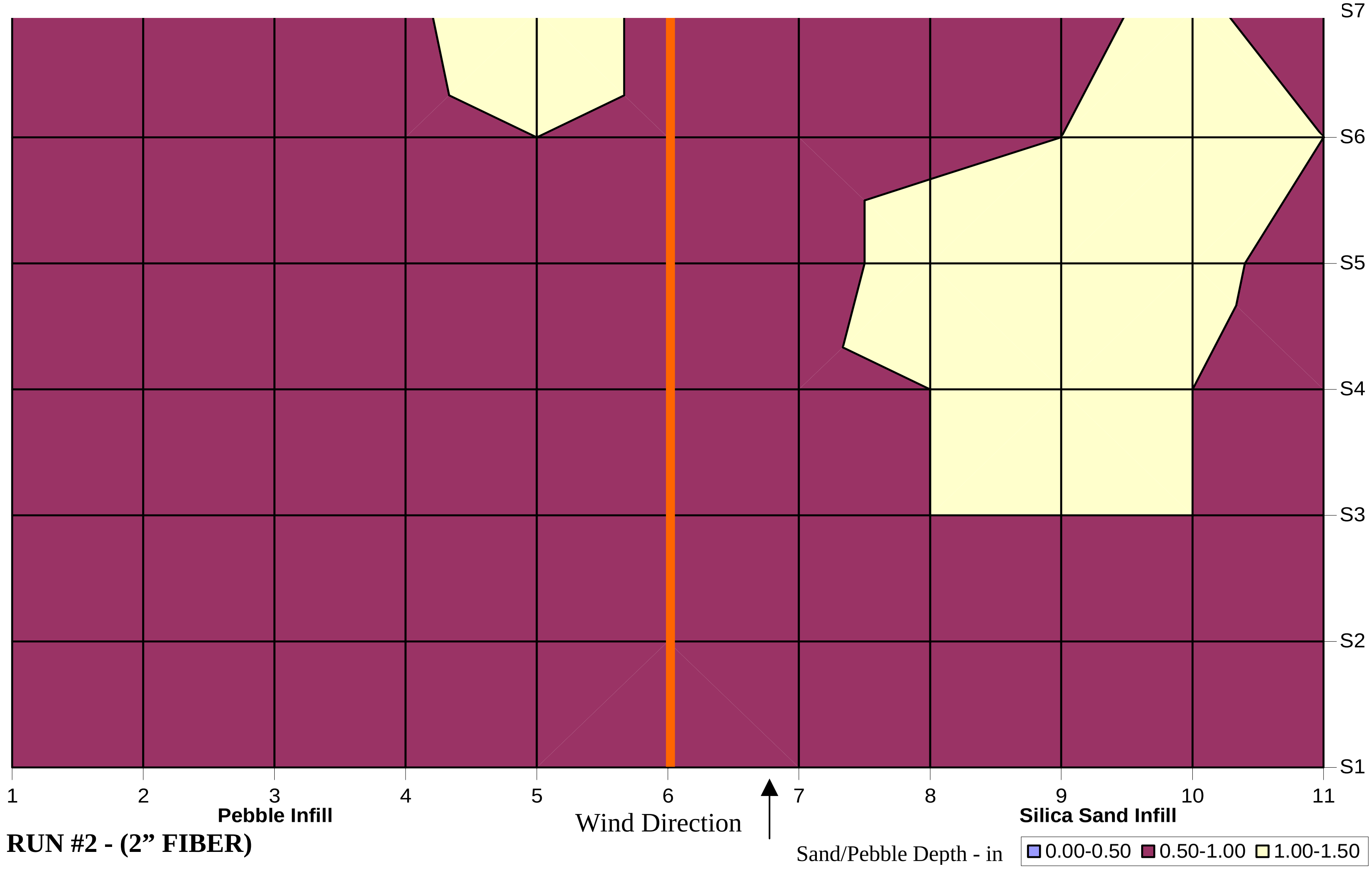



FIGURE C-28. TEST 3—RUN 1, 1 MONTH AT 75 FEET

Air FieldTurf Wind Tunnel Test 10/9/03




RUN #2 - (2” FIBER)

FIGURE C-29. TEST 3—RUN 2, 1 MONTH AT 40 FEET

## C.7 TEST 4—AIR FIELDTURF 1.0-INCH FIBER.

### C.7.1 DESCRIPTION.

An experiment was conducted to determine how short a fiber length could be and still retain the ballast sand (figure C-30). A test was performed on a 1-inch fiber at 75 ft from the runway to determine how the artificial turf fibers retained the ballast sand.

FIGURE C-30. THE 1.0-INCH TEST PLOT

Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths. A total of 3 rows and 7 columns were marked. Figure C-31 shows a cross-sectional view of the 1.0-inch fiber test plot installation at the wind tunnel.

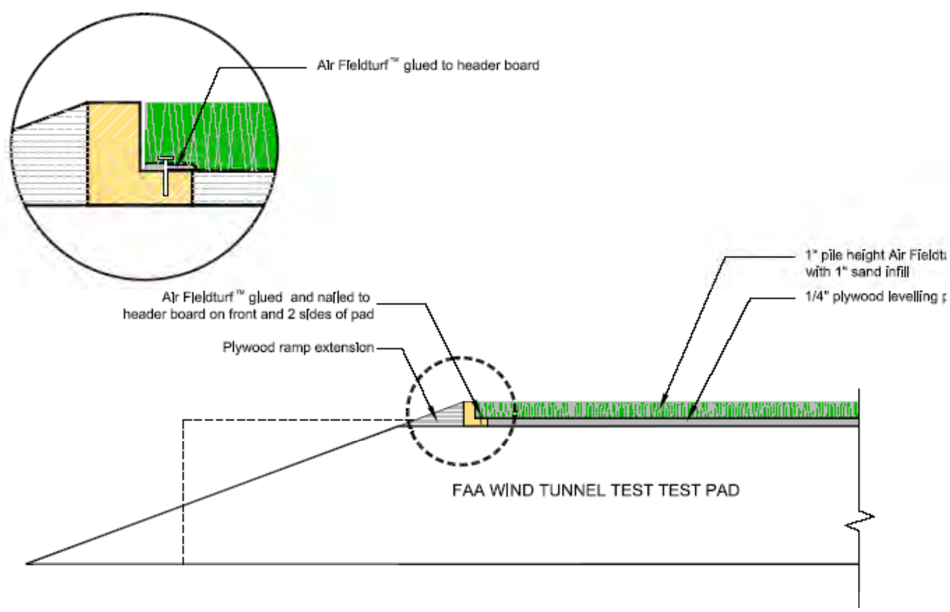



FIGURE C-31. AIR FIELDTURF ENGINEERING DRAWING FROM WIND TUNNEL, 1.0-INCH FIBER

C.7.2 RESULTS.

After the first few cycles of test one it became evident that the fiber was too short to retain any of the ballast sand (figure C-32). The 1-inch fiber was determined to be unsuccessful.

FIGURE C-32. TEST 4—1.0-INCH FIBER TEST PLOT

C.8 TEST 5—AIR FIELDTURF 1.5-INCH FIBER.

C.8.1 DESCTIPTION.

The test was performed at 75 ft from the runway to determine how the artificial turf fibers retained the ballast sand (figures C-33 and C-34). Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths; a total of 3 rows and 7 columns were marked.

FIGURE C-33. TEST 5—1.5-INCH FIBER TEST PLOT

FIGURE C-34. TEST 5—1.5-INCH FIBER TEST PLOT AFTER TESTS

Note: When measuring the baseline depths of ballast sand, it was discovered that the right most portion of the test plot (rows 5-7) were frozen. Once the test was performed, the frozen areas thawed, thus allowing for a more accurate depth reading.

C.8.2 RESULTS.

- Baseline (figure C-35). The baseline depth of the ballast sand measured from 0.75 to 1.30 inches. Rows 6-7 were frozen, so no measurements were recorded.

- Run 1—1 Month at 75 ft (figure C-36). Once the test was completed, measurements were taken at the plot points. The depth of the ballast sand measured from 0.70 to 1.40 inches. Very minimal sand movement was noted. It was determined that the 1.5-inch fiber was successful for 1 month at 75 ft.

- Run 2—1 Month at 75 ft (figure C-37). A second 1-month test was performed at 75 ft to determine if the 1.5-inch artificial turf fibers would no longer retain the ballast sand. No sand was added to the turf. Once the test was completed, measurements were taken at the plot points. The depth of the ballast sand measured from 0.50 to 1.25 inches. Very minimal sand movement was noted. It was determined that the 1.5-inch fiber was successful for a second 1-month test at 75 ft. Figure C-38 shows a cross-sectional view of the 1.5-inch fiber test plot installation at the wind tunnel.

**Air FieldTurf Wind Tunnel Test 02/04/04**

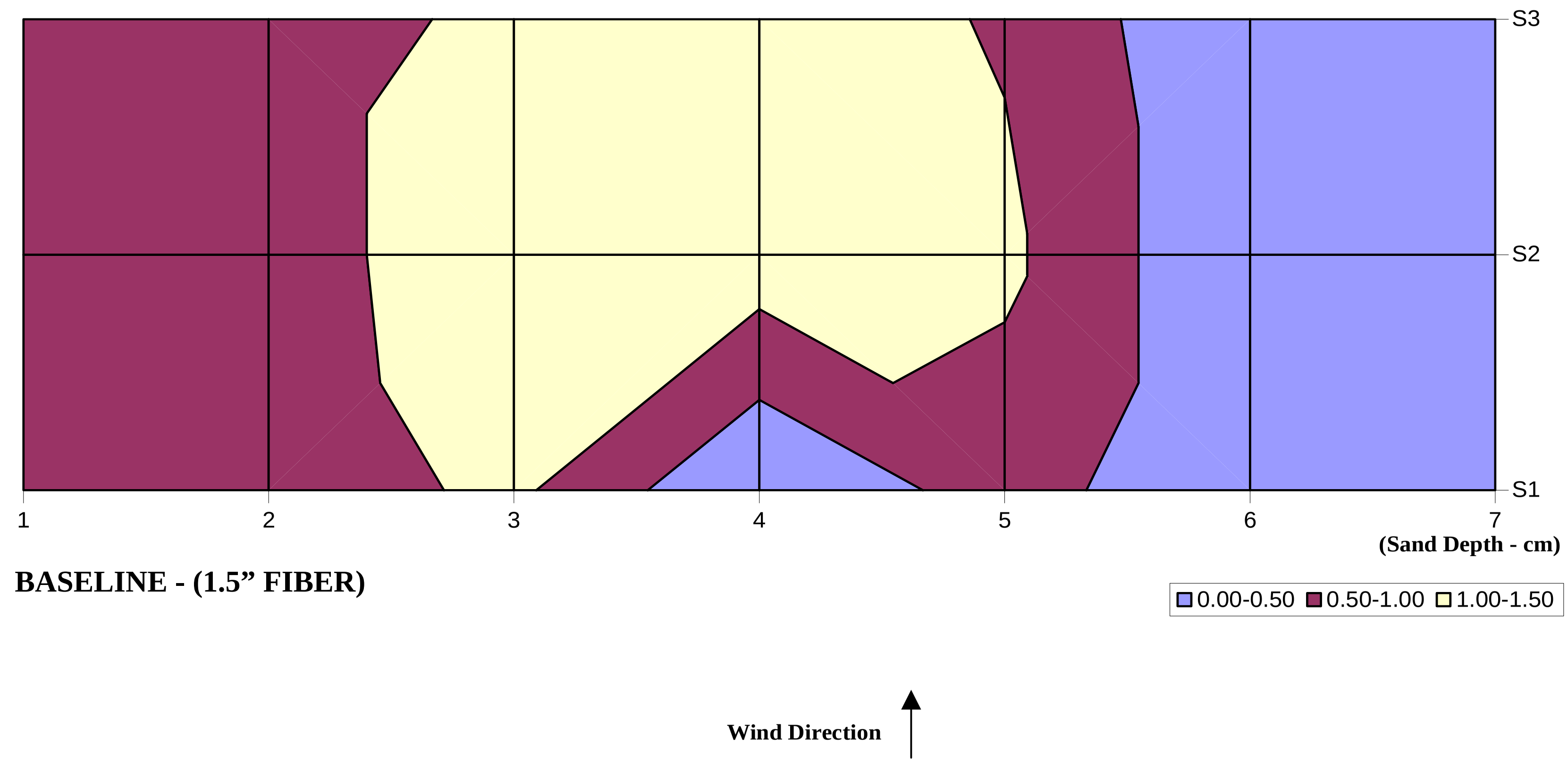
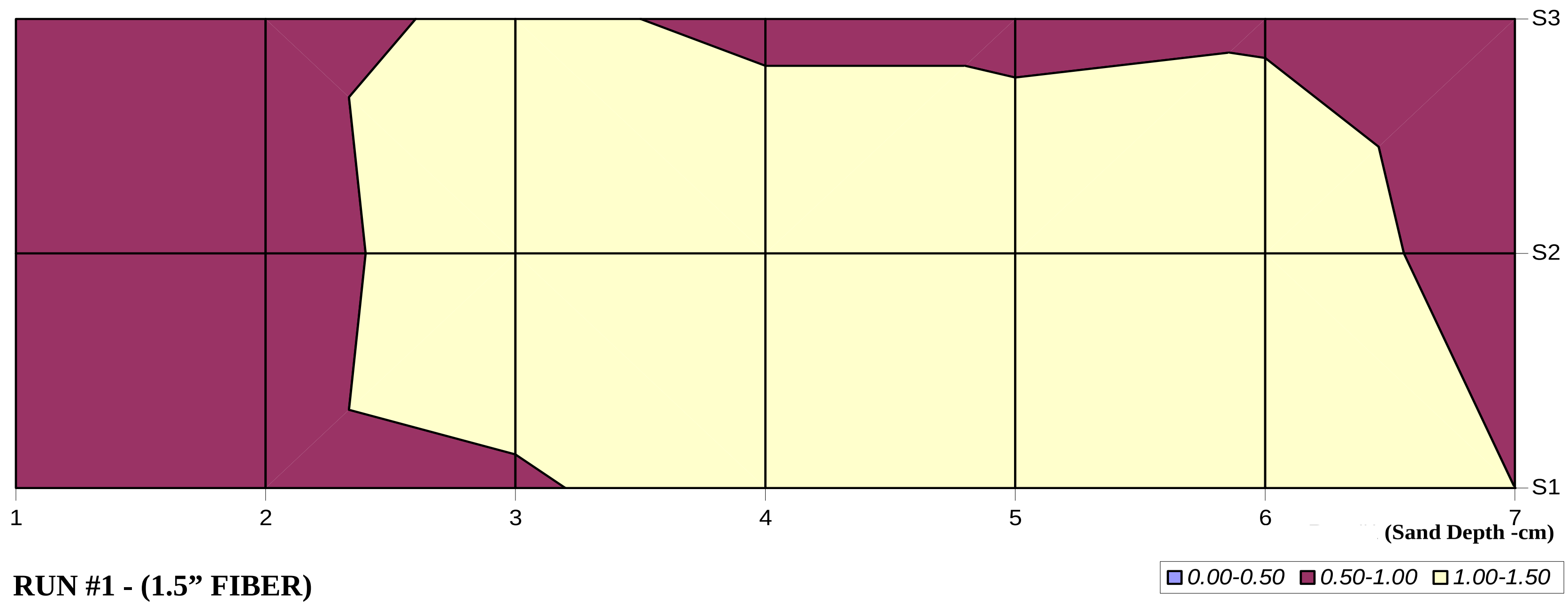



FIGURE C-35. TEST 5—BASELINE LAYOUT

## Air FieldTurf Wind Tunnel Test 02/04/04




**RUN #1 - (1.5” FIBER)**

**Wind Direction**

FIGURE C-36. TEST 5—RUN 1, 1 MONTH AT 75 FEET

# Air FieldTurf Wind Tunnel Test 02/04/04

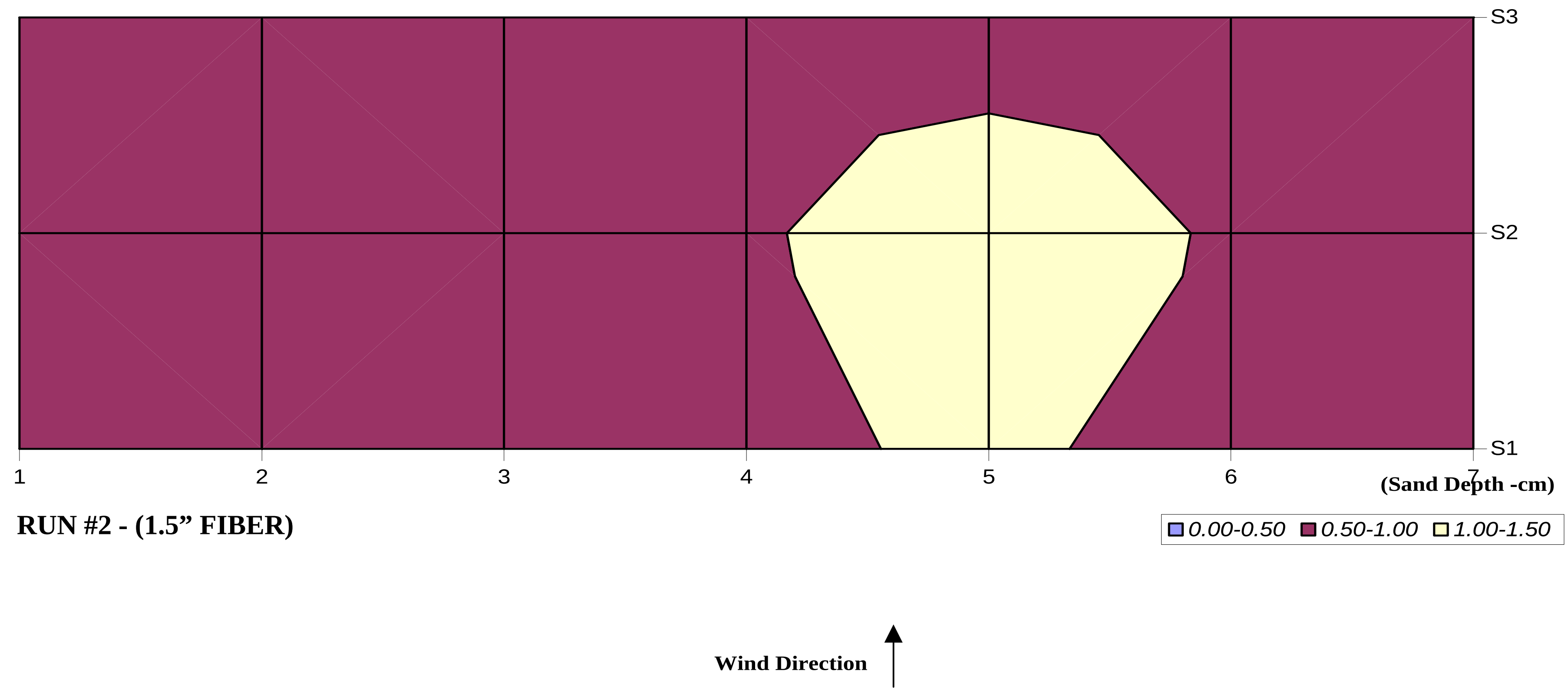



FIGURE C-37.  TEST 5—RUN 2, 1 MONTH AT 75 FEET

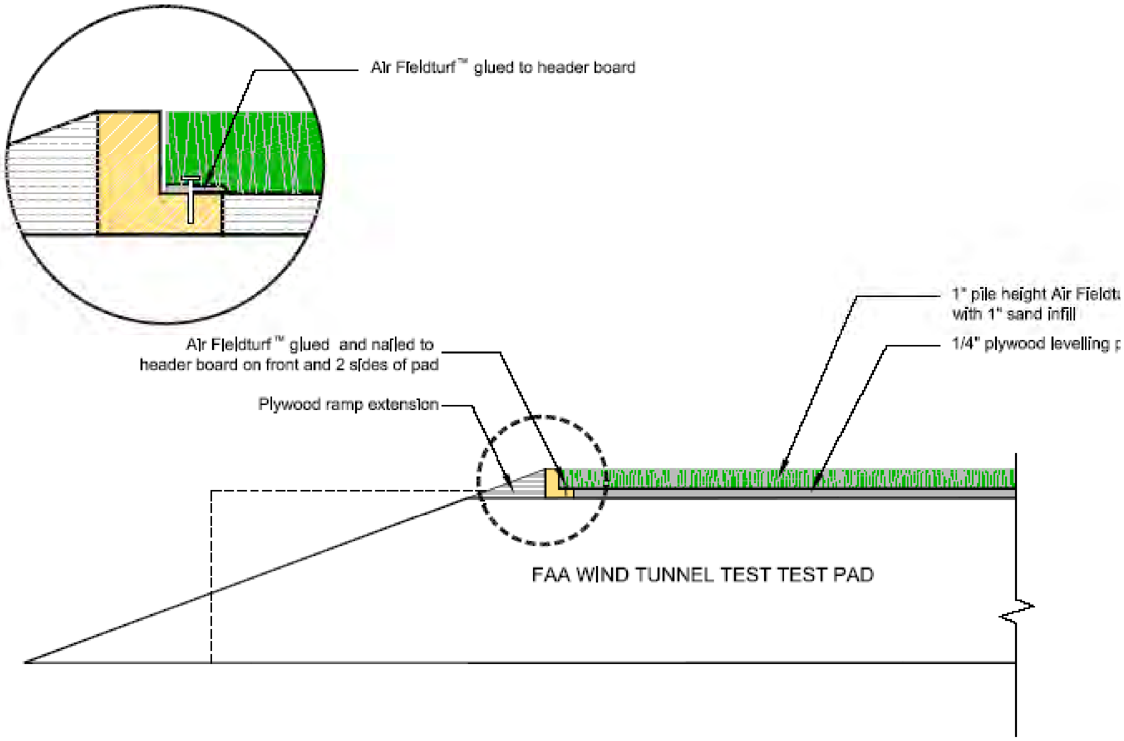



FIGURE C-38. AIR FIELDTURF ENGINEERING DRAWING FROM WIND TUNNEL, 1.5-INCH FIBER

## C.9 TEST 6—AIR FIELDTURF 2.0-INCH FIBER GLUED TO CONCRETE SURFACE (NO INFILL).

To test the glued concrete application for the artificial turf, a 12- by 12-ft concrete slab 4 inches thick was poured on top of the existing test pad (figure C-39). Once the concrete was dried, the surface was acid washed with an industrial-grade citric acid. After the acid wash was complete, the concrete pad was scored with two 2-inch-deep lines across the test pad. The artificial turf that was glued to the concrete did not have any sand infill; the purpose of the wind tunnel test was to check the ability of the glue to hold the artificial turf in place during high wind speeds. The glued artificial turf application had two different header systems along the front edge of the test pad; each header was 6 ft wide, dividing the pad in the half. On the left side of the pad, a quick-drying concrete header was set up (figure C-40). On the right side of the pad, a flexible rubber header was attached to the turf (figure C-41).

A seven-cycle test at 40 ft was conducted to check the adhesion of the glue to the concrete and artificial turf. After the cycles were completed, the turf was checked by pulling up on the turf to see if it was still adhered to the concrete. It was determined that the glue would hold the turf, but a long-term analysis must be done to see how the glue holds up over time.

FIGURE C-39. APPLICATION OF ARTIFICIAL TURF TO CONCRETE

FIGURE C-40. THE 2.0-INCH FIBER WITH QUICK-DRYING CONCRETE HEADER

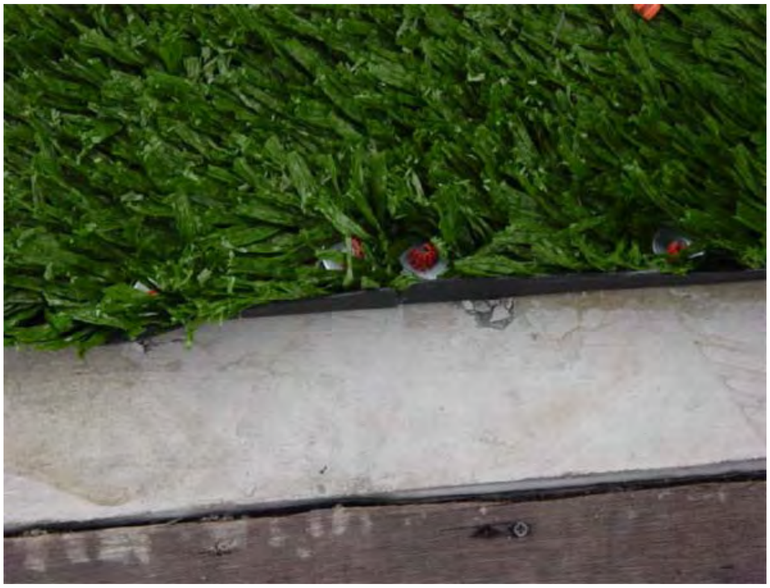


FIGURE C-41.  THE 2.0-INCH FIBER WITH RUBBER HEADER

## C.10  TEST 7—AIR FIELDTURF 2.0-INCH FIBER GLUED TO CONCRETE SURFACE (WITH INFILL).

### C.10.1  DESCRIPTION.

A 16-cycle test was conducted to experiment with the ballast sand infill for the concrete surface glued application (figure C-42).  The purpose of the test was to determine if the ballast sand would remain in the turf glued to the surface, as opposed to the turf installation being even with the ground.

FIGURE C-42.  THE 2.0-INCH FIBER TEST PLOT

Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths; a total of 3 rows and 11 columns were marked (figures C-43 and C-44). Figures C-45 and C-46 show a cross-sectional view of the 2.0-inch fiber test plot with the two different headers installed at the wind tunnel.

FIGURE C-43. TEST 7—2.0-INCH FIBER TEST PLOT AFTER TESTS

FIGURE C-44. TEST 7—2.0-INCH FIBER TEST PLOT AFTER TESTS, CLOSE-UP

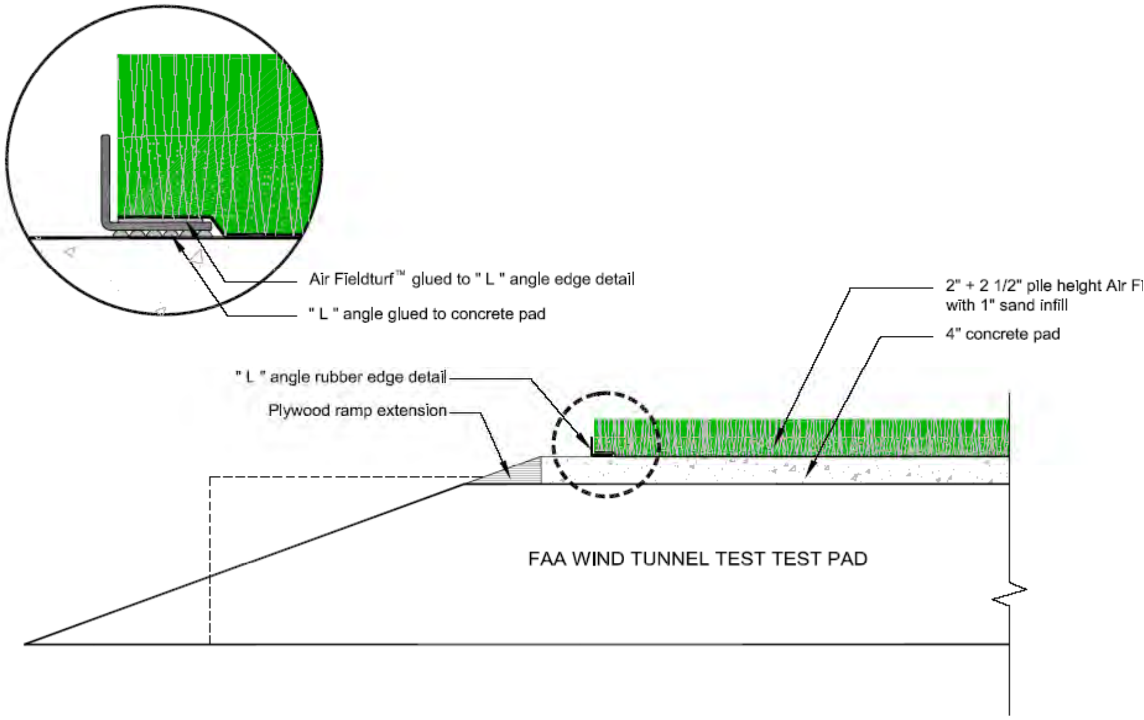



FIGURE C-45. AIR FIELDTURF ENGINEERING DRAWING FROM GLUE DOWN TEST, 2.0-INCH FIBER WITH L ANGLE EDGE

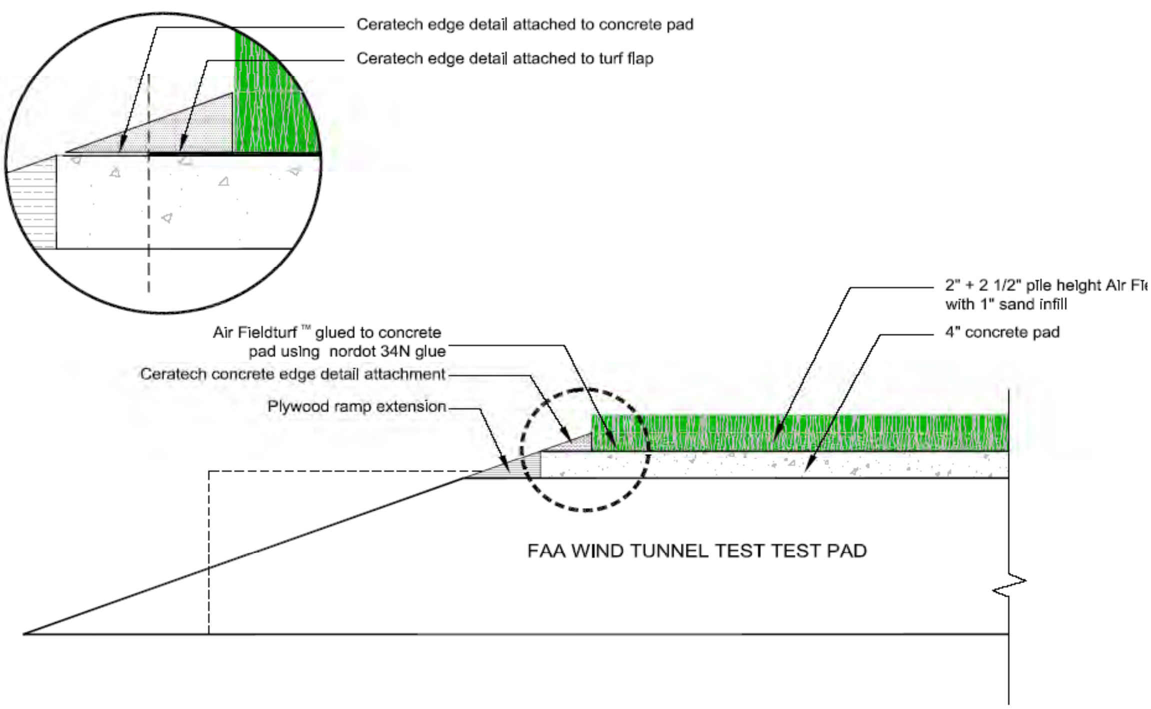



FIGURE C-46. AIR FIELDTURF ENGINEERING DRAWING FROM GLUE DOWN TEST, 2.0-INCH FIBER WITH CERATECH EDGE

C.10.2 RESULTS.

- Baseline (figure C-47). The baseline depth of the ballast sand measured from 0.75 to 1.30 inches.

- Run 1—Eight cycles at 40 ft (figure C-48). Once the test was completed, measurements were taken at the plot points. The depth of the ballast sand measured from 0.40 to 1.35 inches. Very minimal sand movement was noted. It was determined that the glued 2.0-inch fiber was successful for eight cycles at 45 ft.

- Run 2—Eight cycles at 40 ft (figure C-49). A second eight-cycle test was performed at 40 ft to determine if the 2.0-inch glued artificial turf fibers would no longer retain ballast sand. No sand was added to the turf. Once the test was completed, measurements were taken at the plot points. The depth of the ballast sand measured from 0.50 to 1.25 inches. Very minimal sand movement was noted. It was determined that the 2.0-inch fiber was successful for the second eight-cycle test at 40 ft.

## Air FieldTurf Wind Tunnel Test 03/10/04

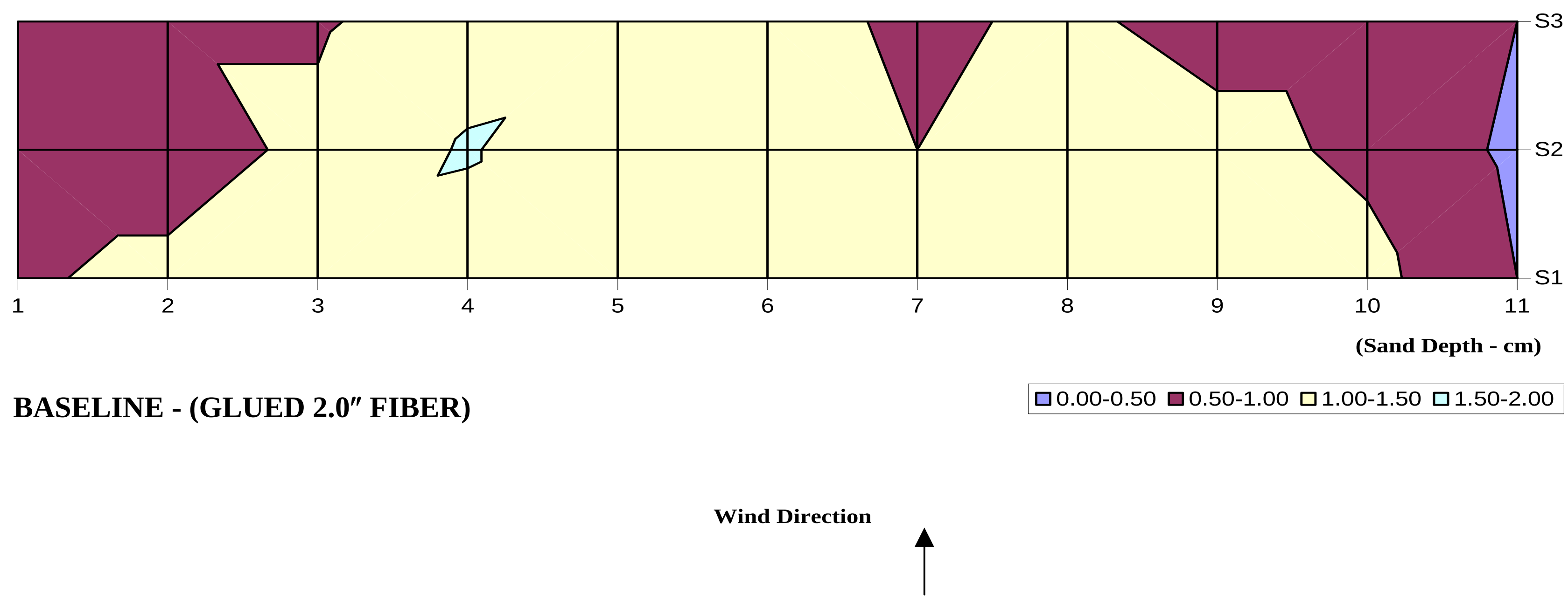



FIGURE C-47. TEST 7—BASELINE LAYOUT

**Air FieldTurf Wind Tunnel Test 03/010/04**

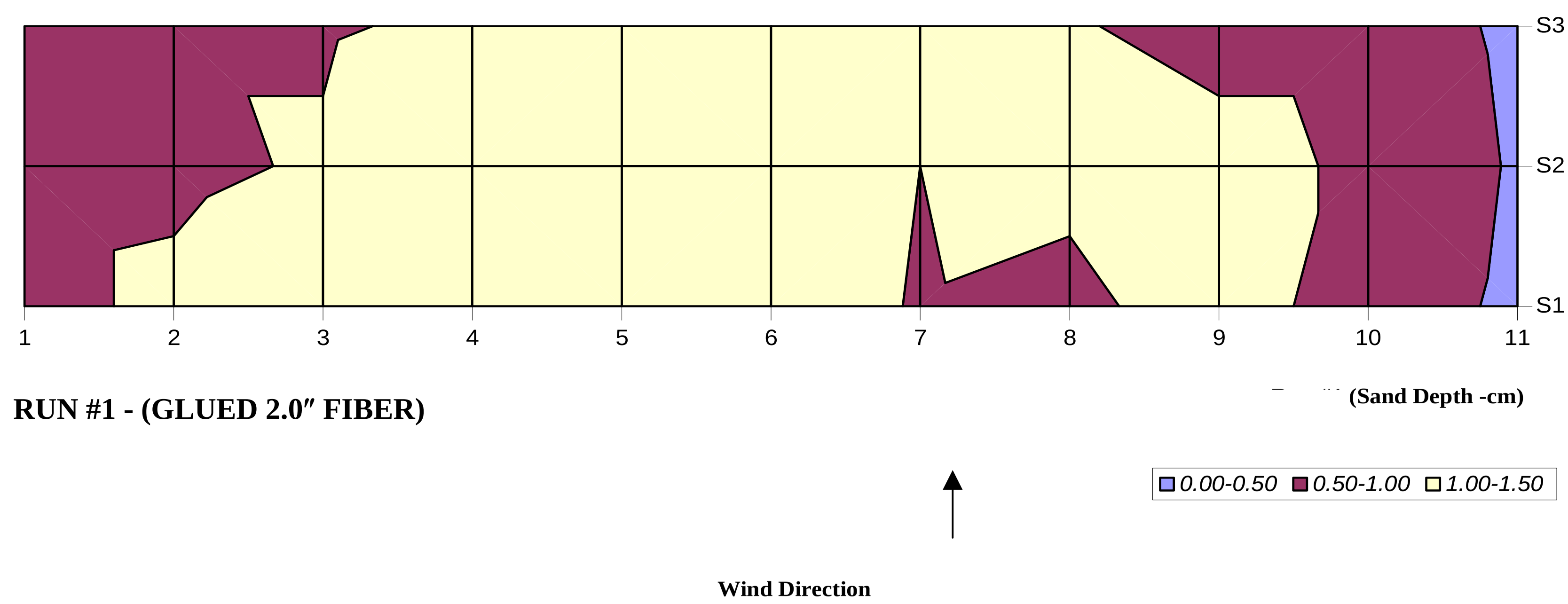



FIGURE C-48. TEST 7—RUN 1, EIGHT CYCLCES AT 40 FEET

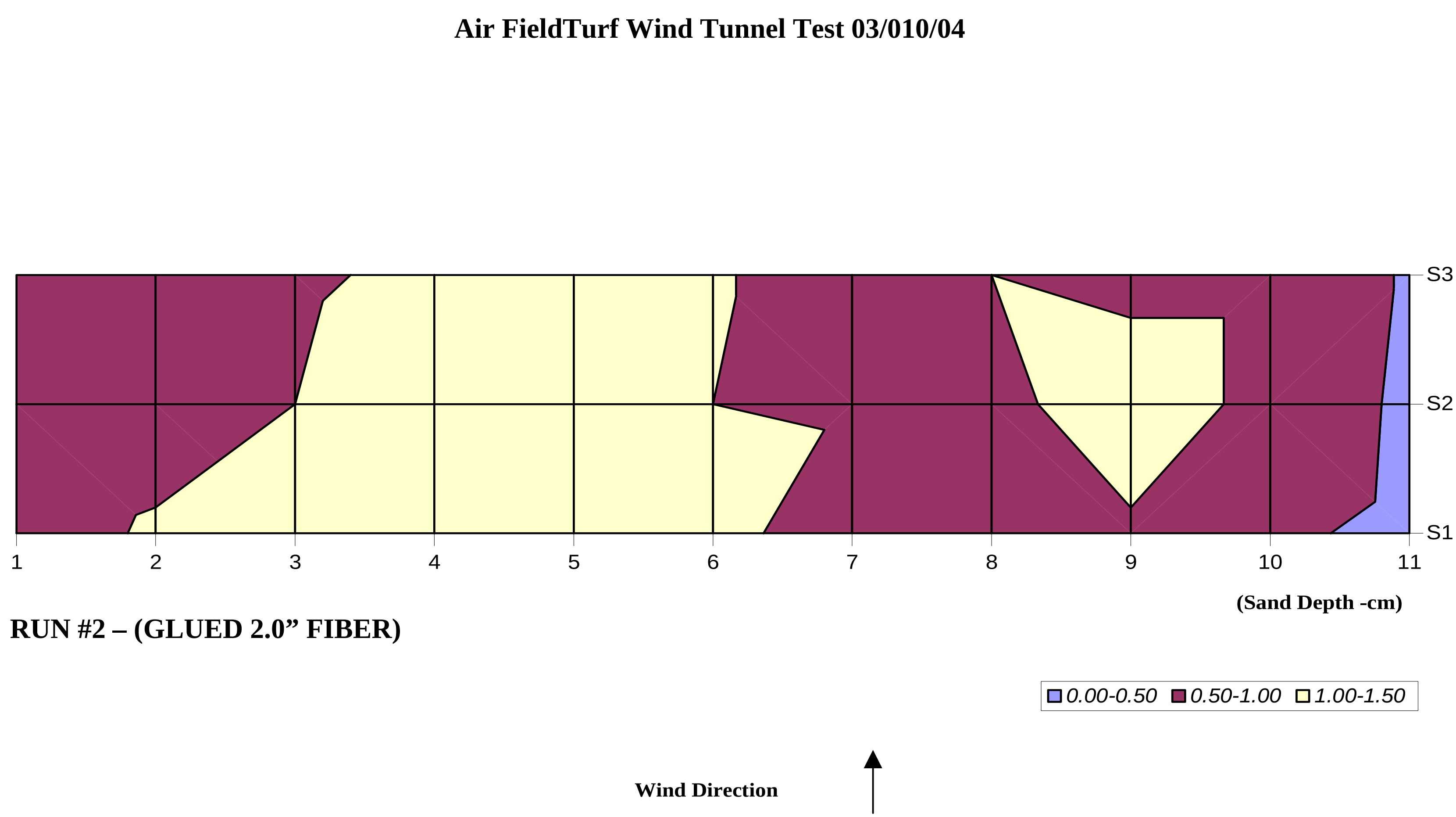



FIGURE C-49. TEST 7—RUN 2, EIGHT CYCLCES AT 40 FEET

C.11 TEST 8—AIR FIELDTURF 1.5-INCH FIBER.

C.11.1 DESCRIPTION.

The original 1.5-inch fiber test plot installation only covered half the test pad and was tested at 75 ft from the runway (figure C-50). A test cycle was conducted with the installation covering the entire test plot at 40 ft from the runway.

FIGURE C-50. THE 1.5-INCH FIBER TEST PLOT

Measurement points of 1 by 1 ft were marked into the turf surface to determine sand depths; a total of 5 rows and 11 columns were marked. (Figure C-38 shows a cross-sectional view of the 1.5-inch fiber test plot installation at the wind tunnel.)

C.11.2 RESULTS.

- Baseline (figure C-51). The baseline depth of the ballast sand measured from 0.40 to 0.80 inch.

- Run 1—Four cycles at 40 ft (figure C-52). The test was conducted at the 40-ft profile. During the course of the testing, it was noted that sand was being significantly removed from the artificial turf. After the fourth cycle was completed, the testing was stopped to conduct a visual inspection of the sand evacuation. It was determined that on the right side of the centerline, there was no sand remaining in a five-column space. The left side of the centerline experienced minimal sand movement. The depth of the ballast sand on the left side of the centerline measured from 0.50 to 0.80 inch (figures C-53 and C-54).

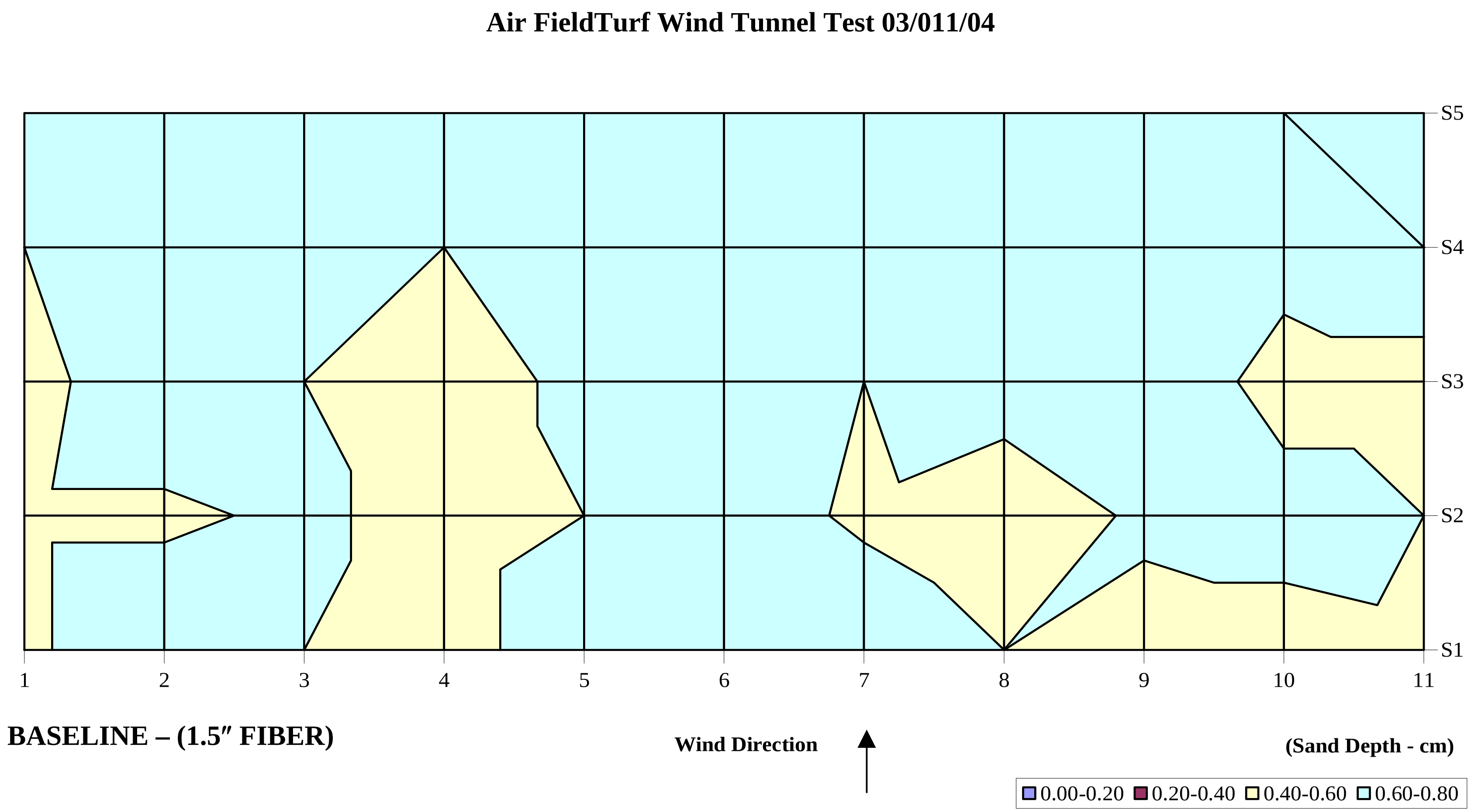



FIGURE C-51.  TEST 8—BASELINE LAYOUT

**Air FieldTurf Wind Tunnel Test 03/011/04**

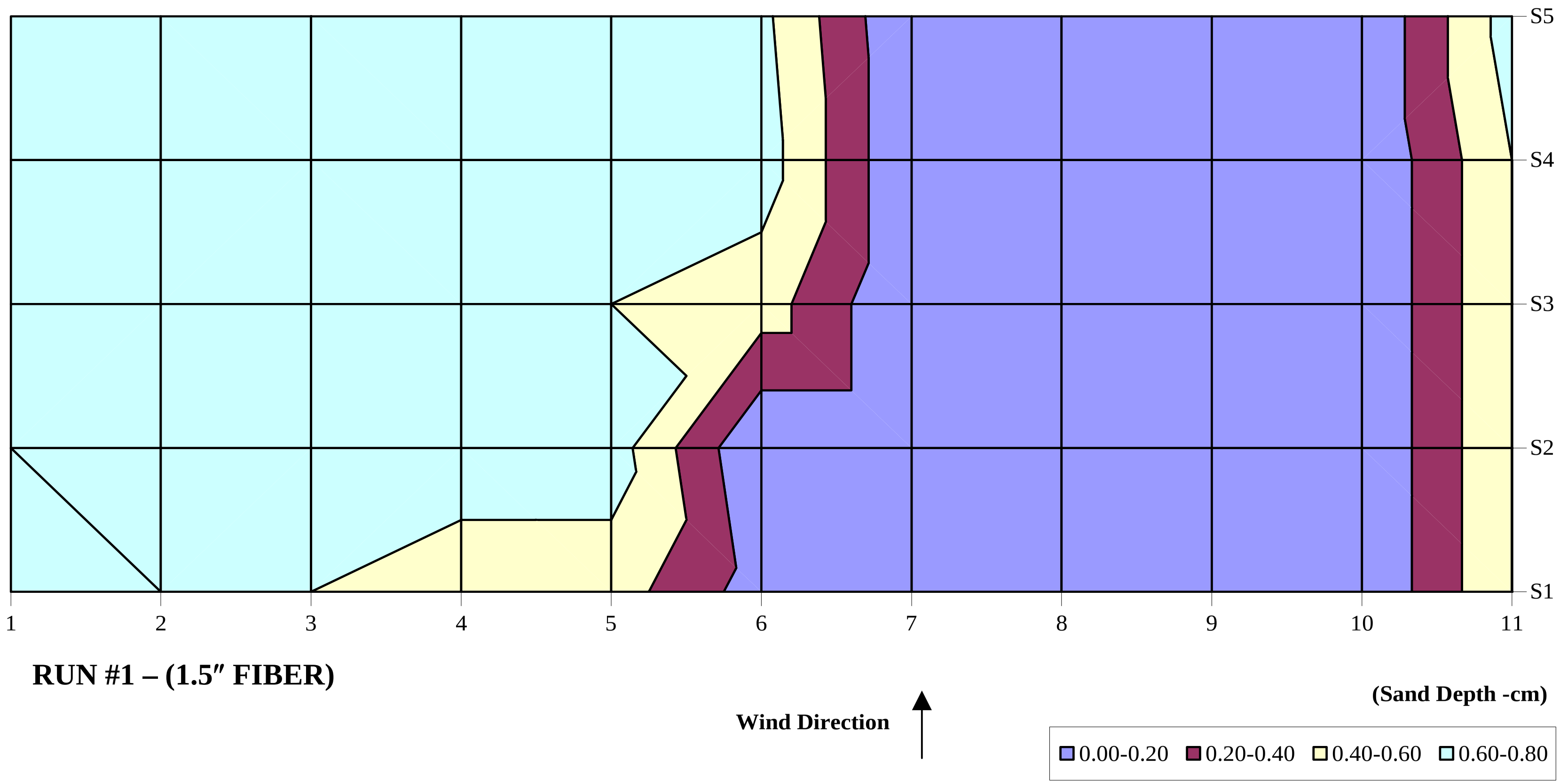



FIGURE C-52. TEST 8—RUN 1, FOUR CYCLES AT 40 FEET

FIGURE C-53.  TEST 8—1.5-INCH FIBER TEST PLOT AFTER TESTS

FIGURE C-54.  TEST 8—1.5-INCH FIBER TEST PLOT AFTER TESTS, CLOSE-UP

# APPENDIX D—FEDERAL AVIATION ADMINISTRATION WILLIAM J. HUGHES TECHNICAL CENTER FIRE TESTS

## D.1 AVTURF BURN TEST BACKGROUND.

Live fire demonstrations were conducted on the artificial turf AvTurf. AvTurf is a polypropylene artificial turf product being marketed for runway safety areas on airports. There were several safety concerns with using this artificial turf on an airfield that had to be addressed by the Federal Aviation Administration (FAA). One of the prime concerns is fire safety. The FAA had no data regarding what could happen in the event of a postcrash fire involving a fuel spill on this material.

## D.2 OBJECTIVES.

- Determine how easy the artificial turf ignites.
- Determine how rapid the fire spreads.
- Evaluate the condition of burnt material.
- Determine the intensity and temperature of the fire.
- Determine the degree of difficulty to extinguish.
- Evaluate the condition of burnt material when mixed with aqueous film forming foam (AFFF).

## D.3 TEST METHOD.

The demonstrations were conducted at the FAA William J. Hughes Technical Center Airport Rescue and Firefighting (ARFF) Research Program's Fire Test Facility. All demonstrations were conducted using one of the two, two-dimensional (2D) fire test pans shown in figure D-1. The smaller pan measured 4 by 8 ft, while the larger pan dimensions were 7 ft 4 in. by 8 ft.

FIGURE D-1. LARGE AND SMALL TEST PANS

To maintain installation consistency, for each demonstration, the artificial turf was installed by the manufacturer, per their specification. Materials for the base and ballast were selected by the manufacturer.

In each of the demonstrations, JP-8 fuel was used. Application amounts varied with each of the four demonstrations.

Fire tests were conducted using 10 and 20 gallons of JP-8 on a pool of water only to baseline fire temperatures. Additional baseline tests were conducted using 10 and 20 gallons of JP-8 on sod test beds. These were conducted to baseline the fire propagation and AFFF interaction.

D.3.1 DEMONSTRATION 1.

For the first demonstration, the smaller 2D pan was used. The product was installed by the manufacturer, per their specification. There was no fuel used in this demonstration. The objective was to record the degree of difficulty in igniting the artificial turf itself. Using a propane torch, the demonstration coordinator attempted to ignite the artificial turf. The degree of difficulty in igniting the material was recorded.

D.3.2 DEMONSTRATION 2.

This demonstration used the same installation in the smaller pan. For this demonstration, 3 gallons of fuel was poured into the upwind corner of the pan. The fuel-soaked area was measured and recorded.

Using a propane torch, the demonstration coordinator ignited the fuel. The main objective of this demonstration was the fire spread; therefore, the following data were recorded:

- The time it took for fire to propagate across the pan.
- The infrared pyrometer temperature of the fire.
- The amount of fire propagation (burnt area).
- The temperature of the artificial turf after the fire extinguished, as taken with an infrared pyrometer and a thermocouple probe.
- The condition of the burnt artificial turf.

D.3.3 DEMONSTRATION 3.

The third demonstration used an installed sample in the smaller pan as well. Ten gallons of fuel was evenly poured onto the entire sample. The fuel was then ignited using the propane torch. For this evaluation, the fire was allowed to self-extinguish.

The primary objective of this demonstration was to determine the condition of the burnt material. This was investigated because of concerns for the passengers that may be able to selfevacuate an aircraft involved in a postcrash fire. A primary concern was to ensure that by installing the material on an airport, no additional hazards are introduced.

The following data were recorded during the demonstration:

- The infrared pyrometer temperature of the fire.
- The temperature of the artificial turf after the fire extinguished, as taken with an infrared pyrometer and a thermocouple probe.
- The condition of the burnt artificial turf.

D.3.4 DEMONSTRATION 4.

The final demonstration was conducted in the larger pan, as shown in figure D-2. The demonstration was conducted to determine if there is any change in the condition of the burnt material when AFFF is applied to the burning material. Twenty gallons of fuel was evenly poured onto the entire sample. The fuel was then ignited using the propane torch. For this evaluation, the fire was allowed to fully involve the pan before using AFFF to extinguish the fire.

FIGURE D-2. LARGE 2D PAN SAMPLE

For this evaluation the following data were recorded:

- Extinguishment time.
- Gallons of AFFF used.

- The temperature of the artificial turf after the fire extinguished, as taken with an infrared pyrometer and a thermocouple probe.

- The condition of the burnt artificial turf.

## D.4 RESULTS.

### D.4.1 DEMONSTRATION 1.

The objective of this demonstration was to record the degree of difficulty in igniting the artificial turf itself. Several attempts were made to ignite the artificial turf using a propane torch. When the torch flame came in contact with the artificial turf, it would melt away under the torch. The material would not support combustion on it own, as shown in figure D-3. The air temperature for the day was 48°F with 11-mph winds. Immediately after the torch was removed from the surface of the material the temperature was recorded at 300°F and dropped to 58°F within 3 minutes.

FIGURE D-3. BURNT AREA (OUTLINED IN YELLOW) FROM PROPANE TORCH

### D.4.2 DEMONSTRATION 2.

For this demonstration, 3 gallons of fuel was poured into the pan. The fuel-soaked area measured 46 by 210 inches. The fuel was then ignited. The fire did not spread throughout the entire fuel-soaked area. The area burnt was 35 by 17 inches. Both an infrared pyrometer and a thermocouple probe were used to record the temperature of the fire area. Both units recorded a temperature of 330°F with a rapid decline. In the areas where the material was able to completely burn and self-extinguish, the remaining material was a powdery dust, as shown in figure D-4.

FIGURE D-4. FUEL-SOAKED (OUTLINED IN RED) AND BURNT AREAS (OUTLINED IN YELLOW)

D.4.3 DEMONSTRATION 3.

The third demonstration again used an installation in the smaller pan. Ten gallons of fuel was evenly poured onto the entire sample. The fuel was then ignited using the propane torch. For this evaluation, the fire was allowed to self-extinguish. The fire burned for 12 minutes and 30 seconds before the demonstration coordinator determined that the fire had subsided enough to call the end of the test. Figure D-5 shows the small pan fully involved in fire.

FIGURE D-5. SMALL PAN FIRE—10 GALLONS OF JP-8

In comparison, when 10 gallons of JP-8 was allowed to burn freely on a bed of water, it took 5 minutes to completely burn off the fuel. This increase in time to burn off the fuel in the artificial turf test bed was determined to be caused by the slower vaporization of the fuel from within the fuel-soaked ballast material. When 10 gallons of fuel was applied to natural grass test beds, as shown in figure D-6, the fire had little intensity and remained low to the ground. The natural grass burned for 10 minutes before the test was called. Within 5 minutes of each natural grass test, the fire was only visible at the seams of the sod used to create the test bed, as shown in figure D-7. Figures D-8 and D-9 show the temperature traces and peak temperatures of the sod and AvTurf demonstrations.

FIGURE D-6. NATURAL GRASS FIRE—10 GALLONS OF JP-8

FIGURE D-7. NATURAL GRASS FIRE—ONLY SEAMS INVOLVED

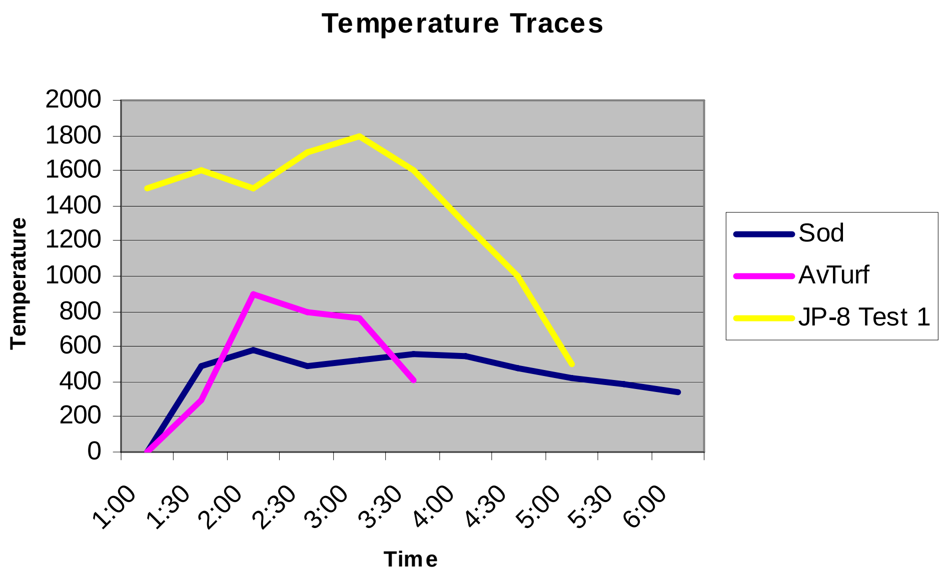



FIGURE D-8. SOD AND AVTURF TEMPERATURE TRACES

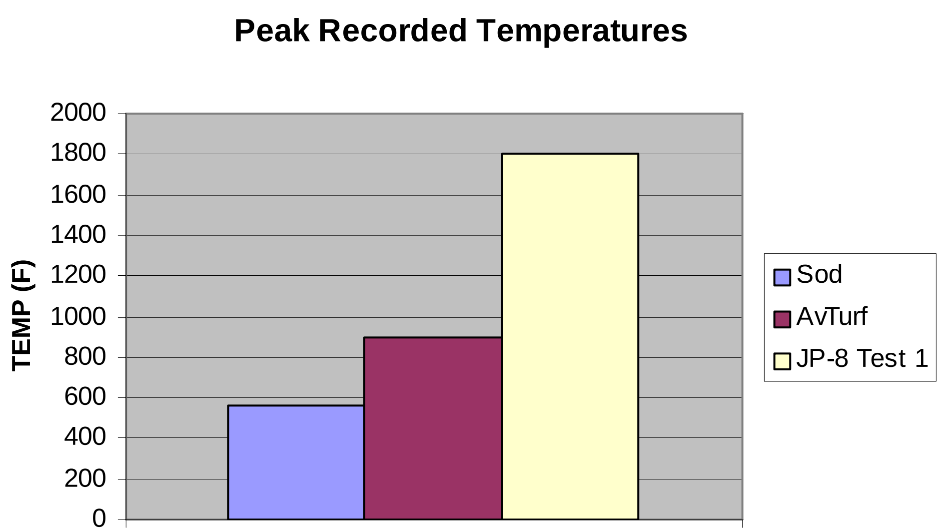



FIGURE D-9. PEAK RECORDED TEMPERATURES

The primary objective of this demonstration was to determine if the condition of the burnt material would hinder the evacuation of passengers across an area with artificial turf installed in a postcrash fire event. The infrared pyrometer recorded temperatures of up to 1000°F during the demonstration. As in the earlier demonstration, in the areas where the material was able to completely burn and self-extinguish, the remaining material was a powdery dust. This is evident in figure D-10 of the postfire inspection. With the exception of where the edges of the material came into contact with the stainless steel pan, the backing material stayed intact with no damage. In most areas, there was still a small amount of artificial turf fiber that was buried in the ballast material that remained intact. The exposed portion of the fiber was melted away but the buried material remained.

FIGURE D-10.  POSTFIRE INSPECTION

Also of interest in this demonstration was the lack of fuels that permeated through the artificial turf and its backing material onto the base material.  As shown in figure D-11, the artificial turf backing material had a grid of perforation holes in it for drainage.  The dots on the base material are the areas where fuel seeped through the backing material.  These wet spots were only on the surface of the base material and did not saturate the area.

FIGURE D-11.  POSTFIRE INSPECTION OF TURF AND BASE MATERIAL

D.4.4 DEMONSTRATION 4.

The final demonstration was conducted to determine if there is any change in the condition of the burnt material when AFFF is applied. For this demonstration, 20 gallons of fuel was evenly poured onto the entire sample installed in the large pan. The fuel was then ignited using a propane torch. For this evaluation, the fire was allowed to become fully involved in the pan before using AFFF to extinguish the fire, as shown in figure D-12.

The fire was extinguished very rapidly by the AFFF agent with only a small amount of agent discharged. The peak temperature recorded with the infrared pyrometer during the burn was 1000°F and rapidly dropped to 130°F upon agent application.


FIGURE D-12. APPLYING AFFF

The condition of the burnt artificial turf was similar to the previous burns with the burnt artificial turf turning to a powdery substance. There were some portions of the material that did burn enough to damage the backing material of the artificial turf, as shown in figure D-13. A firefighter in protective gear walked across the test bed to determine what it would be like to evacuate across the burnt material. Even in the areas where the backing material was damaged, the traction was good. When the integrity of the artificial turf and backing material was compromised, the base material was exposed and gave a solid surface for evacuation.

FIGURE D-13.  DAMAGED BACKING MATERIAL

## D.5 CONCLUSIONS.

- The artificial turf demonstrated could not be ignited using a propane torch. The artificial turf would melt under the flame of the torch but would not continue to burn. The artificial turf was unable to support combustion on its own.

- The fire did not spread across the test beds. The only signs of fire spread were with gusts of wind, which then subsided as the wind gust diminished.

- The condition of the burnt artificial turf was the same in all demonstrations. The burnt artificial turf turned to a powdery substance. There were some portions of the material that did burn enough to damage the backing material of the artificial turf.

- Some of the initial fire, immediately after ignition, was more intense with the artificial turf beds than the natural grass. However, in most cases, that fire quickly died down to a low-level burn closer to the ground. Temperatures of the artificial turf burns were consistent with those using JP-8 alone.

- The fires involving the artificial turf were very easy to extinguish and required minimal agent application.

- There was no noticeable adverse reaction of the aqueous film forming foam solution mixing with the burnt artificial turf.

## D.6 AIR FIELDTURF BURN TEST.

A series of nine live fire demonstrations were conducted on the artificial turf Air FieldTurf. Air FieldTurf is a polyethylene artificial turf being marketed for runway safety areas on airports. There were several safety concerns with using this artificial turf on an airfield that had to be addressed by the FAA. One of the prime concerns is fire safety. The FAA had no data regarding what could happen in the event of a postcrash fire involving a fuel spill on this material.

## D.7 OBJECTIVES.

The objectives of the burn tests were to

- determine how easy the artificial turf ignites.
- determine how rapid the fire spreads.
- evaluate the condition of the burnt material.
- determine the intensity and temperature of the fire.
- determine the degree of difficulty to extinguish the fire.
- evaluate the condition of the burnt material when mixed with AFFF.

## D.8 TEST METHOD.

The demonstrations were conducted at the FAA William J. Hughes Technical Center ARFF Research Program Fire Test Facility. All demonstrations were conducted using one of the two 2D fire test pans. The smaller pan measured 4 by 8 ft, while the larger pan measured 7 ft 4 in. by 8 ft.

To maintain installation consistency, for each demonstration, the artificial turf was installed by the manufacturer, per their specification. Materials for the base and ballast were selected by the manufacturer. In each of the demonstrations, the fuel used was JP-8.

Demonstrations 1 through 5 used a 2-inch fiber material with 1 inch of sand infill. The variation between samples in the first five demonstrations was in the backing material. The demonstrations used either a permeable or nonpermeable backing material. Demonstrations 6 through 9 also used a 2-inch fiber; however, the infill materials varied. These demonstrations were conducted to compare combinations of sand versus pebble infill with permeable- and non-permeable-backed material. All samples were applied over a base material of crushed stone.

Fire tests were conducted using 10 gallons of JP-8 on a pool of water in the smaller pan to baseline fire temperatures. Additional baseline tests were conducted in the smaller pan using 10 gallons of JP-8 on sod test beds. These were conducted to baseline the fire propagation and AFFF interaction.

### D.8.1 DEMONSTRATION 1.

For the first demonstration, the smaller 2D pan was used. The product was a 2-inch-tall fiber with 1-inch infill and a permeable backing. The manufacturer, per their specification, installed the artificial turf. There was no fuel used in this demonstration. The objective was to record the degree of difficulty in igniting the artificial turf itself. Using a propane torch, the demonstration coordinator attempted to ignite the artificial turf. The degree of difficulty in igniting the artificial turf was recorded.

D.8.2 DEMONSTRATION 2.

This demonstration used the same installation in the smaller pan. For this demonstration 3 gallons of fuel was poured into the pan. The fuel-soaked area was measured and recorded.

Using a propane torch, the demonstration coordinator ignited the fuel. The fire spread was the main objective of this demonstration; therefore, the following data were recorded:

- The infrared pyrometer temperature of the fire.
- The amount of fire propagation (burnt area).
- The temperature of the artificial turf after the fire extinguished, as taken with an infrared pyrometer and a thermocouple probe.
- The condition of the burnt artificial turf.

D.8.3 DEMONSTRATION 3.

The third demonstration was a non-permeable-backed sample installed in the large pan, as shown in figure D-14. Twenty gallons of fuel was evenly poured onto the entire sample, then ignited using a propane torch. For this evaluation, the fire was allowed to free-burn for a period of time before AFFF was applied.

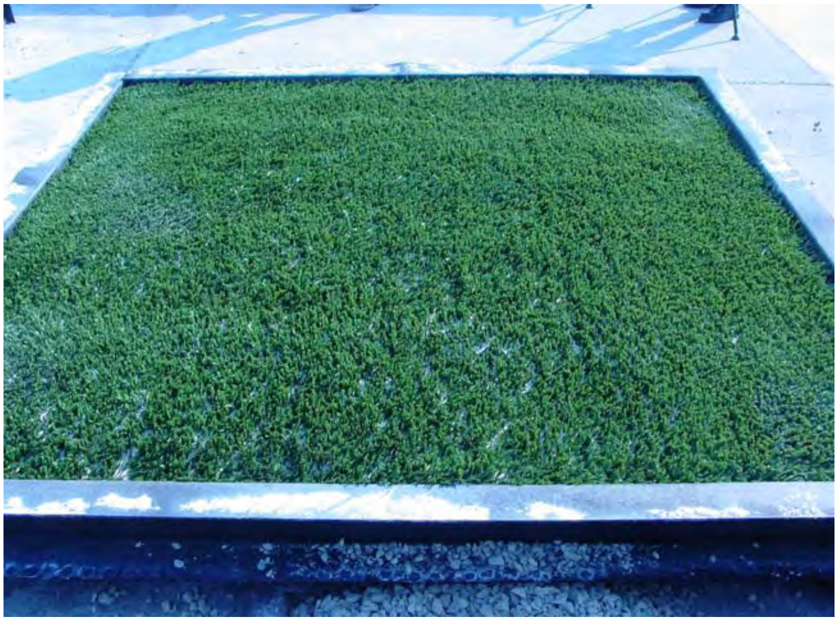


FIGURE D-14. LARGE 2D PAN SAMPLE

The primary objectives of this demonstration were to determine the difficulty in extinguishment, and the condition of the burnt material. This was investigated because of concerns for the passengers that may be able to selfevacuate an aircraft involved in a postcrash fire. A primary concern is to ensure that by installing this material on an airport, no additional hazards are introduced.

The following data were recorded during the demonstration:

- The infrared pyrometer temperature of the fire.
- The temperature of the artificial turf after the fire extinguished, as taken with an infrared pyrometer and a thermocouple probe.
- The condition of the burnt artificial turf.
- The degree of difficulty to extinguish the fire.

D.8.4 DEMONSTRATIONS 4 AND 5.

Demonstrations 4 and 5 were conducted in the smaller pan to evaluate the effects of the permeable and nonpermeable backing of the samples. Demonstration 4 used a permeable-backed material, and demonstration 5 used a non-permeable-backed material. Ten gallons of fuel was evenly poured onto the entire sample, then ignited using a propane torch.

D.8.5 DEMONSTRATIONS 6 THROUGH 9.

Demonstrations 6 through 9 were conducted to compare combinations of sand versus pebble infill with permeable- and nonpermeable-backed material. These demonstrations were also conducted in the smaller pan using 10 gallons of JP-8 fuel. Table D-1 shows the matrix of infill used and backing material for each sample.

TABLE D-1. INFILL MATRIX

| Demonstration No. | Infill | Backing Material |
|---|---|---|
| 6 | Sand | Nonpermeable |
| 7 | Pebble | Nonpermeable |
| 8 | Pebble | Permeable |
| 9 | Sand | Permeable |

D.9 RESULTS.

D.9.1 DEMONSTRATION 1.

The objective was to record the degree of difficulty in igniting the artificial turf itself. Several attempts were made to ignite the artificial turf using a propane torch. The air temperature for the day was 69°F with 11-mph winds. When the torch flame came in contact with the artificial turf, it melted away under the torch. The artificial turf did not support combustion on its own, as shown in figure D-15. Immediately after the torch was removed from the surface of the artificial turf the temperature was recorded at 200°F and dropped to 115°F 30 seconds later.

FIGURE D-15. BURNT AREA (OUTLINED IN YELLOW) FROM PROPANE TORCH

D.9.2 DEMONSTRATION 2.

For this demonstration, 3 gallons of fuel was poured into the pan, then ignited. The fire did not spread throughout the entire fuel-soaked area. An infrared pyrometer was used to record the temperature of the fire area, with the initial temperature being 625°F, then peaking at 768°F, and a final recorded temperature of 525°F 8 minutes into the demonstration. There was more fire spread with this demonstration than in a similar demonstration run with a different artificial turf. This was attributed to the more permeable backing material and the looser crushed stone base material, which allowed for more propagation of the fuel and increased vaporization. Figure D-16 shows the fire in the initial fuel-soaked area. Figure D-17 shows the spread of the fuel once the artificial turf was removed from the base of crushed stone. In the areas where the artificial turf was able to completely burn and self-extinguish, only a powdery dust remained, as shown in figure D-18.

FIGURE D-16.  INITIAL FIRE ON FUEL-SOAKED AREA

FIGURE D-17.  FUEL-SOAKED AREA (OUTLINED IN YELLOW) ON BASE MATERIAL

FIGURE D-18. BURNT MATERIAL

D.9.3 DEMONSTRATION 3.

Demonstration 3 used an installation in the larger, 8- by 8-ft pan to determine if there was any change in the condition of the burnt material when AFFF was applied. For this demonstration, 20 gallons of fuel was evenly poured onto the entire sample installed in the large pan and ignited with a propane torch. For this demonstration, the fire was allowed to free-burn for approximately 4 minutes to fully involve the sample, as shown in figure D-19. At that point, AFFF was applied to extinguish the fire and evaluate the residual material. The fire was extinguished very rapidly by the AFFF agent with only a small amount of agent discharged. The peak temperature recorded with the infrared pyrometer during the burn was 1350°F, which rapidly dropped to 200°F upon agent application.

FIGURE D-19. LARGE PAN FIRE—20 GALLONS OF JP-8

Figure D-20 shows the condition of the material after extinguishment. The base material shown in figure D-21 had no fuel contamination due to this sample having a nonpermeable backing.

FIGURE D-20. CONDITION AFTER FIRE IS EXTINGUISHED

FIGURE D-21. BASE MATERIAL WITH NO FUEL CONTAMINATION

D.9.4 DEMONSTRATIONS 4 AND 5.

Demonstrations 4 and 5 were conducted in the smaller pan to evaluate the effects of the permeable and nonpermeable backing of the samples. Demonstration 4 used a permeable-backed material, and demonstration 5 used a non-permeable-backed material. Ten gallons of fuel was evenly poured onto the entire sample, and then ignited with a propane torch. In demonstration 4, the fire was more intense initially with a long lasting low-level, sustained fire as the fuels burned off, as shown in figures D-22 and D-23.

FIGURE D-22. INITIAL PHASE OF FIRE

FIGURE D-23. LOW-LEVEL, SUSTAINED FIRE

The low-level, sustained fire of demonstration 4 began at the 10-minute mark of the demonstration and continued until the test was called at 45 minutes. For demonstration 5, the test was called at the 9-minute mark when the fire reached the same low-level intensity as in demonstration 4 with limited fire area involved. This was a subjective decision made by the demonstration coordinator. The recorded peak temperature for demonstration 4 was 1220°F, while demonstration 5 achieved a peak temperature of 1050°F. While these peak temperatures were very close, the fire in demonstration 5 died down to the low-level, sustained fire much quicker than in demonstration 4. This can be seen in the data traces shown in figure D-24.

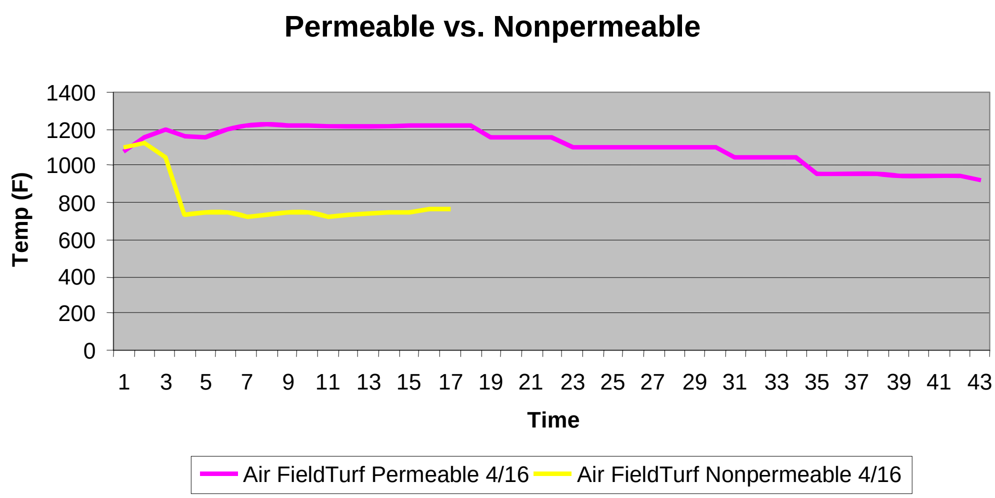



FIGURE D-24. DATA TRACES OF PERMEABLE- AND NON-PERMEABLE-BACKED SAMPLES

A key objective of this demonstration was to determine if the condition of the burnt material would hinder the evacuation of passengers across an area with artificial turf installed during a postcrash fire event. The infrared pyrometer recorded temperatures in excess of 1000°F during the demonstrations. As in demonstration 4, in the areas where the material was able to completely burn and self-extinguish, the remaining material was a powdery dust. With the exception of where the edges of the material came into contact with the stainless steel pan, the backing material stayed intact with no damage. In most areas, there was still a small amount of artificial turf fiber that was buried in the ballast material that remained intact, whereas exposed portion of the fiber was melted away.

## D.9.5 DEMONSTRATIONS 6 THROUGH 9.

Demonstrations 6 through 9 were conducted to compare combinations of sand versus pebble infill with permeable- and non-permeable-backed material. These demonstrations were also conducted in the smaller pan using 10 gallons of JP-8 fuel. In demonstrations 6, 8, and 9, the duration of the demonstration lasted 28 minutes at which time the evaluation was called by the demonstration coordinator. These three burns had very similar characteristics. The peak recorded temperatures for these burns were between 1000° and 1100°F as shown in chart in figure D-25.

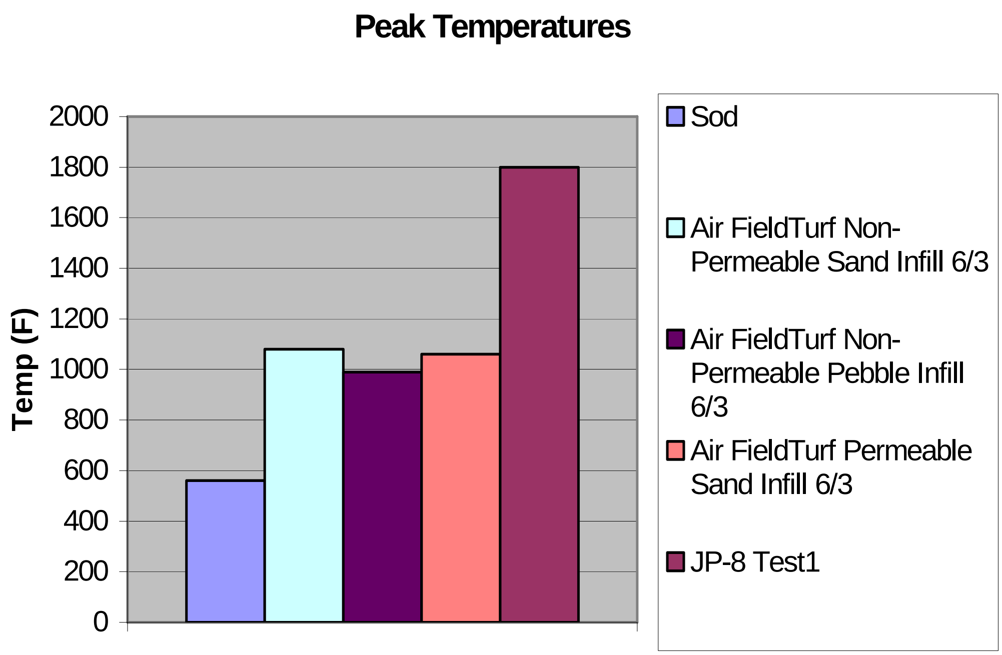



FIGURE D-25. PEAK RECORDED TEMPERATURES

Demonstration 7 appeared to be the best combination of infill and permeability. In this demonstration, the fire self-extinguished in 1 minute and 30 seconds. As could be expected, there was also much less damage to the material than in the other three in this group. Figures D-26 and D-27 show the extent of the damage to the material between the burn that lasted 1 minute and 30 seconds and the ones that were called at 28 minutes.

FIGURE D-26. DAMAGE TO MATERIAL AFTER A SHORT BURN (1:30)

FIGURE D-27.  DAMAGE TO MATERIAL AFTER A LONG BURN (28:00)

For comparative purposes, 10 gallons of fuel was applied to natural grass test beds, as shown in figure D-28.  The fire had little intensity and remained low to the ground.  The natural grass burned for 10 minutes before the demonstration was called.  Within 5 minutes of each natural grass demonstration, the fire was only visible at the seams of the sod used to create the test bed, as shown in figure D-29.  To baseline temperatures and burn durations, 10 gallons of JP-8 was allowed to burn freely on a bed of water, it took 5 minutes and 20 seconds to completely burn off the fuel.  The fire reached a maximum recorded temperature of 1800°F.  The increase in time to burn off the fuel in the artificial turf test bed was determined to be caused by the slower vaporization of the fuel from within the fuel-soaked ballast material.

FIGURE D-28.  NATURAL GRASS FIRE—10 GALLONS OF JP-8

FIGURE D-29. NATURAL GRASS FIRE—ONLY SEAMS INVOLVED

Figure D-30 shows the temperature traces over the duration of demonstrations 6 through 9 and the sod baseline. Due to the rapid self-extinguishment of demonstration 7, there was insufficient data to create a trace of that burn.

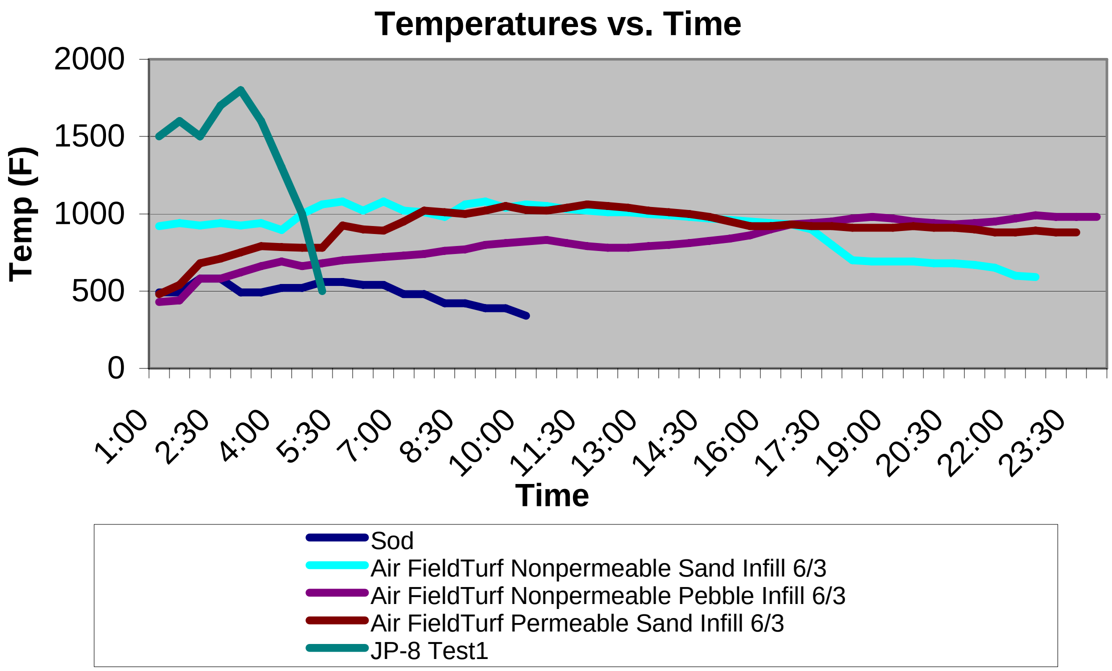



FIGURE D-30. TEMPERATURE TRACES

D.10 CONCLUSIONS.

- The artificial turf demonstrated could not be ignited using a propane torch. The artificial turf would melt under the flame of the torch but would not continue to burn and was unable to support combustion on its own.

- The fire could spread across the test beds. This appeared to be as a result of the free flow of the fuel through the permeable backing material and the loose stone base material. In comparison to the artificial turf previously tested, this artificial turf allowed for more fuel spread and further contamination of the soil around the spill.

- The burnt artificial turf turned to a powdery substance. There were some portions of the material that did burn enough to damage the backing material of the artificial turf.

- Some of the initial fire, immediately after ignition, was more intense with the artificial turf beds than the natural grass beds. However, in most cases, that fire quickly died down to a low-level burn closer to the ground. Temperatures of the artificial turf burns did not peak as high as those as the baseline test using JP-8 only, but remained at a reasonability high temperature for a longer length of time.

- The fires involving the artificial turf were very easy to extinguish and required minimal agent application.

- There was no noticeable adverse reaction of the AFFF solution mixing with the burnt artificial turf material.

D.11 AIR FIELDTURF GLUE APPLICATION BURN TEST BACKGROUND.

A series of live fire demonstrations were conducted on the Air FieldTurf artificial turf glued to concrete. The artificial turf developed a secondary use as a surface contrasting material for vast concrete apron areas. Airports with large continuous concrete apron areas would traditionally delineate taxiways and other vehicle movement areas by painting green island areas to appear as grass. As a follow-up to previous live fire demonstrations, the FAA needed to determine if the proposed adhesive materials used in attaching the turf to the concrete would pose any additional fire hazard.

D.11.1 OBJECTIVES.

- Determine if the adhesive material adds to the intensity or spread of the fire.
- Determine how the use of an infill affects the fire on a solid surface.

D.11.2 TEST METHOD.

Seven 4- by 8-ft concrete pads were constructed in metal frames. The pads were constructed to simulate the concrete surfaces the artificial turf would be installed on at an airport. For purposes of containing the fuel applied to the artificial turf, the edges were flared approximately 4 inches, as shown in figure D-31.

FIGURE D-31. CONCRETE TEST PAD

Test samples were installed by the manufacturer on the concrete pads. The samples consisted of variations of artificial turf installations both attached and unattached as well as with and without sand infill. All tests had an initial JP-8 fuel application of 3 gallons. The samples with sand infill had an additional 2 gallons applied in one specific area to compensate for fuel absorption into the sand as well as providing an area of pooled fuel to allow for more rapid fire development. Figure D-32 shows the fire intensity with sand infill, while figure D-33 shows the fire intensity without the sand infill.

FIGURE D-32. DEMONSTRATION WITH 1-INCH SAND INFILL

FIGURE D-33. DEMONSTRATION WITHOUT SAND INFILL

Two baseline tests were conducted. Approximately 1 inch of water was poured into a test pad. In the first baseline, 3 gallons of JP-8 fuel was applied to the surface of the water and ignited. Data were recorded for temperature and duration of the burn. The same baseline was then repeated using 5 gallons of fuel to compare to the sand infill demonstrations.

## D.12 RESULTS.

The key objective of this round of demonstrations was to determine if either selected adhesive materials (rubberized or hot-melt glue) contributed to the fire intensity. Figures D-34 and D-35 show the peak temperatures of the samples without and with sand infill, respectively. As can be seen from these figures, the addition of the adhesive materials did not add to the fire intensity.

Figures D-36 and D-37 show the relationship of temperature and time during the demonstrations for samples without and with sand infill, respectively. It is apparent in these figures that adding the sand infill variable greatly affects the ability to have consistent and repeatable demonstrations. One key factor that was drawn from this data was that the fire burned longer due to the slower release of fuel vapors from the sand infill. The demonstrations with sand infill had a tendency to have initial peak intensity, fully involving the 4- by 8-ft sample, then declined into a fire that only involved portions of the sample. This added some subjectivity to the selection of areas to record the data. While the recorded temperatures for these demonstrations remained high well past the 20-minute mark, the overall intensity of the fire was lower, as shown in figure D-38.

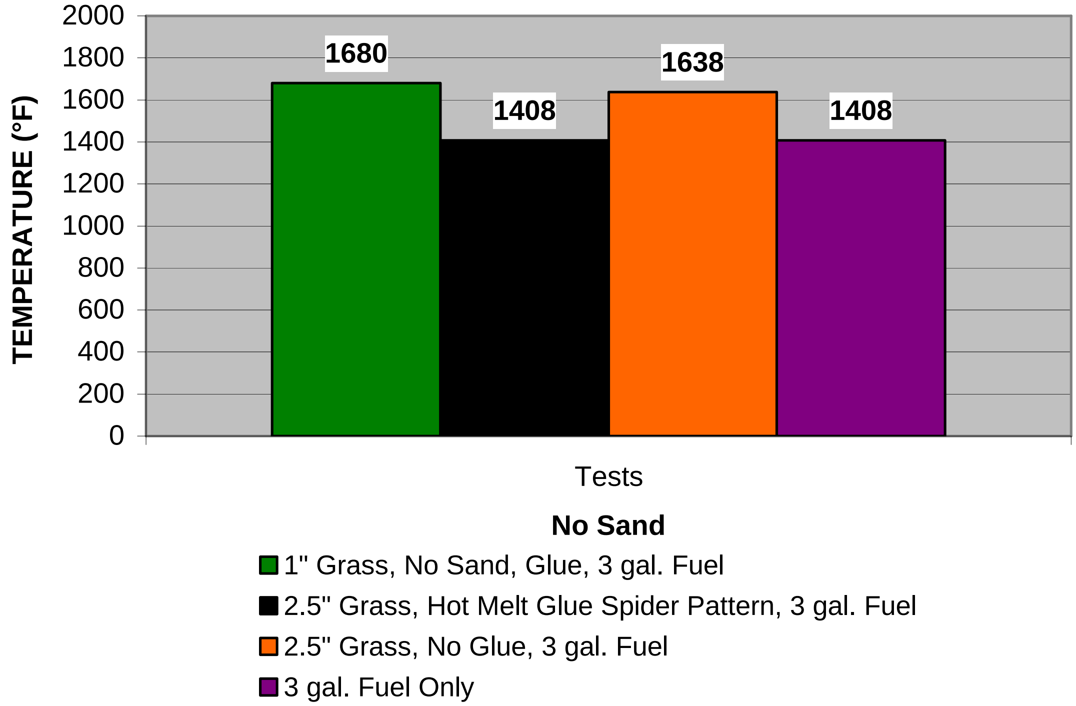



FIGURE D-34. PEAK TEMPERATURES (NO SAND INFILL)

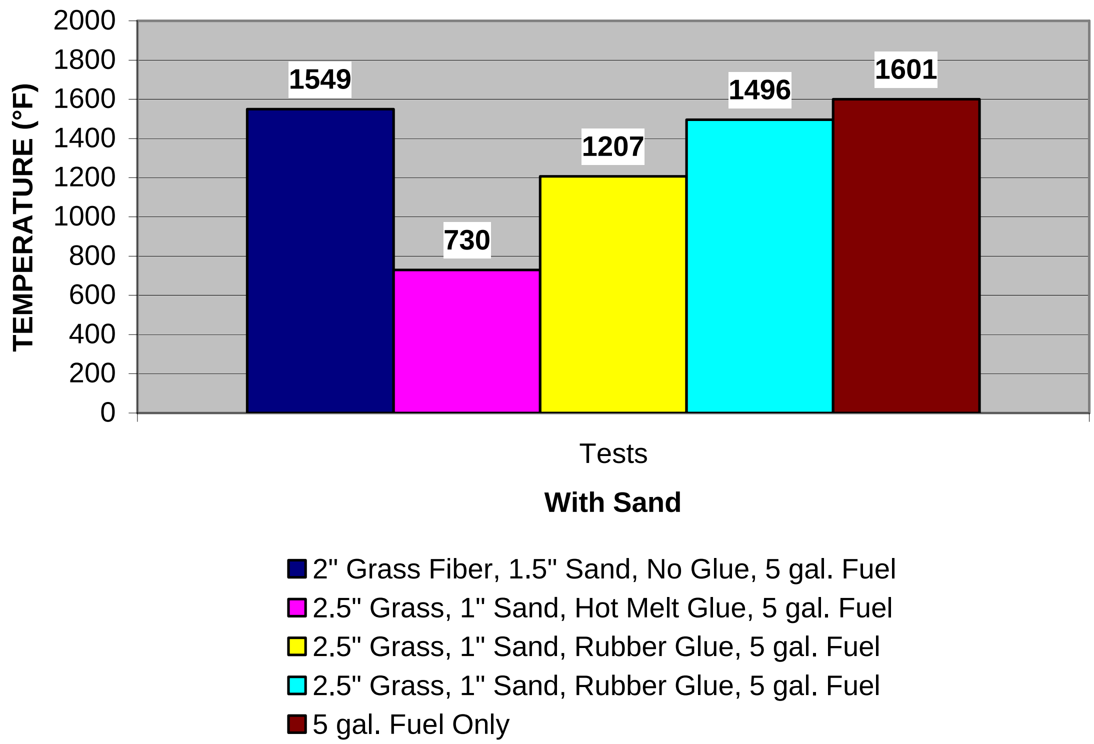



FIGURE D-35. PEAK TEMPERATURES (SAND INFILL)

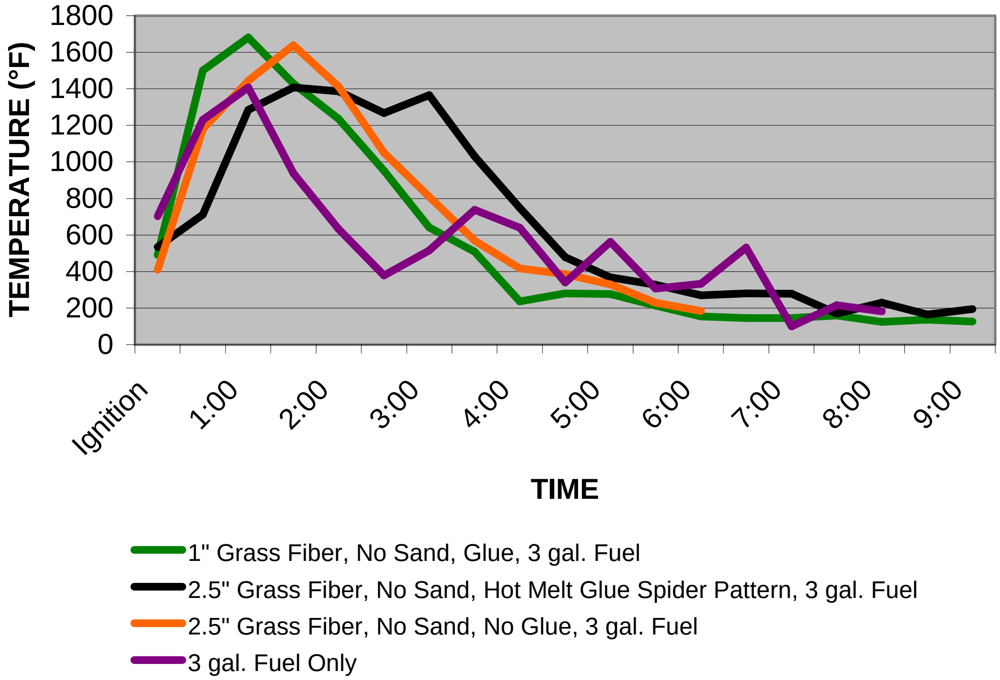



FIGURE D-36. TEMPERATURE VS TIME (NO SAND INFILL)

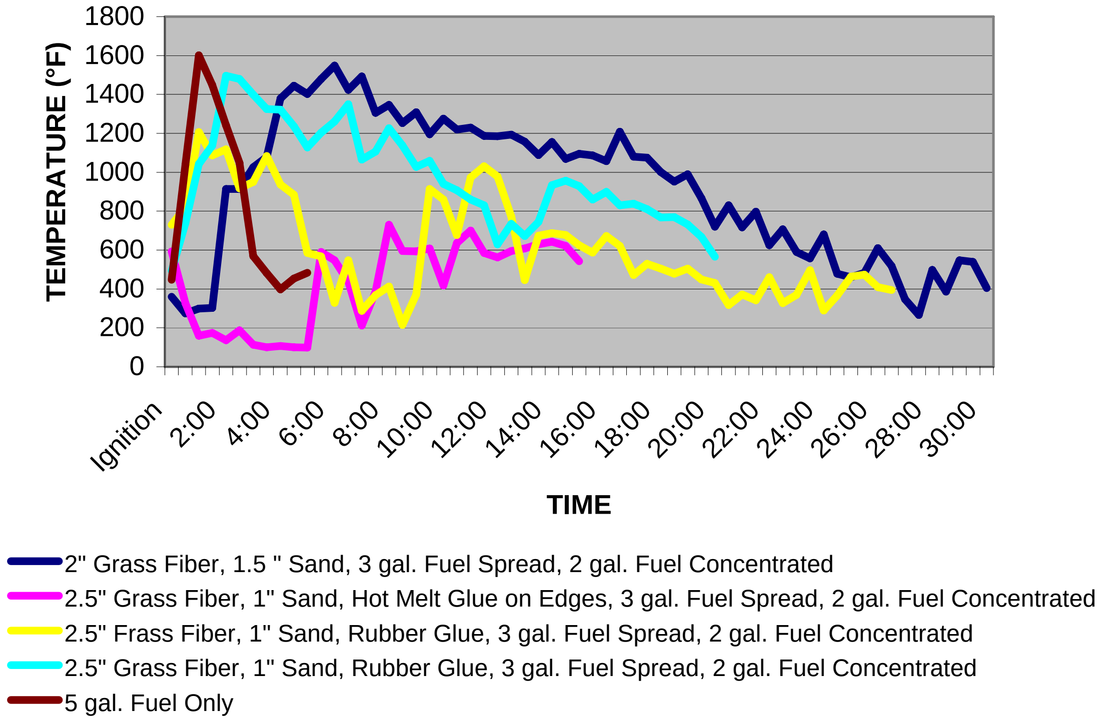



FIGURE D-37. TEMPERATURE VS TIME (SAND INFILL)

FIGURE D-38.  PARTIAL INVOLVEMENT OF SAMPLE AREA

D.13  CONCLUSION.

It was determined through this demonstration that neither adhesive material significantly contributed to the intensity of the fire or fire propagation.  However, of particular importance, none of the products of combustion from the smoke plume were collected and analyzed during this demonstration.  Data should be collected to determine whether the adhesive materials significantly add to the toxicity levels of the smoke plume.