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IMPROVING ACCESS AND ENVIRONMENTAL SENSITIVITY WITH PORTABLE SURFACES ON LOW VOLUME ROADS

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ABSTRACT

Native soil, low volume road beds are a vital part of road networks on many government and industry owned lands. A common concern of low volume road managers and designers is rut development through short, unstable sections. Ruts reduce vehicle access, impact local streams and hydrology, increase maintenance, and accelerate the loss of surfacing material due to erosion. San Dimas Technology and Development Center (SDTDC) investigated portable surfaces as a low cost alternative for providing extended or temporary access while reducing the environmental and accessibility impacts caused by rut development. This report discusses a field evaluation to quantify the reduction of rut depth for three types of surfaces. Grating, wood pallets and wood mats were installed on native soil, timber harvest roads in north central Florida. The surfaces reduced rut depth by up to 10.5 inches (267 mm) compared to the control sections and limited rut depth to less than 5 inches (127 mm) within the surfaced sections.

INTRODUCTION

Within government and industry owned lands, low volume roads are a vital part of the road network. Many consist of native soil road beds and are constructed according to minimal engineering design standards. Often, roads are constructed to provide short term access with routine maintenance. A concern for designers and managers is short sections of unstable surface or subsurface material, typically due to increased moisture content. This unstable material leads to rut development (see figure 1). Ruts increase in depth with continued traffic until blading is performed or crushed aggregate surfacing material is added to the unstable section.

Figure 1. Rut development on Florida low volume road.

Limiting rut development is important for several environmental and accessibility reasons. As ruts develop, surface or intercepted subsurface water is diverted from the designed road drainage which may alter local hydrology especially in very flat areas. Water, running along the road alignment in the ruts, loosens and transports soil particles causing erosion of the road bed. Subsequent erosion may damage sections of road. Also, water with suspended soil particles may eventually drain into local streams potentially increasing stream turbidity. With increasing rut depth, continued access may damage vehicles or cause a need for vehicle assistance.

The Forest Service recognized the need for portable surfaces to inhibit rut development. The surfaces were visualized as a low cost alternative for allowing temporary access across short sections of unstable soil while decreasing potential environmental impacts. SDTDC performed a market search and published a report describing twelve surfaces (Mason 1990). From these twelve surfaces, six were chosen for field evaluation based on the following criteria: easily transported, ability to be reused, purchase price, and availability. The six surfaces were evaluated on the Osceola Ranger District (RD) in north central Florida under normal low volume forest road use. The surfaces were all qualitatively judged successful at visibly reducing rut depth and increasing the duration of vehicle access (Mason and Greenfield 1995).

Field evaluations continued to quantify the reduction in rut depth for three portable surfaces (Hislop 1996). This document briefly overviews the field evaluation and results, and provides recommendations on the preferred portable surfaces. Evaluations were performed on existing native soil road beds in north central Florida in cooperation with Rayonier Corporation and the Osceola RD. The three portable surfaces evaluated were grating, wood pallets, and wood mats. Geotextile separated the surfaces from the road bed. The majority of the vehicles driven over the sections during field evaluations were five-axle, loaded and unloaded log trucks with a gross vehicle weight of 80,000 pounds (355.9 kN).

SITE DESCRIPTION AND DATA COLLECTION METHODS

The previous SDTDC study concluded that portable surfaces visibly reduced rut depth. The objective of this field evaluation was to measure the reduction in rut depth when using the surfaces. The evaluation consisted of determining soil characteristics and collecting rut depth data for control and portable surface sections. A complete description of the materials, construction, and installation of each portable surface is covered in two previous publications (Hislop 1996 and Mason and Greenfield 1995).

Two separate sites were chosen for the field evaluations due to the unstable section being too short for placement of all the surfaces at either site. For both sites, the control sections were only long enough to gather the necessary data, typically 1 to 2 foot (0.3 to 0.61 m) in length. For Site 1, figure 2 shows the 8-foot long 4-inch by 4-inch (2.4 m long 102 mm by 102 mm) wood mats as ramps on either side of the 14-foot long 6-inch by 6-inch (4.3 m long 152mm by 152 mm) mats. The 14-foot (4.3 m) long wood pallets butted up to the mats. Nonwoven, needle-punched filter fabric was placed under the surfaces. The control section was on the same road, approximately 180 feet (55 m) from the surfaces (see figure 3). The log truck traffic volume was approximately 30 round trips each day.

For Site 2, the deck span safety grating surface was used with three, 3-foot by 10-foot (0.9 m by 3.0 m) grates placed in each wheel path. Nonwoven, needle-punched geotextile was placed underneath the grating. The control sections were located 2 feet (0.6 m) from the end of the grating, at both ends. Figure 4 shows Site 2 at the end of the field evaluation with two gratings removed from the right wheel path. The log truck traffic volume was approximately 15 round trips each day.

Figure 2. Portable surface section—Site 1.

Figure 3. Control section—Site 1.

Figure 4. Portable surface and control sections, end of evaluation—Site 2.

SOIL CHARACTERIZATION AND RUT DEPTH

The control and portable surface sections soils were characterized to determine similarities within each site. Provided the sections were similar, differences in rut depth would be attributable to the surfaces. Soil samples were taken to determine moisture content as the main indicator of soil instability. To characterize soil strength, cone penetrometer data were gathered. Figure 5 shows the Irregular Cone Index penetrometer. Rut depth was determined from road cross section profiles using a stringline method. Stakes were permanently placed along the road edges and marked 1-foot (0.3 m) above the soil surface for placement of the stringline (see figure 6).

ANALYSIS OF RESULTS

The control and portable surface sections moisture content and soil strength were analyzed to verify that the control section was representative and a viable baseline for the site. Cone penetrometer readings were converted to soil strength (California Bearing Ratio (CBR)) using conversion factors supplied with the equipment. The other variables—soil, traffic, climate, construction and maintenance were the same for the control and surface sections. The soil was determined to be a silty sand. The evaluations were performed in late June with measurable rainfall occurring every evening.

Figure 5.
Cone penetrometer device.

Soil Characteristics

During the evaluation period, the average moisture content was 20 percent at Site 1 and 26 percent at Site 2. Within the portable surface sections, the moisture content of Site 1 was 0 to 7 percent higher than the control section, and Site 2 was 1 to 11 percent higher. Because the portable surface sections averaged higher moisture content, they were potentially more unstable than the control sections. Based on moisture content the differences in rut depth will be conservative estimates of the benefit due to portable surfaces.

CBR is an index of the soil strength in regards to shear failure under a load (Barksdale 1991). Thus, a relatively low CBR indicates rutting might occur under heavy loads. CBR ranges from 0 to over 100, with 100 equaling the strength of well compacted aggregate. Prior to traffic for the portable surface and control sections, the CBR gradually increased from 1 to 6 within the top 4 inches (102 mm) for Site 1 and from 1 to 7 within the top 3 inches (76 mm) for Site 2. At greater depths, for both sites, a trend of higher CBR values in the control sections became apparent (see figure 7). At the end of the evaluation, CBR values under the portable surfaces and within the wheel paths in the control sections remained approximately the same as the CBR values prior to traffic.

Based on CBR, rut depths should remain the same between the control and portable surface sections within the initial 3-to 4-inch depth (76 to 102 mm). However, for the total number of traffic passes, ruts should develop to the depths where the CBR values in the control section are higher. This would result in a conservative estimate of the expected rut depth for the portable surface section.

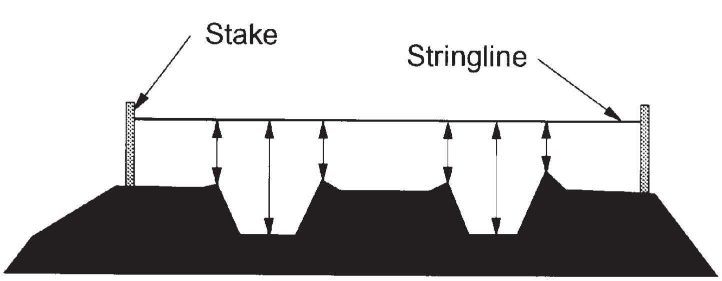
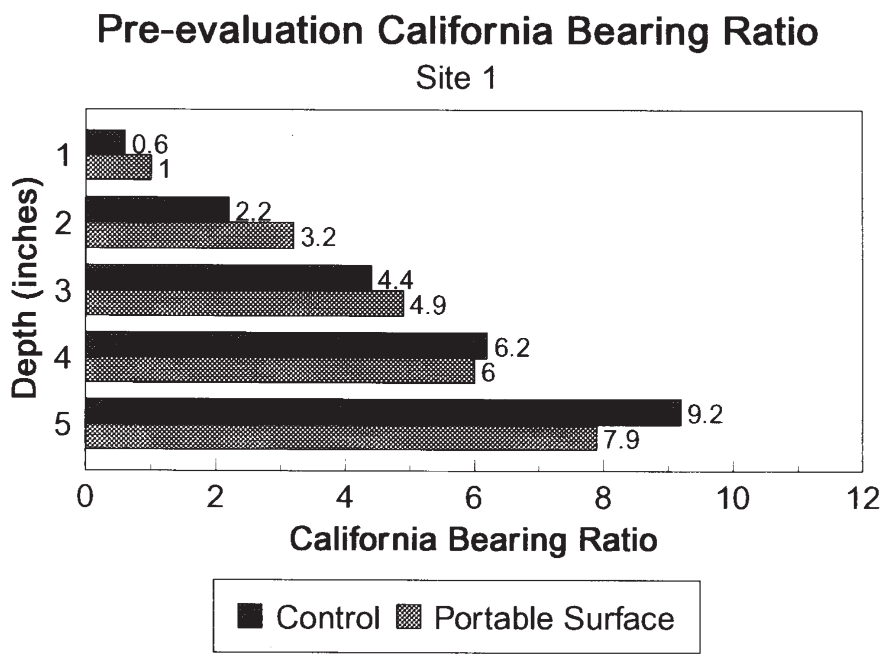


Figure 6. Stringline method to measure rut depth.

Rut Depth

Rut depth was interpreted as the difference between the low point within a wheel path and the average of the high points on either side of a wheel path (see figure 8). Control and surface sections were compared for rut depth differences within the same wheel path. For Site 1, the number of round trip vehicle passes was approximately 240 at the completion of the evaluation. For Site 2, the total number of round trip passes was approximately 75.



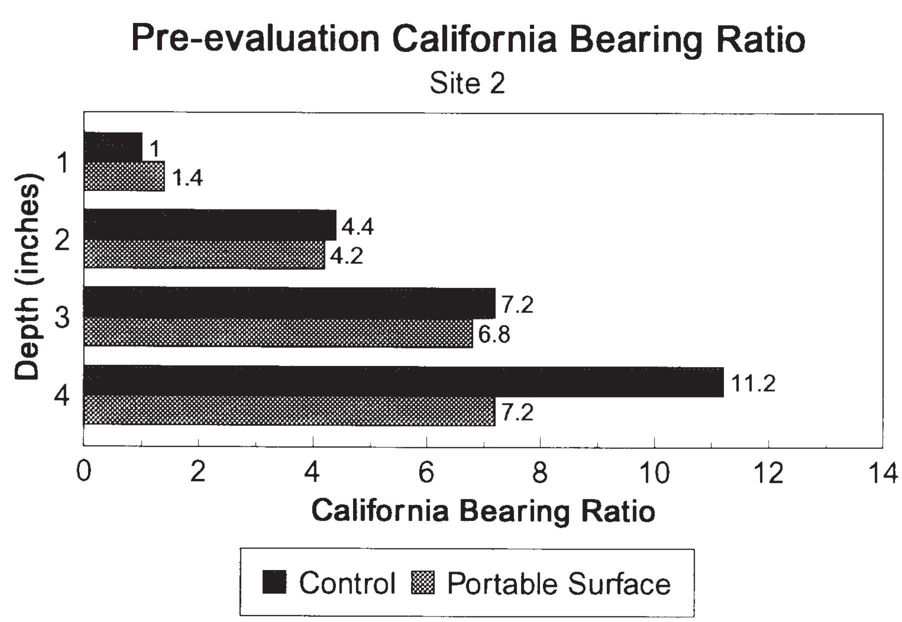


Figure 7. CBR comparison prior to traffic—Site 1 and Site 2.

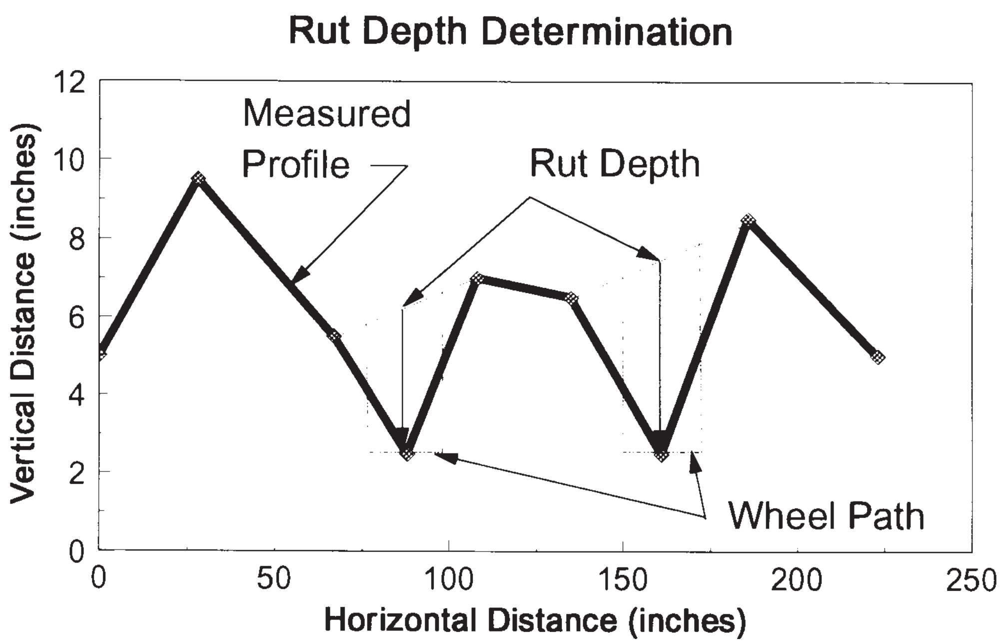
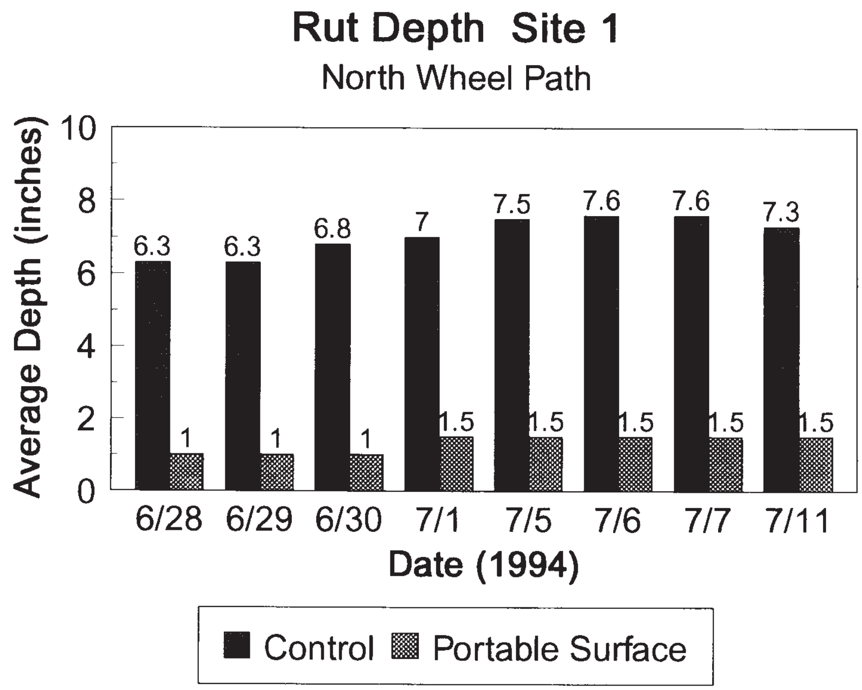


Figure 8. Determination of rut depth.

For Site 1, measurements taken along the edges of the portable surfaces, upon completion of the field evaluation, indicated that the portable surfaces were embedded into the road bed surface approximately 1-1/2 inches (38 mm). This compares with ruts of up to 7.5 inches (190.5 mm) in the control section. In the north wheel path, the difference between the portable surface and control sections varied from 5.3 inches to 6.1 inches (135 to 155 mm). In the south wheel path, the difference varied from 2.6 inches to 4 inches (66 to 102 mm) (see figure 9).



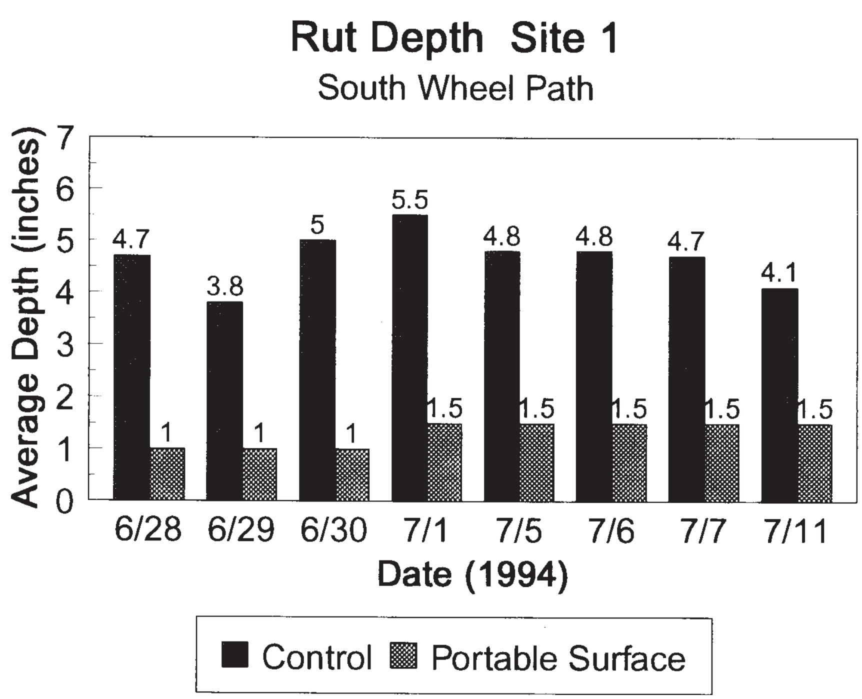
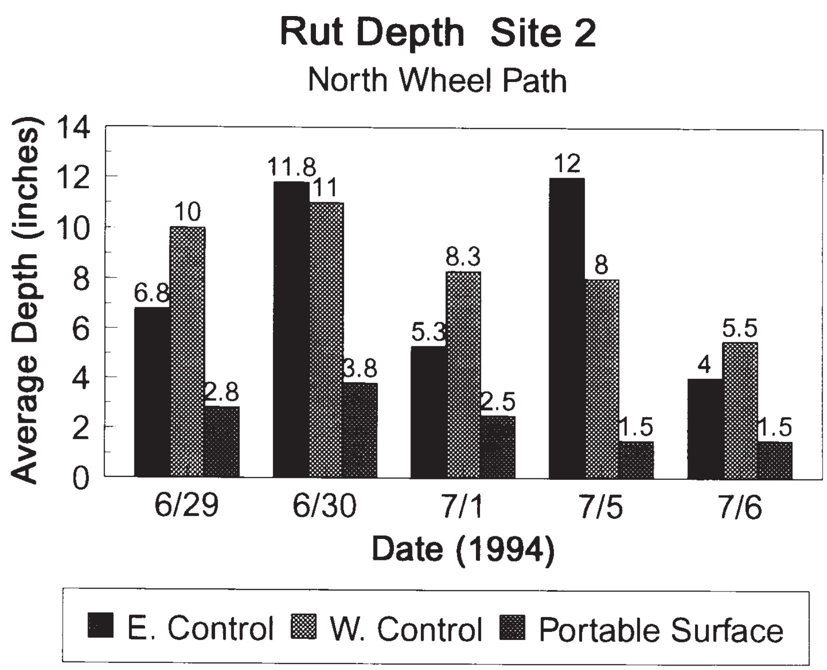


Figure 9. Comparsion of north and south wheel path rut depth—Site 1.



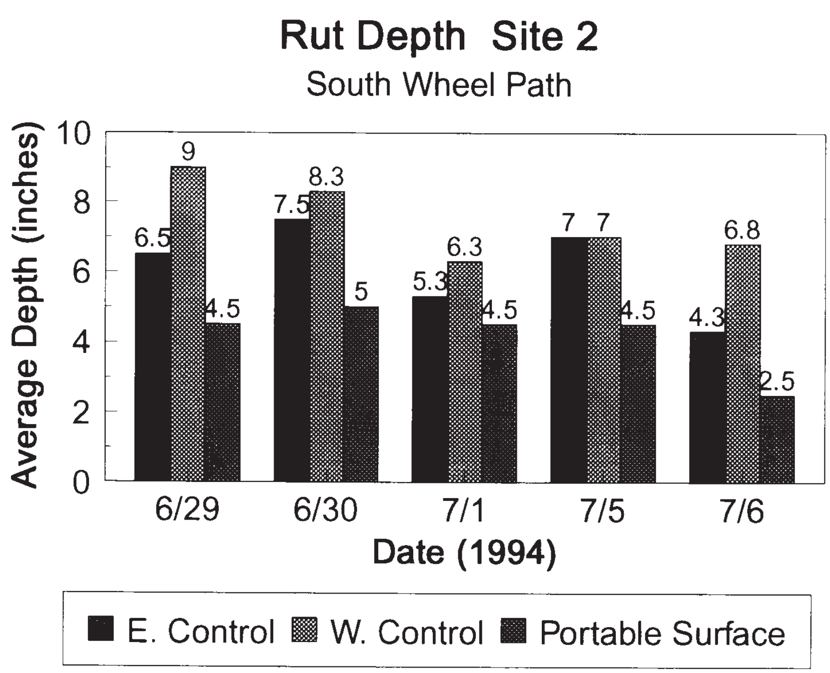


Figure 10. Comparison of north and south wheel path rut depth—Site 2.

For Site 2, determination of a final difference in rut depth was difficult. Deep ruts formed at the ends of the grating which lead to the drivers maneuvering the vehicles out of the ruts and to the side of the portable surfaces. Lateral movement of the soil continuously changed rut location and development. Also, for the south wheel path, there appears to be an error in the location of the rut high point used for measurements. It is likely that the measured embedment is greater than the actual. However, from the collected data, the portable surfaces embedded up to 4 inches (102 mm) in the north wheel path and 5 inches (127 mm) in the south wheel path. This compares to ruts up to 14.5 inches and 9.5 inches (0.37 m and 0.24 m) in the control section in the north and south wheel paths. The difference between the control and portable surface section being up to 10.5 inches (267 mm) for the north wheel path and 4.5 inches (114 mm) for the south wheel path. See figure 10.

COMPARISON OF SURFACES

Table 1 summarizes information on the portable surfaces and crushed limestone aggregate. Crushed limestone aggregate is typically used to stabilize road beds in the north central Florida area. The table includes information on the weight and cost of each alternative including labor to construct the portable surfaces as well as costs for installation and removal. Geotextile is included in the cost of each portable surface. Costs are based on the quantity necessary to cross an unstable road bed section 30 foot (9.1 m) in length on a straight section of a single lane road. This would require: six grating with three placed longitudinally in each wheel path; ten grating placed perpendicular; two 8-foot by 16-foot (2.4 by 4.8 m) pallets cut in half with two 4- foot (1.2 m) sections placed in each wheel path; two 10-foot by 15-foot (3.0 m by 4.6 m) wood mats; or crushed limestone aggregate covering 10-foot by 30-foot (3.0 m by 9.1 m) and 8 inches (203 mm) in depth. Information on the useful life is too limited to determine life cycle costs. Unlike portable surfaces, crushed limestone aggregate is difficult and costly to remove and reuse. Transportation cost to the site is not included.

Table 1. Information on stabilization alternatives.

Surface Type	**Weight**		**Cost**	
(lb) (kN)	**($/ft^2)**	**($/m^2)**		
Grating				
Longitudinal	290	(1.3)	4.40	(48.89)
Perpendicular			7.25	(80.55)
Wood Pallet - Half	1260	(5.6)	4.20	(46.92)
Wood Mat, 4 inch	2060	(9.2)	2.35	(25.93)
Wood Mat, 6 inch	2810	(12.5)	3.15	(34.57)
Crushed Limestone Aggregate*	28000	(124.6)	1.12	(12.35)

*****Also, several applications of aggregate may be necessary depending on soil conditions and quantity of traffic.

The most effective surface depends on the project, equipment, available funding, and the initial and allowable final site constraints. For manual installation, the easiest and quickest is the grating. Wood mats can be assembled and disassembled on site, time permitting. For limited funding, wood mats made of 4 inch by 4 inch (102 by 102 mm) posts are the least costly. However, it is likely that all of the surfaces can be reused several times making all the portable surfaces worth the initial cost. For initial site conditions that are not flat, such as rolling dips, wood mats are the only surface that readily conforms to variations in road grade changes. None of the portable surfaces have been evaluated on steep grades with respect to potential problems of traction and movement. For final site constraints of little or no ruts, wood mats embed a small distance into the entire road bed width. The wood pallets leave very wide, shallow channels and the grating leaves deeper channels. The wood mats are recommended as the best overall portable surface from the three tested. In addition to the three portable crossings tested here, there are other portable surfaces available for crossing short sections of unstable road bed soil. One of the more recently available designs is discussed in *The Plastic Road* (SDTDC publication 9624 1206) and can be constructed and installed for approximately $63.00 per linear foot.

CONCLUSIONS

This report briefly described a field evaluation of the portable surfaces used to cross short sections of unstable road bed soil in north central Florida. The evaluation quantified their effectiveness in reducing rut depth from log truck traffic. This, in turn, reduces environmental impacts associated with rut development. Moisture content and cone penetrometer data were gathered to determine soil characteristics of portable surface and control sections. Cross section profiles were measured to compare rut depths in portable surface and control sections.

The control sections were determined to be conservatively representative of the portable surface sections. Thus, the rut depths that would have occurred in the portable surface sections would have been deeper than those that occurred in the control section if surfaces had not been used. For Site 1, there was a reduction in rut depth of up to 6.1 inches (155 mm) with embedment of the surfaces limited to 1.5 inches (38 mm). For Site 2, there was a reduction in rut depth of up to 10.5 inches (267 mm) with embedment of the surfaces limited to 5 inches (127 mm).

These surfaces have proven successful at reducing rut depth which limits impacts to the environment while providing continued access. By using the geotextile, erosion is limited during use due to the soil being retained by the geotextile. Future impacts are limited after removal with little or no blading to the original road bed conditions. Because embedment of the portable surfaces is limited, moisture interception and collection is limited. They have proven successful as alternatives for crossing unstable aggregate or native surfaced, low volume road beds under specific conditions. For the field evaluations performed, those conditions are short sections prone to continual rut development in silty sand soil road beds which provide access for log trucks. The surfaces are portable, temporary, reusable, inexpensive, and made of readily available products for road designers to consider as an alternative to intensive maintenance, reconstruction, or placement of crushed aggregate.

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