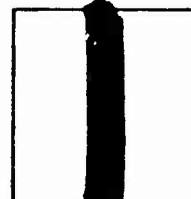


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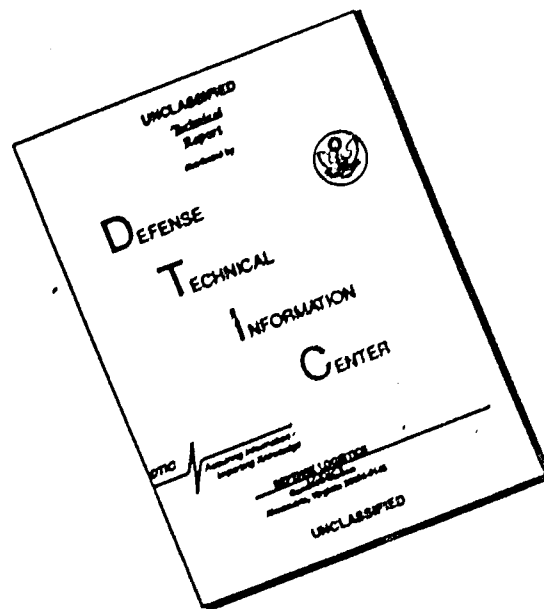
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SYLLABIE

This report covers a limited investigation made to correlate data on the trafficability of soils with the mobility of standard military vehicles and to present the results as tables or charts suitable for use by the Army and the Navy.

The investigation studied the principal factors affecting the trafficability of soils and investigated instruments and procedures for measuring these factors. Trafficability tests were conducted using certain military vehicles, and the results were correlated with the values obtained with the selected instruments and procedures. In addition, laboratory tests were conducted to determine the effect of varying moisture conditions on the trafficability of soils.

The time allotted for the study was so short that only a limited range of vehicles, soil types, and soil conditions could be tested. In addition, the accumulated data could not be subjected to thorough and complete analysis. Therefore, the information presented here must not be considered as entirely accurate or final. Additional study and testing are necessary to refine the data.

In this study, all standard military vehicles were divided into five classes (A, B, C, D, and E) depending on their ability to negotiate in mud. Density of traffic was divided into two groups: limited operation - less than approximately 25 repeated trips, and unlimited operation - greatly in excess of 25 repeated trips. For any given class of vehicle and density of traffic, the principal factors affecting trafficability of soils and the instruments or procedures selected for evaluating these factors are:

<u>Factor</u>	<u>Selected Instrument or Procedure</u>
Soil type	Grouping of soil types based on a modification of the Corps of Engineers (Casagrande) soil classification system.
Stability	Cone penetrometer instrument based on a modification of the North Dakota bearing apparatus.
Slipperiness and Stickiness	Moisture content in connection with liquid and plastic limits (standard soil tests).
Gradient	Mathematical method based on drawbar pull developed on level ground under similar conditions.

The results of the investigation indicate that soils can be divided into three phases of moisture conditions with respect to trafficability: (1) moisture content below about the plastic limit, (2) moisture content above the liquid limit, and (3) moisture content between about the plastic limit and just above the liquid limit. The soils in the first group exhibit semisolid characteristics. They represent normal off-the-road conditions which have not been considered as the principal problem of this report. Soils in the second group exhibit semiliquid characteristics and are so soft that bridging or roadways are required for vehicular traffic. The soils in the third group are in the plastic range and, in this report, have been termed mud. These soils present serious problems in predicting trafficability and in actual operations. Certain types of vehicles can traverse soils in this condition for limited operation but roadways are required for unlimited operation. The greater part of the traffic tests were conducted to obtain data for correlation of trafficability of this range of moisture conditions for limited operation.

On the basis of data obtained and observations and experience of personnel conducting the tests, a table has been prepared which shows the relationship of moisture content, cone bearing value (measure of stability), slipperiness, and stickiness to the mobility of standard military vehicles. Reconnaissance procedures for obtaining necessary data for use with the table are presented. With these data the table can be used to estimate, in broad brackets, the equipment that can operate, the minimum drawbar pull it can be expected to develop, and the maximum gradient it can traverse. In addition, a chart is presented showing the probable effect of variations in moisture content on the cone bearing values, slipperiness and stickiness. This chart can be used to estimate the effect of changes in moisture content caused by rain or periods of dry weather. The chart and table, which are presented in the report as figs. 18 and 19, respectively, are considered to be the most reliable information on the trafficability of soils that could be prepared in the allotted time.

In addition to the chart and table, general and specific conclusions on trafficability of soils and on the particular soils and conditions tested are made in the report. These conclusions appear on pages 20 through 22.

It is recommended that the information presented here be used for any present emergency and as a guide for future investigations. A suggested scope for future investigations is briefly outlined in the recommendations presented on page 23.

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TRAFFICABILITY OF SOILS

I. SUBJECT

1. Subject. This report covers a limited investigation of soils classification and trafficability in relation to military vehicles.

2. Authority. Authority for the investigation is contained in a letter dated 16 July 1945 from the President, The Engineer Board, to the Director, Waterways Experiment Station (through the President, Mississippi River Commission) subject, "Soils Classification and Trafficability Data (Service Project MRS 597)".

3. Purpose. The purpose of this study was to correlate data on the trafficability of soils with the mobility of standard military vehicles and present the results as tables or charts suitable for use by the Army and Navy.

4. Definitions. The words and terms listed in this paragraph are defined for use in this report as follows:

Mud. Soil and water mixtures of fine-grained plastic soils in the Corps of Engineers (Casagrande) classification SP, ML, CL, OL, MH, CH, and OH with moisture contents ranging from about the plastic limit to just beyond the liquid limit.

Cone Bearing Value. A measure of the stability of mud obtained with the cone penetrometer. The value is a dimensionless number representing the resistance to penetration of a 30-degree cone into the soil.

Mud Mobility. Ability of vehicle to move or be moved in mud.

Trafficability. Ability of soil to pass traffic.

Limited Traffic. Less than approximately 25 repeated trips.

Unlimited Traffic. Greatly in excess of 25 repeated trips.

Flotation. The distribution of a load over a sufficiently large area to prevent appreciable sinking.

Plastic Range. The plastic range is the range of moisture content between the plastic and liquid limits in which the soil is in a plastic state. The plastic range is numerically equal to the plasticity index. The liquid limit is the upper end of the plastic range and the plastic limit is the lower end.

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II. PREVIOUS INVESTIGATION

5. Previous Investigation. Previous studies relating to the classification and trafficability of soils were made in conjunction with the Engineer Board investigations of methods of crossing artificial mud areas which were conducted at Yuma, Arizona, Salton Sea, California, and Camp Hulen, Texas. Pertinent information from these investigations is included in this report. The details of the Yuma, Salton Sea, and Camp Hulen tests are covered by the Engineer Board report.

III. PRESENT INVESTIGATION

6. Personnel. This investigation was conducted by personnel of the Embankment, Foundation, and Pavement Division of the Waterways Experiment Station under the general supervision of Mr. W. J. Turnbull, Chief of the Division, and under the direct supervision of Mr. W. K. Boyd, Chief of the Flexible Pavement Branch. Mr. W. H. Jervis, Chief of the Embankment and Foundation Branch, assisted in planning the investigation. Mr. George W. Vinzant, Chief of the Operations Division, Waterways Experiment Station, gave valuable assistance in constructing the test sections and in obtaining various equipment that expedited the tests. Testing at Vicksburg was conducted by Mr. J. M. Griffith assisted by Messrs. J. F. Redus, Lawrence McConville, and other personnel from both branches. The soils investigation at Yuma, Salton Sea, and Camp Hulen were conducted by Mr. C. R. Foster who made the analysis of the data and prepared this report. He was assisted at Yuma and Salton Sea by Mr. Felton L. Bingham of the Waterways Experiment Station, and T/5 H. G. Hansen and other personnel of the Yuma Test Branch; at Camp Hulen by Messrs. David M. Groer, R. R. Guerra, and Edward Lindsay of the Galveston District Engineer Office; and at Vicksburg by Messrs. Stuart M. Fergus, John R. Lilly, and other personnel from both branches. The study was accomplished under the general direction of Mr. Gerard H. Matthes, Director of the Experiment Station. Acknowledgment is made to the following from the Engineer Board for advice and assistance in planning and conducting the test and in preparing the report: Col. C. W. Meyer, Lt. Col. G. E. Beverly, Major V. G. Gould, Major M. M. Popernik, Capt. W. R. Wallace, Capt. R. M. Minear, Capt. H. Garrett, Lt. H. E. Ricketson, Messrs. Edward A. Willis, Elmer Ward, W. B. Spangler, and Miss Loring Nicholson.

7. General.

a. Preliminary Studies. Conferences of representatives of the Office, Chief of Engineers, the Engineer Board, the Navy Department, the Ordnance Department, and the Waterways Experiment Station were held

at Yuma, Arizona, on 4 July 1945, and at Fort Belvoir, Virginia, on 11 July 1945, at which time the present soils study was planned to determine (1) the trafficability of all major soil types (Corps of Engineer classification) at various moisture contents for all military vehicles, (2) the effect of density of traffic and gradients on vehicular mobility, (3) the classification of the soils found at the various test sites (Yuma, Salton Sea, Camp Hulen, Fort Pierce, and Vicksburg), and (4) the correlation between trafficability and California Bearing Ratio (CBR) data and/or the readings of the cone penetrometer.

b. Method of Approach. The study was divided into several phases, i.e., laboratory tests, traffic tests, a paper study of related reports and military equipment specifications, correlation of the data from tests at Vicksburg with that from other test sites and interpolation of trafficability of other soil types from test data.

8. Laboratory Tests. The laboratory tests were divided into tests to determine (1) the classification of soils found at the various field areas, (2) the correlation of cone bearing with California Bearing Ratio, and (3) the effect of varying moisture content on cone bearing values.

a. Classification. Soils classification tests consisting of sieve and hydrometer analysis, liquid limit, and plastic limit were made on all soils tested at Vicksburg and on representative samples of soils tested at Yuma, Salton Sea, Camp Hulen, and Fort Pierce. On the basis of these tests and visual observations, the soils have been classified according to the Corps of Engineers (Casagrande), Public Roads Administration, and Ordnance systems. The results of the tests together with the classifications are shown on figs. 1 and 2. Charts showing summaries of these three classification systems are presented in Appendix A.

b. Correlation of Cone Bearing with California Bearing Ratio. Comparison tests were made using the standard North Dakota Cone Bearing apparatus (30-degree cone) and the California Bearing Ratio apparatus. The procedure for performing the cone test is described in the Yuma Test Branch Test Report No. 47 and in Volume 22 of the Proceedings of the Highway Research Board. The North Dakota Cone Bearing apparatus was used rather than the cone penetrometer in this correlation since it can measure a wider range of stability values; however, the readings obtained with the two types of cone bearing instruments are practically identical. For comparison of the two cone bearing instruments see Yuma Test Branch Report No. 67. The procedure for performing the California Bearing Ratio test is given in TM 5-255, Aviation Engineers. The result of the correlation tests are shown on fig. 3.

c. Tests to Determine Effect of Varying Moisture Content on Cone Bearing Values. Tests were made on prepared soil samples from the traffic areas at Yuma, Camp Hulen, and Fort Pierce. Approximately 1 cu yd of each of these materials was first dried, then pulverized, and

thoroughly mixed with water to form a heavy slurry well above the liquid limit. The slurry was then poured into forms 3 ft sq by 2-1/2 ft deep which had been placed on a 6-inch layer of free draining sand. Moisture was permitted to drain through the sand at the bottom and to evaporate from the surface. No attempt was made to increase the density by compaction and except for periodic sampling operations the material was not disturbed during the entire period of test. In addition to the soil samples previously mentioned, five local materials were prepared in the same manner but on a larger scale. These soils ranged from a nearly cohesionless silt to a highly plastic clay. Two forms 9 by 3 by 2-1/2 ft were constructed for each of the five soils. In one form partitions were placed at 3-ft intervals to permit running daily tests in triplicate. The soil in these forms was not disturbed except for the testing operations. In the second form the soil was remolded daily by mechanical tampers and by tramping by foot immediately prior to testing. Cone bearing values and moisture contents were obtained at the surface and at 6-, 12-, and 18-inch depths in all forms. The tests were made daily until either the bearing values exceeded 80 or until it was necessary to discontinue testing because of lack of time. Plots of cone bearing versus moisture content for each soil type except those from Camp Hulien are shown on figs. 4 and 5. Tests on materials from Camp Hulien were not completed in time to be included in this report. Grain size curves and physical characteristics of the materials tested are shown on fig. 1.

9. Traffic Tests. Tests were conducted in artificially prepared mud areas at Vioksborg to determine the mud mobility of typical vehicles in mud of various depths and moisture contents and the effect of gradients and of traffic density.

a. Site. The tests were conducted at three sites as shown on fig. 6. Sites A and B contained 9 and 6 level sections, respectively; Site C contained one level section, one section on a 3-1/2 percent slope, and one section on a 7 percent slope. Soil conditions at the three sites were similar; however, there are differences in the plasticity of the soil at the three sites. Physical characteristics together with grain size curves of the soil in the three sites are shown on fig. 1. Preparation of the test sections, except No. 7, consisted of scarifying to depths of 12, 18, or 24 inches, and flooding. Section No. 7 was flooded without scarifying. Tests were made in each depth of scarified material under four conditions; flooded at time of test, and for three conditions in which the soil was allowed to dry back for varying periods of time. The variation of cone bearing and moisture content with depth was determined for each condition before traffic was started.

b. Trucks. Tests were made using 2-1/2-, 4-, and 6-ton trucks. A schedule of the tests conducted is shown on fig. 7. Standard high pressure tires inflated to highway pressures as designated by the Engineer Board Transportation Branch were used for all tests with the exception of a few tests conducted with low pressure tires. Tests were made both without traction devices and with standard high traction chains.

Tandem mounted chains were used on the 2-1/2- and 4-ton trucks with low pressure tires (photo on fig. 8) and on the 2-1/2-ton truck with high pressure tires (photo on fig. 9). Single mounted chains were used for the remainder of the trucks (photo on fig. 10). The test procedure consisted of making trips back and forth in a given traffic lane until the truck stalled, until 100 trips had been made, or until it was determined that the truck was travelling on a firm layer and would probably continue for 100 or more trips. Drawbar pull, depth of rut, cone bearing, and moisture content determinations were made after the first trip and at intervals throughout the test. Visual observations were made during the tests. The data obtained are presented in tabular form on figs. 11, 12, and 13.

c. Tractors. A majority of the tractor tests were performed with the standard D-7 and D-8 tractors both with and without wooden track extensions. A few tests were conducted with the special D-7 with 32-inch wide crawler tracks. The schedule of tests conducted is shown on fig. 7. Because of the lateness of arrival of the equipment these tests were not as extensive as were those with the trucks. The tractor tests were conducted primarily to determine the drawbar pull of the tractor alone for various depths of ruts and for different cone bearing values. Where there was no tendency for the freely moving tractor to deepen ruts readily, the tractor was held back by means of a cable and winch to force it to dig more rapidly. The criteria used to limit the duration of each test were: (1) 100 passes, (2) drawbar pulls in excess of 25,000 lbs, (3) ruts developed to full depth of scarification, and (4) failure of tractor to negotiate. Drawbar pull, depth of rut, cone bearing, and moisture content were determined after the first pass and at intervals throughout the test. Visual observations were made throughout the test. The data obtained are shown on figs. 14 and 15.

d. Crawler Wagons. Tests were conducted with 6-ton Athey crawler wagons as shown in the schedule on fig. 7. The procedure was similar to that for the tractors as outlined above. Wooden track extensions were used on alternate track plates on the wagons whenever they were used on the tractors and were removed from the wagons when not used on the tractors. It was impracticable to couple a dynamometer between the tractor and the Athey wagon so it was necessary to make drawbar pulls for the tractor alone and for the tractor and train in order to obtain the pull required to move the train. The data obtained are shown on figs. 14 and 15.

e. Mud Slods. A few tests were made with a mud sled constructed at the Experiment Station which was similar to the Engineer Board 4-ton cargo sled. A schedule of the tests conducted is shown on fig. 7. Drawbar pulls were determined between the towing unit and the sled. Cone bearing values and moisture content determinations of the material carrying the sled were made. The data are presented on figs. 14 and 15.

10. Correlation and Interpolation of Data. Investigations to determine the effect of repetitions of traffic and correlation of indicator values with trafficability consisted of reviewing information and data from the tests at Yuma, Salton Sea, Camp Hulen, and Vicksburg. Pertinent information was extracted from the tests and used in this analysis. Since the basic data for the Yuma and Salton Sea tests are available in report form, they have not been repeated. The basic data for the Camp Hulen tests are not available in report form and are presented on figs. 16 and 17.

IV: DISCUSSION

11. General. This discussion is divided into three phases. The first phase is a general discussion of the classification of soils and soil conditions under consideration and the factors affecting trafficability of muddy areas. This phase also discusses the magnitude of the problem and the limitations of this particular test program. The second phase covers the indicators selected for use in predicting trafficability. In connection with this phase, an appendix is presented which gives recommended reconnaissance procedures. In the third phase, the correlations between the trafficability of the muddy areas, the mud mobility of the vehicles tested, and the indicator values are presented. On the basis of these correlations, a general table showing the trafficability of soils in general and the mud mobility of all standard Army vehicles is presented. This table is of necessity limited to broad brackets.

12. Trafficability of Muddy Areas.

a. Classification System. Soil classification systems have been used by the Corps of Engineers, the Public Roads Administration, the Ordnance Department, and various other agencies to classify soils to fit their particular needs. Geologists and agriculturists have also developed classification systems. The systems in use by the Corps of Engineers (Casagrande classification), the Public Roads Administration, together with geological and agricultural soil terms are discussed in paragraph 94 of TM 5-255. Of all the systems considered, the Casagrande system (the Corps of Engineers classification is referred to as the Casagrande system throughout most of this report) appears to be best adapted to classification of soils for trafficability. The Casagrande system, however, was devised primarily for classifying soils for airfield pavements where base courses and pavements are used, and the fine-grained soils are grouped in order of their rating for stability as subgrades. These subdivisions of the fine-grained soils do not give the desired grouping for classifying soils for trafficability where no base courses or pavements are used. In general, the soil conditions considered in this study are for high moisture

contents where there are relatively small differences in stability of the various fine-grained plastic soils. There is however considerable difference in the stickiness and slipperiness of the various fine-grained plastic soils which appears to be related to plasticity. Therefore, in this report the fine-grained plastic soils have been grouped on the basis of plasticity index.

b. Soil Conditions under Consideration. In general, any of the fine-grained plastic soils (Casagrande classifications SF, ML, CL, OL, MH, CH, and OH) or coarse-grained soils with plastic binders (GC, GF, and SC) can become muddy. Also under certain conditions of water table, the nonplastic soils (GW, GP, SW, and SP) can present problems in trafficability. But the more numerous and serious trafficability problems will be encountered in the first named group, the fine-grained plastic soils, and traffic testing was limited to this group. The term "mud" as used in this report refers to soil and water mixtures within the range of moisture contents from about the plastic limit to just beyond the liquid limit. This range of moisture contents covers cone bearing values from about 5 at or just beyond the liquid limit to about 80 or more in the neighborhood of the plastic limit. The following descriptive adjectives have been selected to designate consistency of mud in these ranges:

<u>Cone Bearing</u>	<u>Adjective</u>
Less than 15	Fluid
15-35	Very soft
35-50	Soft
50-80	Stiff
Above 80	Firm

Information on the stability of soils under controlled conditions is summarized in paragraph 96 of TM 5-255. The system adopted by the Corps of Engineers for measuring stability of soils for flexible pavements, which is probably most closely related to this study, is presented in paragraph 131 of TM 5-255. In this system, a relative modulus of shearing resistance, designated California Bearing Ratio, is used as a measure of the stability of the soil. The range of CBR values that can be expected for the different soils is shown on the charts presented in paragraph 131 of TM 5-255 (fig. 68 and 69). It is noted that the smallest CBR value shown is 3. A CBR of 3 is equivalent to a cone bearing of about 90 (see paragraph 15 of this report), so it can be seen that the stabilities of the muds under consideration have as their higher value approximately the lowest CBR usually measured. The stability values for mud are therefore much less than any stability values previously considered. In general, this investigation deals mostly with mud having cone bearing values between about 15 and 80. For values below 15, bridging or roadways are required which are beyond the scope of this report. Values above 80 represent normal off-the-road conditions which were not considered the principal problem in this investigation.

c. Factors Affecting Trafficability of Muddy Areas. In the investigation of the trafficability of loose sands, previously conducted by the Engineer Board, a definite answer was found. The loose sands had more than sufficient strength for support and for traction provided the sand could be confined. The answer was large, low pressure tires which provided the confinement. But a definite answer has not been found in the case of the trafficability of muds. As noted in the previous paragraph, the strength of the mud is very low. For comparison, the loose sands would probably have a minimum CBR of around 8 when confined (see range of CBR values for SP, SW, and SC soils on fig. 68 of TM 5-255) which is a cone bearing of about 240. The mechanics of vehicle operation in muddy areas are the same as on dry areas except that the strength of the muddy soil is very low. In either muddy or dry areas the vehicle develops traction through contact of the tires or tracks with the ground in order to overcome the rolling resistance. In the muds investigated, the first pass caused considerable rutting or shear deformation and successive passes caused additional shear deformation, deepening the ruts. As the ruts deepened and exceeded the ground clearance of the vehicle, the traction tended to decrease and the rolling resistance to increase. When the two were equal the vehicle was immobilized. Thus it can be seen that the problem of trafficability of muddy areas is that of either "floating" the equipment on the surface or a problem of estimating a rate of failure. For any given soil type there are several factors that affect the trafficability of muddy areas each of which affects either the tractive effort or the rolling resistance of both. In this report, factors of flotation or stability, slipperiness, stickiness, gradient, and repetitions or density of traffic are recognized and analyzed. The effect of each of these on tractive effort and rolling resistance is discussed below. The type of traffic is also a factor, but since this is a different phase of the study it is covered in Appendix D.

(1) Flotation. In order for vehicles to traverse a muddy area there must be a layer of firm soil with sufficient strength so that it will not shear out from under the tires or tracks to the point where the vehicle rests on its undercarriage before the contemplated operations are completed. The depth at which this firm layer is found has a decided influence on the trafficability of the area. During the traffic tests the following terminology regarding the depth to this firm layer has been developed. "Bottomless mud" is the condition where the strength of the mud is uniformly low to a depth greater than will be affected by traffic. "Deep mud" is the condition where the depth to the firm layer is more than 10 inches. Where the depth to firm layer is less than 10 inches, the condition is termed "shallow mud". "Surface mud" designates the case where the top 1 to 2 inches of a firm layer is muddy. These values have been more or less arbitrarily set on the basis of observations during the tests.

(2) Slipperiness. Slipperiness affects the trafficability in that it reduces the traction. Although a material may be capable of supporting the vehicle, the surface may be so slippery due to surface water that the tires or tracks slip and do not develop sufficient traction to overcome the rolling resistance.

(3) Stickiness. A sticky mud adheres tenaciously and builds up to the point where it scrapes the fenders or carriage. In this way it increases the rolling resistance sufficiently to immobilize the vehicle.

(4) Gradient. The effect of an upward gradient or slope in the route traversed is to increase the rolling resistance. A steep slope may also cause a slight reduction in traction due to change in tire load caused by the shift in center of gravity of the weight of the truck.

(5) Repetitions or Density. Repetitions affect trafficability in two ways. In the first, successive passes of the vehicles cut down deeper until finally the ruts are so deep that the vehicles are resting on the undercarriage. In the second, each pass of the vehicle may remold the underlying material causing a reduction in strength. From experience in other studies, this second effect would be greater for natural areas than for artificially prepared areas.

13. Limitations of Test Program. In the directive issued for this test by the Office, Chief of Engineers, is a statement that is recognized that several years would be required to compile data whereby the trafficability of soils could be predicted accurately. The problems encountered in this investigation serve to emphasize this fact. It is pointed out that this investigation has merely scratched the surface. In one sense, this study deals in a range of soil conditions that have not been considered before, and new instruments and procedures are probably necessary. The time allotted was so short that even existing tests such as shear strength could not be investigated. The cone penetrometer which was used in this test is a modification of the North Dakota Cone Bearing device which has been in use for years. Although fair results were obtained with the cone penetrometer, the testing program cannot be considered adequate to prove the instrument. Only a narrow range of soil types and conditions could be tested and only one soil type in one condition was tested on slopes for the effect of gradient. Also, adequate information on soil conditions before and during traffic was not obtained in every case. Only a limited number of vehicles were tested and none were tested that had been designed solely for mud operation. The methods and equipment for obtaining the drawbar pull and the pull required to tow crawler wagons were not entirely satisfactory. The tables of test data (figs. 13 to 17, incl.) were prepared hastily and are not in the most desirable form. The remarks on operation and reason for immobilization represent transcriptions from field notes with little or no editing, and in some cases the meanings are not clear. Also, several obvious errors have been found already, and it is expected that more will be found. In the preparation of the report only a limited analysis of the accumulated data could be made which was not complete or thorough. On the basis of these analyses tentative trafficability and mud mobility values are given for the vehicles tested. Where possible, reasonable interpolations were made for cases not tested. In other instances the tentative values are based on conservative estimates. It is emphasized that the analysis and conclusions made in this report are not entirely accurate or final and must be

considered as merely the best answers that could be given in the limited time available. Additional study is needed on practically all phases of the investigation.

14. Indicators. The previous investigations on the selection of indicators (see Yuma Test Branch Test Reports 47 and 67) were reviewed and the correlations with trafficability presented in report No. 67 were studied. It was considered that the correlations obtained for cone bearing values required for flotation were reasonable. It is pointed out, however, that the technique of using the cone penetrometer introduces a considerable personal element that leads to scattering of data. In conducting the cone penetrometer test, the cone is forced into the soil to the depth desired, the load is released, and then reapplied slowly until the cone just starts moving. Differences in both the rate of reapplication of the load and the determination of the point at which the cone just starts moving cause scattering of results. In this investigation duplicate, and often triplicate, readings were made. The variation between individual readings averaged about 15 percent plus or minus, and variations of 25 percent plus or minus were not uncommon. Some of this variation was due to differences in soil conditions but a large part of the variation was due to differences in test techniques. The scattering of results probably would not be permissible in a deliberate investigation, such as a soils survey for design of an airfield, but it is believed that it is about the minimum that can be expected if instruments suitable for rapid reconnaissance are used. For these reasons the cone penetrometer is considered a satisfactory reconnaissance instrument for obtaining a measure of the relative stability of soils for use in estimating trafficability. The correlation data contained in the Yuma Test Branch Test Report No. 67 on the use of the moisture content together with Atterberg limits to predict slipperiness and stickiness were studied. Although the data were limited, there was a definite trend that was in agreement with accepted ideas on the plastic range of soils. In view of the limited time allotted for testing, it was decided that no new reconnaissance indicators for determining slipperiness and stickiness would be tested and work would be concentrated on obtaining moisture contents for correlation with trafficability. Fairly reasonable correlations were obtained as shown in paragraph 18. Therefore, the moisture content in connection with the Atterberg limits has been selected as the indicator for slipperiness and stickiness. It is recognized that this is not a field reconnaissance indicator for immediately determining slipperiness and stickiness; however, it is considered satisfactory if time is available for conducting the relatively simple moisture and limit tests.

15. Correlation of Cone Bearing with California Bearing Ratio. It can be seen from Fig. 3 that the average ratio between the cone bearing and the California Bearing Ratio is about 30 to 1, that is, a cone bearing of 30 is approximately equivalent to a CBR of 1. From this study it can be seen that the range of cone bearing of from 0 to 80 measures the extreme low range of strengths on a magnified scale as compared with CBR values.

16. Effect of Variations in Moisture Contents. Variations in moisture content of a mud affect the cone bearing value, the slipperiness, and the stickiness. The effect of each is discussed below.

a. Cone Bearing. The tests on the samples in the forms were conducted in such a manner that the variation of cone bearing with moisture could be determined for different depths in the soil and for the condition of remolded daily as compared with the not remolded condition. The initial plots were made grouping cone bearing results for tests at different depths. There was a slight trend for the cone bearing value (for equal moisture contents) to increase with depth but in general the scattering of the data was such that separate plots were not justified. In the plots shown on figs. 4 and 5 test results are plotted without regard to the depth at which the test was made. Separate symbols are used, however, for tests on samples remolded daily and on samples not remolded as shown on figs. 4 and 5. The difference between the two types of tests does not justify separate curves. The samples with the higher plasticity indexes dried so slowly that tests were not completed throughout the entire range. The curves for the higher cone bearing values on these samples are projections which are shown by dashed lines. The samples from Camp Hulen arrived so late that only a few values in the extreme low range of bearing values were obtained, and curves are not presented. The fact that the samples with high plasticity indexes did not dry as fast as those with low plasticity indexes indicates that after certain conditions, such as periods of prolonged rain, highly plastic soils will require longer to dry back to normal off-the-road conditions than soils of low plasticity. The curves on fig. 4 and 5 indicate that the cone bearing varies directly with the moisture content. When the mud is at the liquid limit, the cone bearing is about 5 for the more plastic soils. The cone bearing increases with a decrease in moisture content reaching an approximate value of 80 or more at the plastic limit. In general, the more plastic soils show a lower rate of increase than the less plastic soils. It is known from studies in connection with the CBR test that the density (unit weight) is an important factor in the stability of soils with cone bearings greater than 80; however, in these tests the density apparently had very little effect on the cone bearing. The upper left-hand diagram on fig. 5 shows a plot of cone bearing versus moisture content for tests made before traffic in the Vicksburg test areas. The points do not form regular curves as obtained in the laboratory tests; however, there is a general trend for the cone bearing to increase with a decrease in moisture content.

b. Slipperiness and Stickiness. The slipperiness and stickiness of muds appear to be related to the moisture content and soil type. Test data indicate that muds are slippery above the liquid limit and as the moisture content decreases, the mud passes through a sticky stage and then into a state where it is not sticky. Since the moisture content is used as an indicator of slipperiness and stickiness, more detailed discussion of the effect of moisture content is given in connection with correlation (paragraph 18).

17. Effect of Repetitions of Load (Density of Traffic).

a. Repetitions Required to Cut Excessive Ruts. An attempt was made to develop plots of the test data that would show the number of passes required to develop ruts that would immobilize vehicles, but the plot was not successful. If additional time were available, it is believed that such a plot could be developed. Analysis of this phase has been made by inspection of the tabulated test data. In general, two things were noted. The first is that in most cases where the vehicle made a considerable number of passes, it was operating on a firm hard layer and conditions were not severe. The second is that if trucks cut a rut more than 10 inches deep on the first trip it was almost sure to become immobilized on the first trip. For these reasons it is believed that the trafficability of muddy areas should not be considered for more than limited traffic.

b. Remolding Effect. Analysis of the effect of remolding under traffic has been made by comparing the cone bearing value in the rut with the cone bearing value obtained at the same depth before traffic was applied. The increase or decrease has been computed as a percentage of the "before-traffic" cone bearing value and is shown on the tables of test data for the Vicksburg and Camp Hulen traffic tests (figs. 11 to 17, incl.) in columns labeled "Percent" under the major column heading "During Traffic Data". Data were not available for the tests made at Yuma and Salton Sea. Analysis of the data for Camp Hulen, which was a natural area, shows that the cone bearing value in the surface of the rut averaged about 40 percent less than the cone bearing value before traffic. The data for the Vicksburg areas, which were artificially prepared, show no consistent trend as the cone bearing value in the ruts was higher than the "Before Traffic" value in some cases and lower in others. This indicates that the remolding effect of repetitions of traffic causes a loss of stability in natural areas but has very little effect in artificially prepared areas. For limited operation, however, the remolding effect of repetitions of traffic would probably not be serious for either natural or artificially prepared areas since successive passes of the vehicles tend to cut down to a fresh layer.

18. Correlation of Indicator Values with Trafficability.

a. General. Correlations are presented below for the indicator values obtained at Yuma, Camp Hulen, and Vicksburg. The correlations for Salton Sea data are included with the Yuma values. The traffic data from Fort Pierce were so limited that no correlation is presented.

b. Flotation. Correlation of cone bearing with ability to support the vehicles was made by studying the cone bearing values taken before traffic and after traffic and selecting a reasonable cone bearing for the material on which the vehicle was operating. In selecting this value, more weight was given to the "before-traffic" data than the "during-traffic" data except where the "before-traffic" cone bearing was less

than the "during-traffic" value. This condition indicates that compaction occurred and in view of the fact that the material was saturated it is doubtful if much compaction occurred in the short time of the traffic tests. Some weight was also given to the cone bearing at a depth of 5 inches in the ruts as this material has a definite effect on the bearing capacity of a given muddy area. The minimum cone bearings necessary for flotation of different vehicles in the traffic tests at the various sites together with a summary are given below. In the summary safety factors have been included in some instances where the data are not definite.

(1) Tractors with 60-Inch Extensions and Special D-7.

Yuma. Operated on layer with cone bearing as low as 12.

Hulen. Operated on layer with cone bearing of about 15.

Vicksburg. Operated on material with cone bearing in range of 12 to 20.

Summary. Minimum cone bearing of about 15 required for limited operation.

(2) Tractors without Extensions.

Yuma. Operated on material with cone bearing of from 25 to 50.

Hulen. No tests.

Vicksburg. Operated on layer having cone bearing of about 30 to 35. Stuck in 11-inch rut.

Summary. Minimum cone bearing in the range of 35 to 50 within 10 inches of surface required for limited operation.

(3) Athey Wagons.

Yuma. Without extensions wagons sunk to firm bottom where cone bearing was in excess of 55.

Hulen. Wagons with or without extensions operated on material having a cone bearing as low as 15. In two tests wagons were stuck in 6- to 7-inch rut. Extensions on alternate track plates helped.

Vicksburg. Operated on material with cone bearing as low as 35 without extensions. Extensions caught on bed of wagon on numerous occasions.

Summary. Athey wagons without extensions require layer with minimum cone bearings in the range of 35 to 50 within 4 inches of the surface for limited operation.

(4) Mud Slods.

Yuma, Hulen, and Vicksburg. Slods operated on cone bearing around 10.

Summary. Slods will operate where the cone bearing is about 15.

(5) Trucks with Traction Devices.

Yuma. Material with cone bearing in the range of 25 to 50 is required for limited traffic, layer must be within ground clearance.

Hulen. Cone bearing of about 60 was satisfactory for limited operation. Trucks stuck in ruts 7 to 16 inches deep.

Vicksburg. Trucks operate on cone bearing of 50; however, if the layer is not within 10 inches of the surface, trucks are liable to stick on first pass.

Summary. Minimum cone bearing in the range of 50 to 80 within 10 inches of the surface required for limited operation.

c. Requirements for Stability. The cone bearing values shown above represent the strength of mud required for flotation of the various vehicles. The depth at which this layer is found and the consistency of the mud above the layer are important factors in determining the trafficability of the mud. In general, the layer must be within 10 inches of the surface or the vehicle is liable to become immobilized on the first pass. However, if the mud overlying the firm layer is weak (a cone bearing of less than about 15) vehicles can operate at depths equal to or even greater than the ground clearance. This condition will often exist in artificially prepared muddy areas where a very soft to fluid mud overlies a definite, firm layer. In practically all the cases covered in this investigation the bearing value has increased with depth. Cases can be visualized where there will be a crust near the surface that has the required cone bearing value but the soil will not support traffic because of an underlying soft material. This condition was not tested but from

experience in other investigations it is considered that it is necessary that there be no decrease in bearing value below the firm layer for at least 18 inches for the requirement contained in the summaries above to be applicable. Conditions have also been noted where a firm silty soil accompanied by a high water table would pump water to the surface under the action of traffic and become impassable in a very short time. For these reasons the cone bearing requirements for trafficability cannot be used indiscriminately but must be evaluated on the basis of all existing conditions.

d. Slipperiness and Stickiness. Correlation of slipperiness and stickiness has been made by comparing the moisture content of either a sticky or slippery condition with the moisture content at the plastic and liquid limits. This has been done by converting the moisture content into a figure which is termed the percent in the plastic range. The range of moisture contents between the plastic and the liquid limit is considered the plastic range. This range is numerically equal to the plasticity index. The percent in the plastic range is determined by the formula

$$\% \text{ in P.R.} = \frac{WC - PL}{PR} \times 100$$

where WC is the given moisture content, PL is the plastic limit of the soil, and PR is the plastic range. This arrangement converts the moisture content into a ready index of its location to the plastic and liquid limits. For instance, if the WC of a given soil is 30 percent, it is necessary to know both the plastic limit, say 20 percent, and the liquid limit, say 40 percent, to be able to visualize its behavior as related to stickiness and slipperiness. But when this water content is converted to percent in PR, which is $30 - 20 / 40 - 20 = 50$ percent, the location of the moisture content halfway between the plastic and liquid limits is readily determined. This also gives a common index for all the soils. On the tables of test data, figs. 11 to 17, incl., the percent in the plastic range for the moisture contents is shown in the column "% in P.R." under the major heading "During Traffic Data". The analysis consisted of comparing percent in PR for conditions reported as slippery, sticky, not slippery, and not sticky.

(1) Correlation of Stickiness with Trafficability.

Very few valid points were obtained for stickiness in the field tests as definite stickiness did not often occur. These values were supplemented by comparison of conditions in the tests on effect of varying moisture content with known sticky conditions. Actual moisture contents (in percent in plastic range) for soil conditions which were below the sticky range, within the sticky range, and above the sticky range are shown in the tabulation on the following page.

Test Area	Percent in Plastic Range		
	Below Sticky	Sticky	Above Sticky
<u>Field Data</u>			
Yuma	40	60 - 90	Above 100
Hulen	65	Not determined	Above 100
Vicksburg Areas ABC	Below 40	Not very sticky	Above 100
<u>Laboratory Tests</u>			
Yuma silty clay	48	68 - 100	108
Hulen silty clay	25	50	58
Buckshot	30	60	86
Loess		Not sticky	
Vicksburg Areas ABC	31	75	100

Results of the tests are not definite enough to give precise correlation, but in general they indicate that soils with moisture contents between about 50 and 100 percent in the plastic range are liable to be sticky and soils below 50 percent and above 100 percent in the plastic range will probably not be sticky. This probable sticky range is shown in graphic form on fig. 18; however, on this figure it was found that the information could be shown better by plotting the moisture content as "Percent above the Plastic Limit". On this plot actual moisture contents of 15 and 18 percent for a soil with a plastic limit of 15 would be plotted as 0 and 3 percent above the plastic limit, respectively. When plotted in this manner, curves of varying plasticity index form reasonable nests of curves. The curves shown on fig. 18 for plasticity indexes of 0, 6, 12, 20, 30, and 45 were interpolated from the data presented on figs. 4 and 5. It was also noted that soils with short plastic ranges (low plasticity index) have little or no tendency to be sticky and that soils with high plasticity indexes are extremely sticky. The depth of mud is not as important for stickiness as for flotation. Cases have been observed (not in these tests) where vehicles were immobilized from stickiness where the mud was very shallow.

(2) Correlation of Slipperiness with Trafficability.

Correlation of slipperiness with trafficability is not very definite. For rubber tires, the data indicate that practically any moisture content within or above the plastic range is too slippery for the vehicles to negotiate. This is particularly true if the soil, although firm and at a relatively low moisture content, is covered with a little water or fluid mud. In the traffic tests practically all trucks without chains were immobilized on the first pass in the sections where water was standing. Trucks with chains and tractors were able to cut down to firm material and obtain sufficient traction to negotiate. For tires with traction devices and tracked vehicles, the slippery range is just beyond the sticky range. This slippery range is also shown in graphic form on fig. 18.

e. Gradient. By a simple mathematical analysis, the drawbar pull developed on level ground can be used to estimate the maximum slope that can be traversed under similar soil conditions. The drawbar pull on a level ground divided by the weight of the vehicle gives the tangent of the angle of maximum slope on which the vehicle can operate for similar soil conditions. Since the tangent is the same as percent of slope, except in ratio form, multiplication by 100 gives the percent of slope. For example, if a 25,000-lb truck develops 5,000 lb drawbar on a level area, the maximum slope it can traverse is an angle whose tangent is $\frac{5,000}{25,000}$ or 0.2. An angle with a tangent of 0.2 is a 20 percent

slope. The mathematical analysis can also be used to compute the drawbar pull a vehicle will develop and the pull required to tow vehicles on a given slope. Detailed explanation of the mathematical analysis is given in Appendix C.

(1) Field Correlation. The mathematical method was checked in the field by operating vehicles on level area, a 3-1/2 percent slope, and a 7 percent slope with similar soil conditions. A comparison of the actual drawbar pulls on the 3-1/2 percent and 7 percent slopes with the theoretical computed drawbar pulls is as follows.

Condition	Slope Percent	Drawbar Pull in Pounds	
		Actual	Computed
6-ton truck operating on scarified material, cone bearing 85+	0	6,500	---
	3-1/2	6,500	5,420
	7	3,500	4,190
6-ton truck operating on bottom of scarified layer, cone bearing 85+	0	11,750	---
	3-1/2	10,000	10,525
	7	9,500	9,250
D-8 tractor operating on scarified material, cone bearing 85+	0	15,300	---
	3-1/2	17,000	13,850
	7	14,250	12,050

From this comparison, it can be seen that the computed drawbar pulls are in fair agreement with the measured values for the truck. No explanation is known for the erratic drawbar pulls measured for the tractor on the 3-1/2 percent slope.

(2) Application. If the drawbar pull is to be useful for predicting maximum slopes, the drawbar pull expected under average conditions must be known. Plots of drawbar pull versus cone bearing were attempted but they were not successful. It is believed, however, that a relationship between drawbar pull and cone bearing value may be developed if more careful analysis of the data is made. In lieu of such a relationship conservative estimates were made, based on inspection of the tabulated

test data, of the minimum drawbar value that can be expected for the limiting cone-bearing condition. The minimum drawbar values in ratio of drawbar pull to weight of vehicle developed at the various tests are given below.

Vehicle	Cone Bearing	Minimum Ratio of Drawbar Pull to Weight of Vehicle at Indicated Test Site		
		Yuma	Camp Hulen	Vicksburg
2-1/2-ton truck ⁽¹⁾	50-80	0.12	0.10	0.24
4-ton truck ⁽¹⁾	50-80	0.11	0.10	0.23
6-ton truck ⁽¹⁾	50-80	0.10	0.10	0.20
Tractors with extensions	15-35	0.2 to 0.4	0.36	0.2 to 0.4
	35-50	0.4 to 0.6	-	0.4 to 0.6
	50-80	0.6 to 0.7	-	0.6 to 0.7
Tractors without extensions	35-50	0.2 to 0.3	-	0.2 to 0.3
	50-80	0.3 to 0.4	-	0.3 to 0.4

(1) Trucks equipped with traction devices.

The drawbar pull has been expressed as a ratio of the total weight of the vehicle rather than as a definite number of pounds to permit its application to a wide variety of equipment included in any one type. It is apparent that a total drawbar pull of the same magnitude would not be applicable both to a 6-ton truck and a jeep yet the ratio in proportion to their weight may be comparable. On the basis of these data, drawbar values for all soil types and for the several ranges in cone bearing values are estimated as shown in the table "Mobility of Standard Military Vehicles for Major Soil Types", fig. 19. It can be seen that the necessary interpolations and extrapolations of the basic data have been made in an orderly sequence and are believed to be reasonable. From the drawbar data shown on fig. 19, the maximum slope which any vehicle can traverse was computed as described in paragraph 18e and Appendix C; however, the values for maximum slope shown on fig. 19 were reduced by 20 percent to provide a safety factor which is considered as conservative.

19. Table of Trafficability of Major Soil Types. The chart "Mobility of Standard Military Vehicles on Major Soil Types" presented as fig. 19 was prepared on the basis of the correlations obtained as shown in the preceding paragraph. The chart divides the soils into two major groups on the basis of grain size. Coarse-grained materials are treated as one type and fine-grained materials are treated as another type. The Casagrande classifications for the different soils are shown; however, the grouping used in the Casagrande system was not well adapted to the problem

of trafficability especially for the fine-grained materials. The finer-grained groups are subdivided on the basis of plasticity index. Columns are provided which show approximate conditions of moisture content in percent above plastic limit (for explanation see fig. 18), cone bearing value at a depth of 10 inches, degree of slipperiness and stickiness, the class of vehicles that can operate, the drawbar pull they can be expected to develop, and the maximum gradient they can traverse. A column for hydrometer and sieve analysis was not provided inasmuch as the soils are grouped according to grain size. In addition, qualifying notes and remarks are given. The vehicles are classified by the first five letters in the alphabet in decreasing order of mud mobility. The vehicles covered in each class are given in Appendix D. The classifications of the vehicles actually tested were made in collaboration with representatives from Technical Divisions III and IV of the Engineer Board. Classification of the vehicles not tested was made by these representatives. It should be emphasized that this chart covers soils and vehicles that were not tested and its accuracy is still to be established; however, the chart contains the most reliable information that could be obtained in the allotted time. It is considered that the table can be used to predict trafficability of soils in broad brackets.

20. Prediction of Trafficability. In the prediction of trafficability of areas a survey of the route traversed is necessary. This survey should be conducted or at least supervised by a qualified soils engineer in conjunction with experienced equipment men. Details of conducting the survey and the specific information to be obtained from a soils standpoint are given in Appendix B. After the data from the survey are assimilated, it should be evaluated. Scattering of the data will be found which will be caused both by variations in soil conditions and limitations of the instrument used. In general, the data should be evaluated on the limiting case, that is, a low average value. Other conditions such as location of water table and covering of vegetable mat should be considered in evaluating the data. After the limiting conditions are selected the soil classification, liquid limit, plastic limit, moisture content above the plastic limit, and cone bearing should be compared with the entries on the table of "Mobility of Standard Military Vehicles," fig. 19, and the type or types of vehicles selected that can be expected to negotiate the area under consideration. From the other columns in the table the degree of slipperiness, stickiness, estimated drawbar pull, and estimated maximum gradient can be determined for the limiting condition. The limiting cone bearing values and moisture content should be compared with the plastic range of the soils by referring to the curves showing the variation of cone bearing, slipperiness, and stickiness with moisture content on fig. 18. With these curves estimates can be made of the effect of additional moisture such as rain or of additional drying. From the overall picture thus obtained, estimates of trafficability can be made.

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V. CONCLUSIONS

21. General. It is concluded that:

a. The time allotted for the investigation was too short for adequate testing and for complete and thorough review of accumulated data.

b. Further study of the trafficability of soils as related to the mobility of all types of military vehicles and equipment is needed to refine this relationship.

c. The principal factors that affect the trafficability of soils for a given class and density of traffic are the soil type, the stability, the slipperiness, the stickiness, and the gradient of the route.

d. The moisture content and density (unit weight) of a specific soil are very important factors in determining the stability. The moisture content is also a very important factor in establishing the degree of slipperiness and stickiness of soil.

e. Soil conditions can be divided into three groups with respect to moisture content: (1) soils with moisture content above the liquid limit, (2) soils with moisture content below a point approximating the plastic limit, and (3) soils with moisture content ranging from about the plastic limit to above the liquid limit.

f. The first group requires bridging or roadways and is beyond the scope of this report.

g. The second group represents normal off-the-road conditions which are not considered the principal problem in trafficability of soils for limited operation except for loose sands or similar materials.

h. The third group, mud, is the one which presents serious problems both in prediction of trafficability and in the actual operation.

i. More than limited traffic should not be considered in muds unless roadways are provided.

j. The modification of the Corps of Engineers (Casagrande) system used in this report appears suitable for classifying soils into major types for estimating their trafficability.

k. The table of mobility of standard military vehicles on major soil types, fig. 19, can be used as a guide to predict the trafficability of soils in broad brackets. Further investigation is necessary to verify the accuracy of the table.

l. It is necessary to follow the reconnaissance procedures presented in this report to obtain satisfactory data that can be used with the table referred to above to predict trafficability.

m. Qualified soils engineers are required to supervise the reconnaissance, evaluate the data, and predict the trafficability of an area.

n. The cone penetrometer is a satisfactory reconnaissance instrument for determining the stability of muds.

o. A satisfactory field reconnaissance instrument for immediately determining slipperiness and stickiness has not been found. The relationship of the moisture content to the plastic and liquid limits appears to be a reasonable basis for predicting the slipperiness and stickiness of soils, if time is available for conducting the relatively simple moisture content and limit tests.

p. The mathematical analysis of estimating the maximum traversable gradient on the basis of the drawbar pull developed under similar conditions on level ground appears reasonable; however, it is substantiated by actual test data for only one soil type and one condition.

q. The ratio of cone bearing values to corresponding California Bearing Ratio values is about 30 to 1. In general, the soil stabilities of interest to this investigation range between 0 and 3 California Bearing Ratio which are between 0 and about 80 cone bearing.

22. Specific. The following conclusions refer specifically to limited operation in muddy areas. On the basis of the range of soils and conditions tested, it is concluded that:

a. The present investigations are too limited to predict the trafficability of mud in excess of 10 inches in depth.

b. The classification of vehicles shown in Appendix D establishes suitable classes of mud mobility; however, extensive investigations are required to verify the grouping listed.

c. For each class of vehicle there is a fairly definite cone bearing value required for mobility.

(1) The depth to the required cone bearing value, together with the consistence of the mud above, are important factors in determining the trafficability of muds.

(2) If the overlying mud has a cone bearing value less than about 15, the vehicle may operate to depths approximately equal to its ground clearance.

d. Tractors with 60-inch extensions and the special D-7 require material with a minimum cone bearing value of about 15 within the depths indicated above.

e. Tractors without extensions require a minimum cone bearing in the range of 35 to 50 within 10 inches of the surface, except as noted in c(2) above.

f. Trucks with traction devices will operate on material with a minimum cone bearing in the range of 50 to 80 within 10 inches of the surface, except as noted in c(2) above.

g. Crawler wagons without extensions require material with a minimum cone bearing in the range of 35 to 50 within 4 inches of the surface. The operation of crawler wagons in nonadhesive mud can be improved by the addition of track extensions on alternate track plates. Crawler wagons are unsatisfactory for operation in sticky mud.

h. Mud sleds operate readily on material with a cone bearing of about 15.

i. The cone bearing values given in paragraphs d through h should be used to classify soils according to stability.

j. Traction devices are necessary for wheeled vehicles when operating in mud, as any of the mud conditions are too slippery for successful operation with rubber tires without traction devices.

k. Slipperiness does not appear to be a critical factor for rubber tires equipped with good traction devices or for track-laying vehicles equipped with grousers.

l. Under certain conditions, vehicles can be immobilized by sticky mud regardless of the depth to firm bottom.

m. Stickiness may develop when the moisture content is in the approximate upper half of the plastic range but is not a factor for other moisture contents.

n. The degree of stickiness of a soil increases with an increase in the plasticity index.

o. Flooded areas with a firm bottom within the operating depth of the vehicles should not be drained.

VI: RECOMMENDATIONS

23. It is recommended that:

a. The results of this investigation be used for any immediate emergency and as a guide for future investigation.

b. Additional study and analysis be made of existing data.

c. After the study referred to in b is completed and reported, a deliberate program be planned for investigating the trafficability of soils. A new program covering both limited and unlimited traffic should include:

(1) Tests on a representative range of soil types.

(2) Tests with representative types of vehicles.

(3) Tests on vehicles designed solely for mud.

(4) Provision for accurately determining drawbar pull for all vehicles on all soil types at several cone bearing values.

(5) Proper evaluation of soil conditions both before and after test.

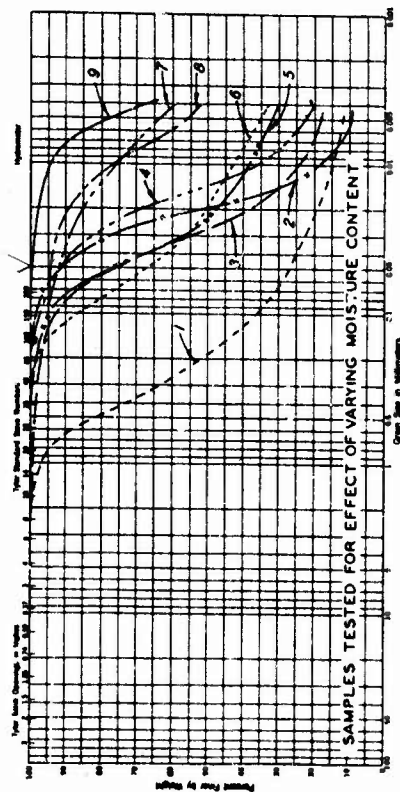
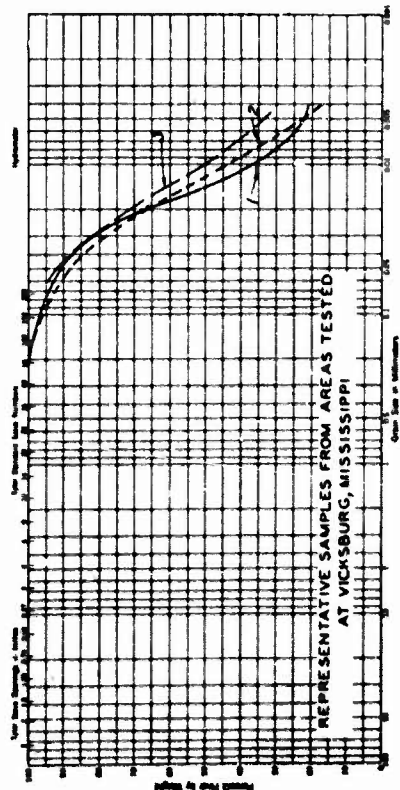
(6) Additional correlation with the present devices and continued exploration of additional test equipment.

(7) Laboratory tests as conducted during the present program and shear and unconfined compression tests on a comprehensive range of soils.

(8) Determination of trafficability on slopes.

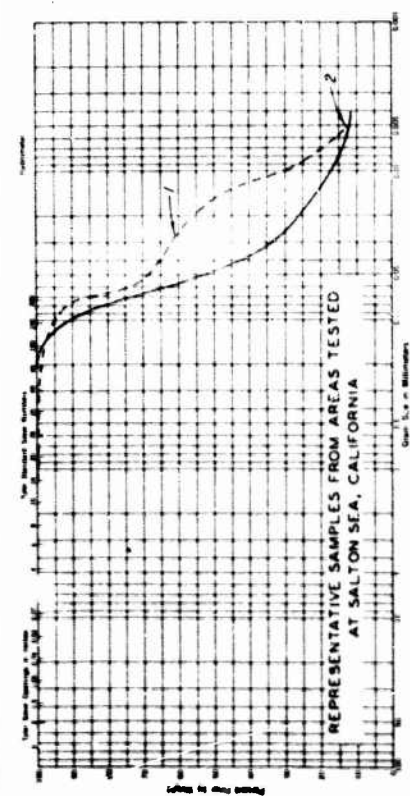
FIGURES

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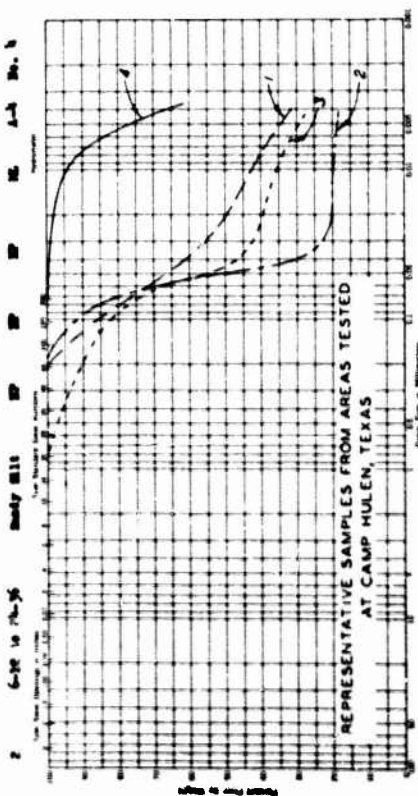


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FIGURE 2

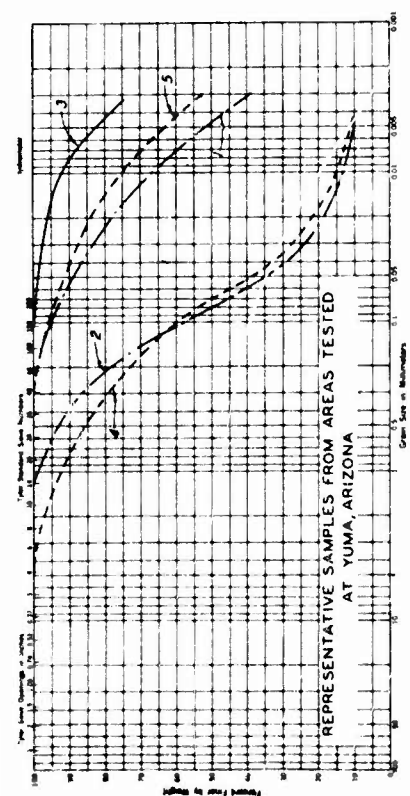


No.	Depth Below Surface	Material	Classification		
			Ca - Grade	Ordinance 7th Class	
		LL	PL		



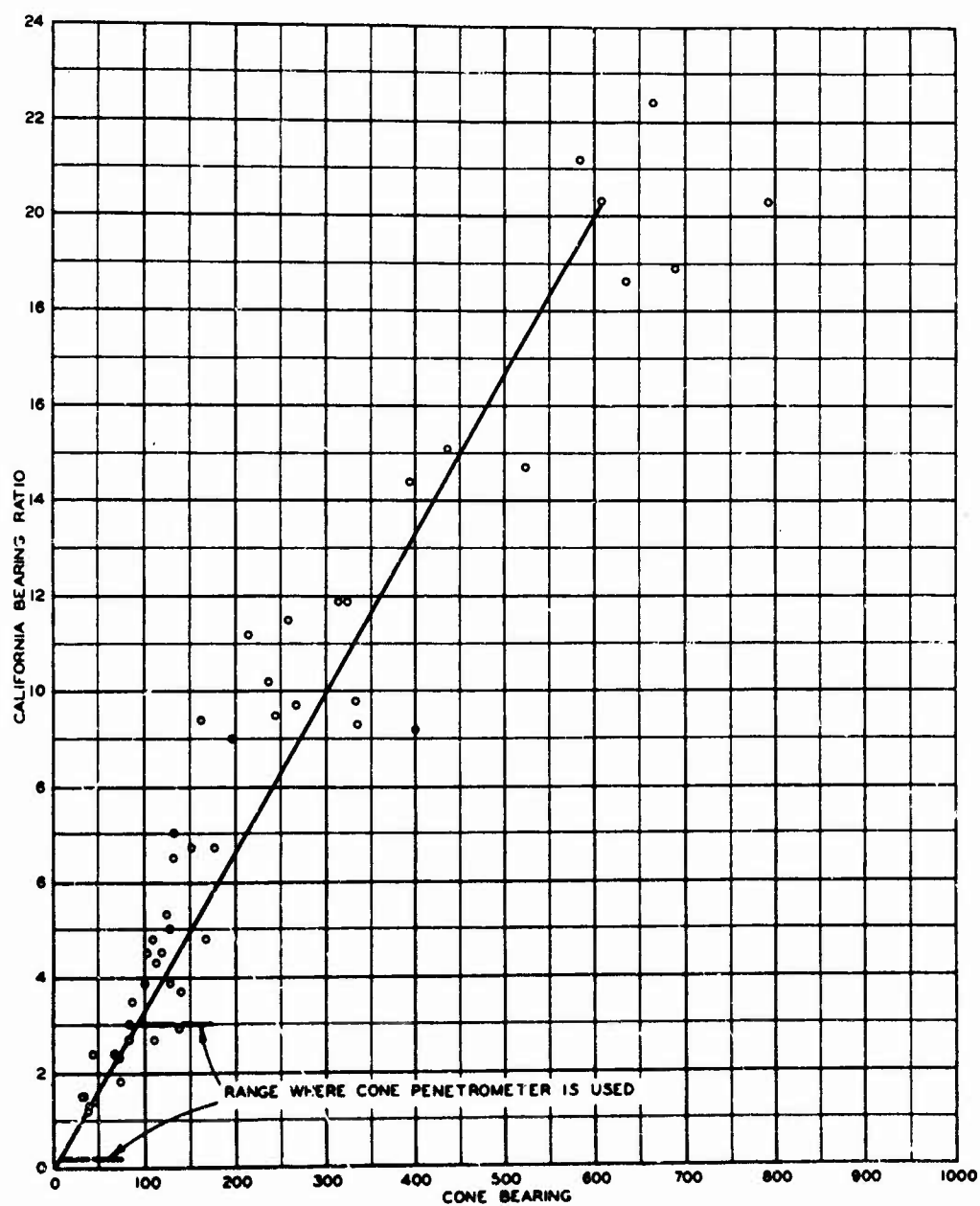
No.	Depth Stratum Number	Material	Classification		
			Case- Grades	PI	Class
			LL	PL	PI

(1) In northwest part of area only.



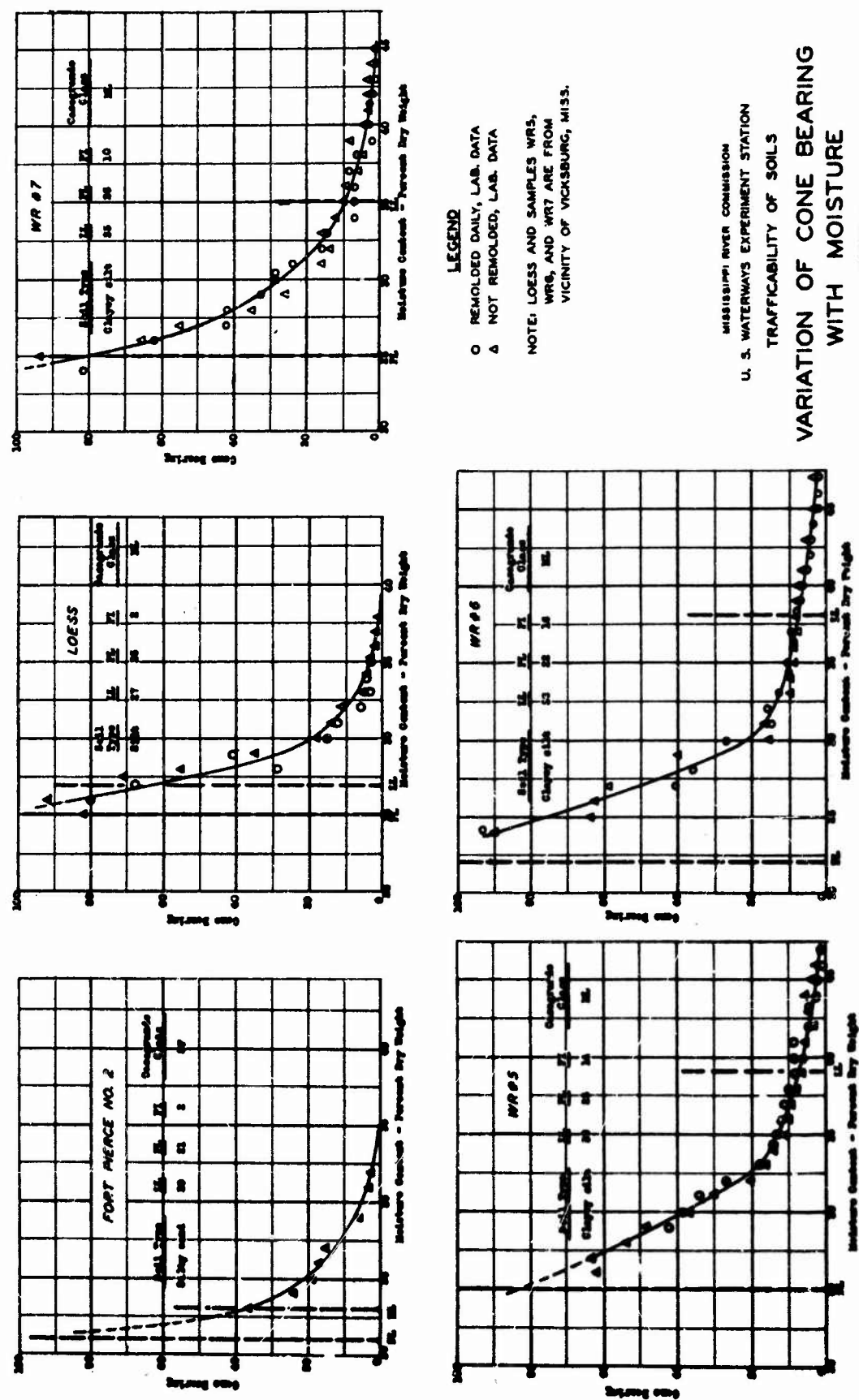
No.	Area	Depth Station Inches	Material	LL	PL	Classification	
						Case- grade	QA Class
1		0 to 24-30	Silty clay	48	20	CL A-4	Mo. 3
2		Below 30-50	Sandy silt	36	14	CL A-4	Mo. 3
3		0 to 66+	Clay	76	25	CL A-4	Mo. 3
4		0 to 12-18	Sandy silt	26	10	CL A-4	Mo. 3
5		Below 12-18	Silty clay	67	21	CL A-4	Mo. 3

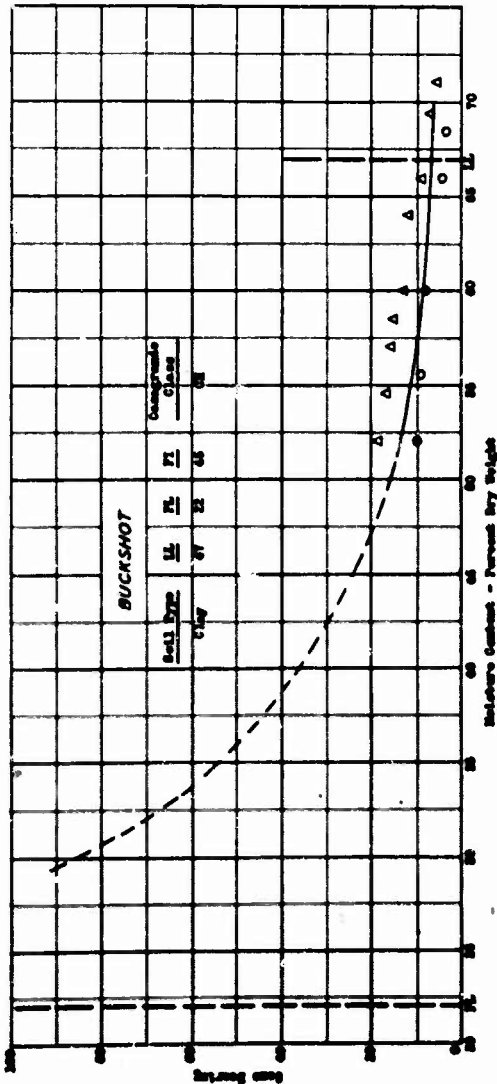
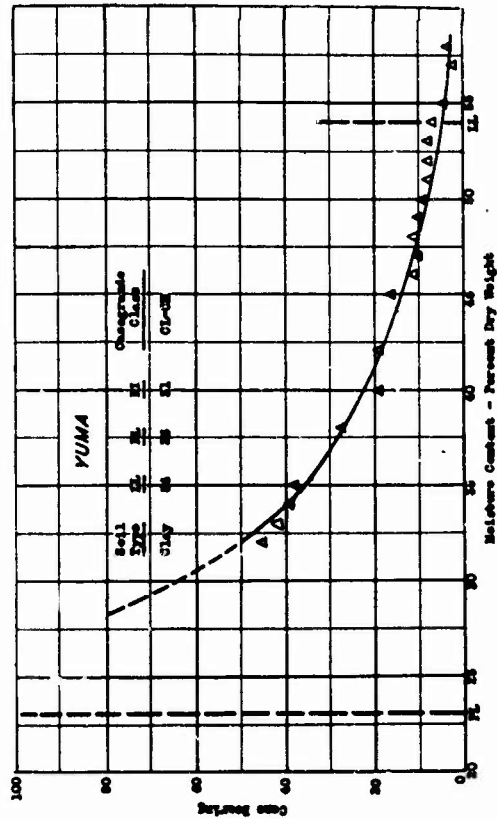
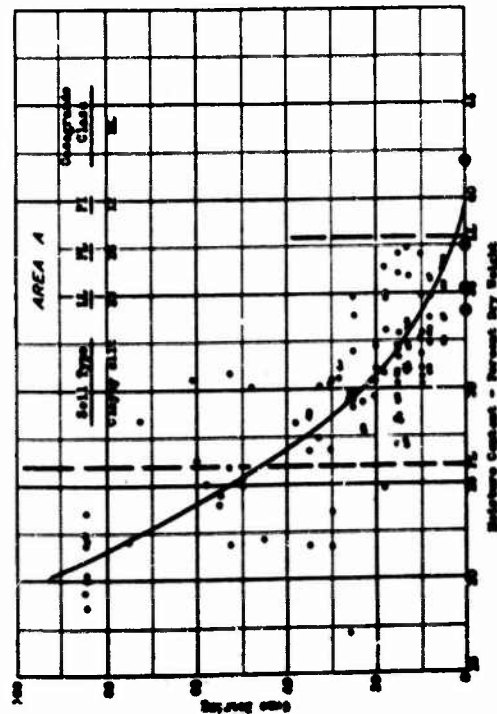
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TRAFFICABILITY OF SOILS
CONE BEARING
VS
CALIFORNIA BEARING RATIO

FIGURE 3





LEGEND

LABORATORY DATA

- REMOLDED ONLY
- △ NOT REMOLDED

FIELD DATA

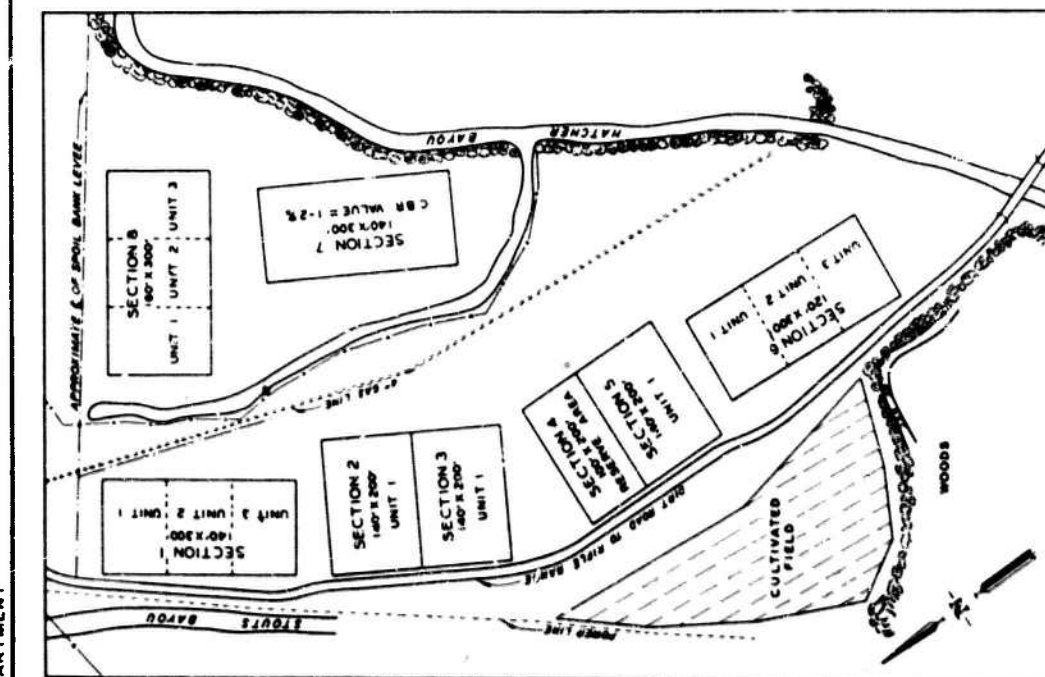
- INDIVIDUAL TESTS
- AVERAGE OF ZERO READINGS

MISSISSIPPI RIVER COMMISSION
U. S. WATERWAYS EXPERIMENT STATION
TRAFFICABILITY OF SOILS
VARIATION OF CONE BEARING
WITH MOISTURE
SHEET 2

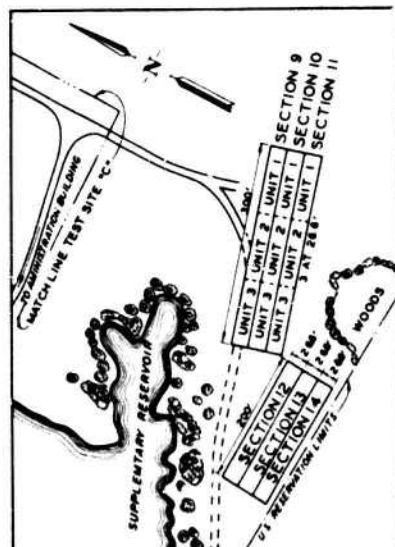
NOTE: AREA A AND BUCKSHOT SOILS ARE FROM VICINITY OF VICKSBURG, MISS.

FIGURE 5

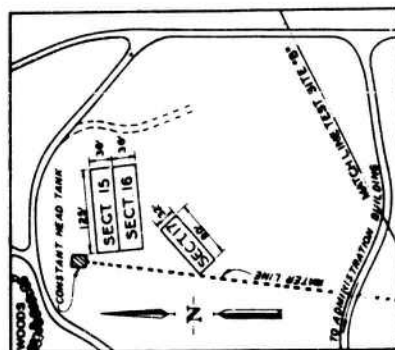
FIGURE 3



TEST SITE "A"



TEST SITE "B"



TEST SITE "C"

TABLED

TEST SITE "A"			TEST SITE "B"			TEST SITE "C"		
Section	Unit	Depth of Penetration	Section	Unit	Depth of Penetration	Section	Unit	Depth of Penetration
1	1	12"	10	1	18"	10	1	18"
2	2	12"	11	2	18"	11	2	18"
3	3	12"	12	3	18"	12	3	18"
4	1	12"	13	1	12"	13	1	12"
5	1	12"	14	1	12"	14	1	12"
6	1	12"	15 (1)	1	12"	15 (1)	1	12"
7	1	12"	16 (2)	1	12"	16 (2)	1	12"
8	1	12"	17 (3)	1	12"	17 (3)	1	12"
9	1	12"						

(1) = Section with 75 slope
(2) = Section with 65 slope
(3) = Section with 55 slope

MISSISSIPPI RIVER COMMISSION
U. S. WATERWAYS EXPERIMENT STATION
TRAFFICABILITY OF SOILS

LAYOUT SHEET FOR
TESTS AT VICKSBURG

[illegible]

FIGURE 7 SHEET 1

[illegible]

FIGURE 7 SHEET 2

[illegible]



FIGURE 8

SINGLE TANDEM MOUNTED CHAINS - LOW PRESSURE TIRES



DUAL TANDEM MOUNTED CHAINS - HIGH PRESSURE TIRES

FIGURE 9

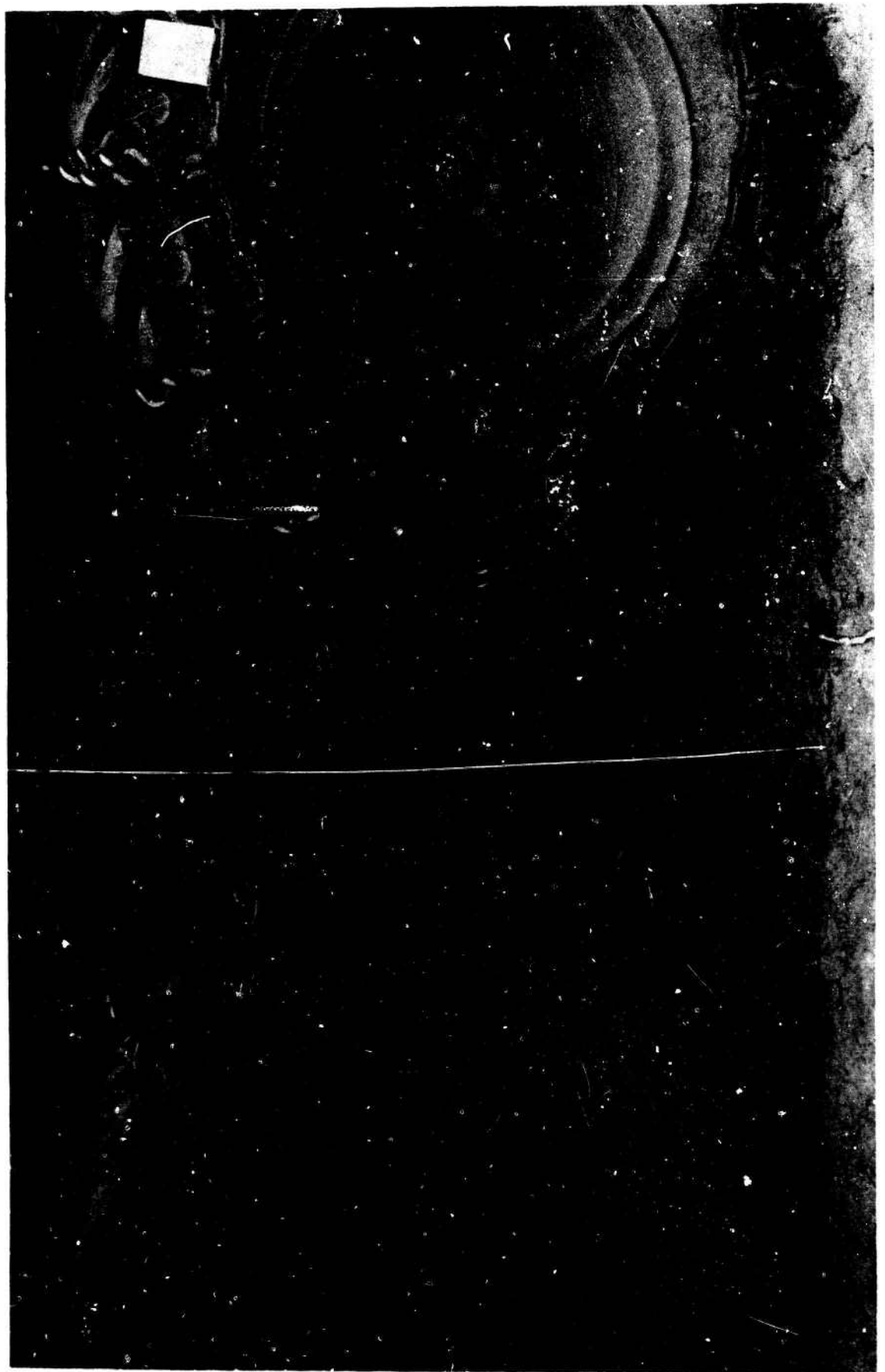


FIGURE 10

SINGLE MOUNTED CHAINS-HIGH PRESSURE TIRES

EQUIPMENT										OPERATION		LOCATION			SOIL					
Tires					Traction Device				Calcu'd Contact Pres. psi		Passes Completed	Reason for Immobilization	Section No.	Unit No.	Lane No.	Remarks	Type	Case-grande	Pub. Rds. Adm.	Or na Cl
Size	Mounting		Inflation Pres. in psi		Name	Mounting		Pres. psi												
Truck No.	USA-2-1/2	T																		
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	3	Stuck	6	1	9	Mud piled up. Bottom of rut good	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	41	Test completed	6	2	9	Apparently would make 100 passes. Truck dragging on 25th & 41st passes caused low dyna. readings	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	41	Test completed	6	3	9	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	0	Stuck 10 feet from bank	6	1	10	Truck stuck on 1st pass. Mud clinging to tires	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	69	End of test	6	2	10	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	69	End of test	6	3	10	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	65	End of test	7	1	3	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	51	End of test	7	2	2	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	55	End of test	8	1	11	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	55	End of test	8	2	11	Apparently would make 100 passes	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	Dual high tr. chains	-	T	73	33	3	Truck stuck	8	3	11	Truck stuck on 4th pass	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	54	Test stopped	8	1	12	Test stopped at 54 passes as bottom of truck was dragging. Soft all the way	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	0	Truck stuck at 0+90	8	2	12	Unable to reach Unit 2, stuck at 0+90	Clayey silt	ML	A-4	No	
7.50x20	S	D	65	25	None	-	-	73	33	0	Truck stuck 5 ft from bank	8	3	12	Truck stuck 5 ft from bank	Clayey silt	ML	A-4	No	

Abbreviations

F Front
 R Rear
 S Single
 D Dual
 LL Liquid Limit
 PL Plastic Limit
 PI Plasticity Index
 PR Plastic Range

NOTE: Percent columns under During Traffic Data refer to the percent that the cone bearing in the ruts is increased or decreased over the cone bearing before traffic.

TESTS CONDUCTED AT VICKSBURG, MISSISSIPPI

1/2-Ton Truck - Gross Weight 16,600 Pounds

SOIL										BEFORE TRAFFIC DATA								DURING TRAFFIC DATA										
Pub. Rds. Adm.	Ord-nance Class	Atterberg Limits			Depth Scari-fied in in.	Flooded	Days Dry-Back	Test	CB = Cone Bearing WC = Water Content								Cone Bearing						Moisture			Draw Bar Pull in Lb		
		LL	PL	PI					Depth in inches								Passes	Depth in in.	Before Traffic	In Rut	Per-cent	3 in. Below Rut	Per-cent	In Rut	Above P.L.		Below P.H.	
									0	1	6	9	12	15	18	In. In.												Traffic
A-4	No. 4	38	26	12	18	Yes	1	CB	0	0	11	26	43	70	1	12.0	43	32	-23					33	7	58		4,600
								WC	46	41	35	35	34	34	3	12.0	43	48	+12					31	5	42		3,000
A-4	No. 4	38	26	12	18	Yes	6	CB	13	18	28	49	85+		1	6.4	31	46	+48					13	-13	-108		9,000
								WC	35	33	31	31	31		11	9.0	49	51	+4					18	-8	-67		9,250
															25	9.9	60	59	-2					20	-6	-90		10,250
															41	11.1	74	54	-27					22	-4	-33		10,000
A-4	No. 4	38	26	12	18	Yes	11	CB	33	42	57	85+		1	2.0	39	47	+20					27	1	8		11,700	
								WC	26	27	28	29		11	5.7	55	44	-20					28	2	17		11,500	
														25	5.5	54	49	-9					29	3	25		5,750	
														41	6.4	61	46	-25					28	2	17		6,500	
A-4	No. 4	38	26	12	18	Yes	1	CB	0	5	17	46	85+		0	-	-	-	-					-	-	-		-
								WC	41	36	30	28												-	-	-		-
A-4	No. 4	38	26	12	18	Yes	6	CB	27	36	51	77		1	4.2	42	63	+50					25	-1	-8		7,000	
								WC	28	28	28	27		17	6.1	52	49	-6					25	-1	-8		8,700	
														37	7.1	61	40	-25					25	-1	-8		10,500	
														69	8.4	73	45	+38					26	0	0		9,300	
A-4	No. 4	38	26	12	18	Yes	11	CB	47	57	85+			1	3.1	58	85	+47					24	-2	-17		10,500	
								WC	22	17				17	3.3	60	85	+42					22	-4	-33		10,650	
														37	5.0	75	82	+9					21	-5	-42		9,500	
														69	6.0	85+	85	0					25	-1	-8		11,000	
A-4	No. 4	38	26	12	None	No	--	CB	49	83	85			1	1.2	62	85	+37					24	-2	-17		5,700	
								WC	27	21	26			7	2.2	73	85	+17					24	-2	-17		7,750	
														65	6.7	85+	76	-11					24	-2	-17		6,750	
A-4	No. 4	38	26	12	None	No	--	CB	77	--				1	1.8		82					23	-3	-25		8,250		
								WC	23	--				37	5.5		--					22	-4	-33		10,500		
														51			--					21	-5	-42		8,000		
A-4	No. 4	38	26	12	24	Yes	11	CB	24	30	70	71	71	85+	1	6.0	70	67	-4				28	2	17		6,125	
								WC	31	31	30	30	30		13	8.4	71	67	-4				29	3	25		7,375	
														43	9.6	71	40	-44				28	2	17		5,000		
														55	11.4	71	44	-37		58	-32		28	2	17		4,500	
A-4	No. 4	38	26	12	24	Yes	6	CB	13	21	69	75	77	85+	1	4.8	50	60	+20				26	0	0		6,750	
								WC	32	30	27	27	27		13	9.6	75	63	-16				26	0	0		9,125	
														43	10.2	75	30	-60				29	3	25		4,125		
														55	10.8	75	42	-47		65	-21		27	1	8		7,000	
A-4	No. 4	38	26	12	24	Yes	1	CB	0	4	28	42	38	68	71	1	8.4	40	57	+43		67	-34	25	-1	-8		4,375
								WC	34	31	27	27	26	26		4	12.6	44	--				--	--	--	--		
A-4	No. 4	38	26	12	24	Yes	11	CB	20	43	73	81	85+		1	3.6	53	35	-34				28	2	17		4,750	
								WC	26	26	26	26	26		11	6.6	75	40	-46				29	3	25		6,625	
														33	9.6	85	35	-59				29	3	25		6,375		
														54	10.8	85	31	-64				28	2	17				
A-4	No. 4	38	26	12	24	Yes	6	CB	18	27	68	74	73	78	78	0												
								WC	31	28	25	26	26	26														
A-4	No. 4	38	26	12	24	Yes	1	CB	0	4	37	40	55	81	77	0												
								WC	41	35	29	26																

FIGURE

, MISSISSIPPI

6,600 Pounds

Depth Scarified in In.	Flooded	Days Dry- Back	Test	BEFORE TRAFFIC DATA								DURING TRAFFIC DATA								Draw Bar Pull in Lb	Analysis			
				CB = Cone Bearing	WC = Water Content								Passes	Depth in In.	Before Traffic	Cone Bearing		Moisture						
					Depth in Inches											In	Per- cent	3 In. Below Rate	Per- cent			In	% in	
					0	1	6	9	12	15	18	Rate											cent	P.L.
18	Yes	1	CB	0	0	11	26	43	70	1	12.0	43	32	-23		33	7	58	4,600	Truck operating on				
			WC	46	41	35	35	34	34	3	12.0	43	48	+12		31	5	42	3,000	cane bearing of				
18	Yes	6	CB	13	18	28	49	85+		1	6.4	31	46	+48		13	-13	-108	9,000	Truck operating on				
			WC	35	33	31	31	31		11	9.0	49	51	+4		18	-8	-67	9,250	cane bearing of				
										25	9.9	60	59	-2		20	-6	-50	10,250	about 50				
										41	11.1	74	54	-27		22	-4	-33	10,000					
18	Yes	11	CB	33	42	57	85+			1	2.0	39	47	+20		27	1	8	11,700	Truck operating on				
			WC	26	27	28	29			11	5.7	55	44	-20		28	2	17	11,500	cane bearing of				
										25	5.5	64	49	-9		29	3	25	5,750	about 50				
										41	6.4	61	46	-25		28	2	17	6,500					
18	Yes	1	CB	0	5	17	46	85+		0	-	-	-	-		-	-	-	-					
			WC	41	36	30	28																	
18	Yes	6	CB	27	36	51	77			1	4.2	42	63	+50		25	-1	-8	7,000	Truck operating on				
			WC	28	28	28	27			17	6.1	52	49	-6		25	-1	-8	8,700	cane bearing of				
										37	7.1	61	40	-25		25	-1	-8	10,500	about 50				
										69	8.4	73	45	+38		25	0	0	9,300					
18	Yes	11	CB	47	57	85+				1	3.1	58	85	+47		24	-2	-17	10,500	Truck operating on				
			WC	22	17					17	3.3	60	85	+42		22	-4	-33	10,650	cane bearing of 85				
										37	5.0	75	82	+9		21	-5	-42	9,500					
										69	6.0	85+	85	0		25	-1	-8	11,000					
None	No	--	CB	49	83	85				1	1.2	62	85	+37		24	-2	-17	5,700	Truck operating on				
			WC	27	21	26				7	2.2	73	85	+17		24	-2	-17	7,750	cane bearing of 85				
										65	6.7	85+	76	-11		24	-2	-17	6,750					
None	No	--	CB	77	--					1	1.8		82			23	-3	-25	8,250	Truck operating on				
			WC	23	--					37	5.5		--			22	-4	-33	10,500	cane bearing of 85				
										51			--			21	-5	-42	8,000					
24	Yes	11	CB	24	30	70	71	71	85+	1	6.0	70	67	-4		28	2	17	6,125	Truck operating on				
			WC	31	31	30	30	30		13	8.4	71	67	-4		29	3	25	7,375	cane bearing as low				
										43	9.6	71	40	-44		28	2	17	5,000	as 40				
										55	11.4	71	44	-37	58	-32	28	2	17	4,500				
24	Yes	6	CB	13	21	69	75	77	85+	1	4.8	50	60	+20		26	0	0	6,750	Truck operating on				
			WC	32	30	27	27	27	27	13	9.6	75	63	-16		26	0	0	9,125	cane bearing of				
										43	10.2	75	30	-60		29	3	25	4,125	from 40 to 75				
										55	10.8	75	42	-47	65	-21	27	1	8	7,000				
24	Yes	1	CB	0	4	28	42	38	68	71	1	8.4	40	57	+43	67	-34	25	-1	-8	4,375	Truck stuck on		
			WC	34	31	27	27	26	26	4	12.6	44	--			--	--	--	--		cane bearing of			
																					about 44			
24	Yes	11	CB	20	43	73	81	85+		1	3.6	53	35	-34		28	2	17	4,750	Truck stopped from				
			WC	26	26	26	26	26		11	6.6	75	40	-46		29	3	25	6,625	slipperiness				
										33	9.6	85	35	-59		29	3	25	6,375					
										54	10.8	85	31	-64		28	2	17						
24	Yes	6	CB	18	27	68	74	73	78	78	0										No analysis			
			WC	31	28	25	26	26	26	26														
24	Yes	1	CB	0	4	37	40	55	81	77	0										No analysis			
			WC	41	35	29	26																	

FIGURE 11 SHEET 1

1 3

2-1/2-Ton Truck - Gross Weight 16,600 Pounds

[illegible]

Condition				Before Traffic Data										During Traffic Data										Analysis	
				C.B. = Cone Bearing W.C. = Water Contents										Cone Bearing Moisture											
				Depth In Inches										Cone Bearing Moisture											
PI	Depth Scarified Inchee	Flooded	Days Dry Sack	Test	0	3	6	9	12	15	18	21	24	Passes	Depth of Ruts	Before Traffic	In Ruts	% + Or -	In Ruts	% Above P.L.	% In P.R.	Draw Bar Pull			
12	12	Yes	0	CB WC	0 38	0 37	16 34	60 31	85+ 27					1 3 5 11 25 54	(e)	85+ 85+ 85+ 85+ 85+ 85+	82 85+ 82 85+ 75 78	-4 0 -4 0 -12 -8	23 23 23 23 23 23	-3 -3 -3 -3 -3 -3	-25 -15 -25 -25 -25 -25	8000 9000 8500 8000 11000	Truck operating on cone bearing of 85+.		
12	12	Yes	0	CB WC	0 39	5 36	16 32	60 29	85+ 25					1	(e)	85+ 85+	85+ 0	0 0					3000	Immobilized by slipperiness.	
12	12	Yes	0	CB WC	0 40	0 40	20 36	85+ 31	28					1	(e)	85+ 85+	75 -12	24 -2	-2 -17					Immobilized by slipperiness.	
12	18	Yes	0	CB WC	0 33	0 31	10 28	30 26	85+ 25					1 3 5 11 25 99	(e)	85+ 85+ 85+ 85+ 85+ 85+	84 85+ 83 85+ 85+ 81	-1 0 -2 0 0 -5	25 26 29 23 25 28	-1 0 3 -3 -1 +2	-8 0 25 -25 -8 17	6667 9667 7167 9000 9833 6500	Truck operating on cone bearing of 85+.		
12	12	Yes	11	CB WC	23 30	34 30	45 30	57 30	70 30	85 30				1 5 7 25 99	2 2 3 5 7	30 30 34 41 49	35 48 53 49 43	+17 +60 +56 +20 -12	28 27 27 25 25	2 1 1 0 -1	17 8 8 0 -8	8250 8250 8500 7750 8250	Truck operating on cone bearing of about 50 in less than 7" ruts.		
12	12	Yes	6	CB WC	3 35	9 31	16 31	70 26						1 3 5 11 25 99	3 6 6 6 9 11	9 18 18 18 70 64	29 52 55 66 58 53	+220 +190 +205 +266 -17 +3	30 29 31 28 31 26	4 3 5 2 5 0	33 25 42 17 42 0	6250 7000 7500 7250 7500 8500	Truck operating on cone bearing of about 50 to 60 after let pass.		
12	12	Yes	1	CB WC	0 34	0 30	15 27	85+ 23						1 7	9 11	85+ 85+	72 70	-15 -17	27 25	1 -1	8 -8	7000 6500	Truck operating on cone bearing of 85+. Reason for stalling not known.		
12	12	Yes	12	CB WC	24 28	33 29	47 29	73 29	28 29					1 3 26	1 2 6	28 30 47	49 50 35	+75 +67 -26	29 26 26	3 0 0	25 0 0	8600 9000	Truck operating on cone bearing of about 50.		
12	12	Yes	7	CB WC	6 6	7 9	11 11	26 30	64 65					1 7 17 99	7 8 10 12	13 18 39 64	40 54 39 66	+208 +200 0 +3	28 29 27 26	2 3 1 0	17 25 8 0	4625 4500 6125 7125	Truck operating on cone bearing as low as 40		
12	12	Yes	2	CB WC	0 28	0 26	39 24	85+ 22																No analysis	
12	12	Yes	0	CB WC	0 40	0 39	20 33	85+ 29	85+ 28															No analysis	
12	18	Yes	0	CB WC	0 36	0 34	8 33	40 30	35 28															No analysis	
12	24	Yes	0	CB WC	0 38	0 35	17 33	28 32	30 32	44 31	38 30	40 30	71 30											No analysis	
12	24	Yes	0	CB WC	0 35	4 35	23 35	37 32	43 30	60 29				1 3 5 13	4 7 11	9 23 43	61 74 61 52	-580 -222 -42	30 31 30 29	4 5 4 3	33 42 33 25	7167 8167 5500 7000	Truck operating on cone bearing of about 60, stuck because of mud balling up on chains. Mud was 25 to 42 per cent in plastic range.		
12	18	Yes	0	CB WC	0 36	0 34	8 32	41 30	85 28					0									9333	No analysis	

Equipment																			
Tires				Infl. Pres. Psi	Traction Device				Contact Pres. Psi		Operation		Location			Remarks	Type	C. Casa-grand	
Size	Mounting		F		R	Name	Mounting		F	R	Passes Completed	Reason for Immobilization	Section No.	Unit No.	Lane No.				
	F	R		F			R												
Truck 251																			
900 x 20	S	D	70	33	Dual high traction chains			S	80	43	99	End of test		1	1	2	Truck went 99 passes without difficulty	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains			S	80	43	10	Stuck at 70 ft on first pass. Stuck again on eleventh pass.		1	2	2	Mud balling on chains. Truck made only 11 passes	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains			S	80	43	4	Stuck at 40 ft on fifth pass		1	3	2	Dyn. stuck truck on 1st and 3rd pass. Truck made only 5 passes. Mud sticking to chains and covering tire.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	99	End of test		1	1	3	Truck made 99 passes without difficulty.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	0	Stuck at 60 ft on first pass.		1	2	3	Truck stalled on first pass. Treads full of mud	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	0	Impassable		1	3	3	Truck stalled after moving 10 ft on first pass	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	1	End of test		2	1	3	Dyn. caused truck to stick. Proceeded after backing	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains	-	S		80	43	1	End of test		2	1	6	Traction test	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains	-	S		80	43	71	Motor drowned on seventieth pass. Drained and drowned on seventy-first pass. End of test.		3	1	3	Performance slow for first four passes. On fifth pass tires cut through to gravel and pull more effective. Motor drowned at 70 and 71 passes.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	0	Truck stuck 20 ft from bank		3	1	5	Stuck on first pass. Traction test	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains	-	S		80	43	4	Stuck on fifth pass		5	1	4	Dyn. stuck truck on 5th pass. Unable to proceed. Mud piled in front of both wheels.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	0	Truck stuck 10 ft from bank		5	1	6	Truck stuck on 1st pass. Traction test.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	0	Truck stuck 10 ft from bank		6	1	7	Truck stuck on 1st pass.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	0	Truck stuck 30 ft from bank		6	2	7	Truck stuck on 1st pass. Mud filled treads.	Clayey silt	ML
900 x 20	S	D	70	33	None	-	-		80	43	65	End of test		6	3	7	Truck made 65 passes without difficulty. Apparently could make 100.	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains	-	S		80	43	0	Truck stuck on first pass		6	1	8	Truck stuck on 1st pass.	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains	-	S		80	43	0	Truck stuck on first pass		6	2	8	Truck stuck on 1st pass.	Clayey silt	ML
900 x 20	S	D	70	33	Dual high traction chains	-	S		80	43	57	End of test		6	3	8	Truck made 57 passes. Apparently could make 100.	Clayey silt	ML

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. USA-2-1/2 T.

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✓ 4-Ton Truck - Gross Weight 26,000 Pounds

[illegible]

ays ried ack	Before Traffic Data										During Traffic Data										Draw Bar Pull in lbs.	Analysis
	CB - Cone Bearing										Cone Bearing											
	WC - Water Content										Moisture											
	Depth in Inches										3 In.											
Test	0	3	6	9	12	15	18	21	24	Passes	Depth Rate in in.	Before Traffic	In Rate	Per- cent	Below Rut	Per- Cent	In Rut	Above P.R.	% in P.R.	% in P.R.		
11	CB WC	15 30	20 29	29 29	57 29	91 30				1	8	42	65	+75	83	-2	25	-1	-8	8,300	Truck operating on a cone bearing of more than 50	
										3	9	57	52	-9	-	-	25	-1	-8	8,500		
										5	9	57	46	-20	-	-	25	-1	-8	8,500		
										11	10	75	60	-20	-	-	35	-1	-8	7,700		
										25	12	91	55	-40	-	-	25	-1	-8	8,700		
6	CB WC	3 31	6 33	11 34	20 32	48 29	85+ 27			99	12	91	48	-47	-	-	26	0	0	7,000	Truck operating on a cone bearing of 85-	
										1	9	20	44	+120	-	-	31	5	42	6,500		
										3	-	-	85+	-	85+	-	26	0	0	7,000		
										5	10	25	85+	+240	85+	+42	27	1	8	8,500		
										11	10	25	85+	+240	85+	+42	27	1	8	8,000		
1	CB WC	0 38	0 36	3 33	23 31	85+ 28			1	8	13	82	+530	85+	+52	26	0	0	7,500	Truck stuck because of stickiness and slipperiness		
									3	6	13	83	+538	85+	+37	27	1	8	5,500			
									5	-	-	-	-	-	-	-	-	-	5,000			
11	CB WC	26 29	36 29	54 29	85+ 29				2	8	75	46	-39	-	-	27	1	8	8,800	Truck operating on cone bearing of 85-. Thin layer of about 50 material in rut after traffic.		
									25	12	85+	56	-34	-	-	27	1	8	9,100			
									99	15	85+	43	-49	-	-	26	0	0	10,700			
6	CB WC	0 35	5 32	11 28	33 26	35+ 23			1	8	26	35	+35	-	-	29	3	25	7,500	Cone bearing of 35 insufficient.		
1	CB WC	0 35	0 33	3 32	23 31	85+ 30			0	10	33	-	-	-	-	-	-	-	-	-	Cone bearing of 33 insufficient.	
None	CB WC	0 39	5 36	16 32	60 29	85+ 25			0	7	33	-	-	-	-	-	-	-	-	1,300	Cone bearing of 33 doubtful.	
None	CB WC	0 37	2 35	6 33	20 32	85+ 30			1	8	32	85+	+166	-	-	-	-	-	-	5,000	Truck operating on cone bearing of 85-	
None	CB WC	0 32	0 30	1 29	14 27	80 25	85+ -	85+ -	1	12	80	95+	+4	-	-	26	0	0	4,700	Truck operating on cone bearing of 85-. After fifth pass cone bearing was probably far in excess of 85.		
									3	13	85+	82	-4	85+	0	25	-1	-8	6,200			
									5	13	85+	85+	0	-	-	24	-2	-17	11,400			
									11	14	85+	82	-4	85+	0	26	0	0	10,500			
									25	15	85+	85+	0	-	-	25	-1	-8	10,000			
									71	18	85+	85+	0	-	-	26	0	0				
None	CB WC	0 36	0 34	8 32	40 30	85+ 28	85+ -	85+ -	0	-	-	-	-	-	-	-	-	-	-	None	Cone bearing of 40 within 9 inches and 85 within 12 inches not sufficient.	
None	CB WC	0 37	2 34	15 31	42 29	85+ 27	85+ -	85+ -	1 3 4	4 6 6	6 15 15	39 38 38	+550 +153 +153	68 64 63	+210 +61 +57	28 30 31	2 4 5	17 33 42	5,000	Cone bearing of around 35 to 40 doubtful.		
None	CB WC	0 39	0 33	2 29	13 28	36 27	68 27	85+ 27	0	-	-	-	-	-	-	-	-	-	-		-	Cone bearing of 36 within 12 inches not sufficient.
1	CB WC	0 46	0 43	7 40	20 37	43 34	85+ 32	85+ 29	0	-	-	-	-	-	-	-	-	-	-	-	Cone bearing of 43 within 12 inches not sufficient.	
6	CB WC	21 31	29 30	43 29	68 27	85+ -	85+ -	85+ -	1	72	53	28	-47	-	-	-	-	-	-	-	Truck stuck from slipperiness.	
11	CB WC	22 29	34 28	53 27	85+ -	85+ -	85+ -	85+ -	1	4	44	39	-11	-	-	29	3	25	11,000	Truck operating on cone bearing of around 50 for first 15 passes, 85- for remainder.		
									15	6	53	46	-15	-	-	28	2	17	16,000			
									25	10	85+	38	-55	-	-	26	0	0	17,000			
									41	11	85+	38	-55	-	-	27	1	8	16,000			
									65	11	85+	47	-45	-	-	25	-1	-8	18,200			
1	CB WC	0 40	0 38	13 36	23 34	48 32	85+ 30	85+ -	0	-	-	-	-	-	-	-	-	-	-	-	Cone bearing of 23 at 9 inches and 48 at 12 inches not sufficient.	
6	CB WC	11 33	14 33	20 31	35 30	80 29	85+ 28	85+ 27	0	-	-	-	-	-	-	-	-	-	-	-	Cone bearing of 35 at 9 inches and 80 at 12 inches not sufficient.	
11	CB WC	32 25	37 27	48 29	63 26	85+ -	85+ -	85+ -	1	4	41	51	+24	-	-	29	3	25	14,700	Truck operating on cone bearing of about 50.		
									17	6	48	36	-25	-	-	29	3	25	13,700			
									56	9	63	44	-30	-	-	27	1	8	13,700			

FIGURE 12 SHEET 1

TRUCK TESTS CONDUCTED AT VICTOR

4-Ton Truck - Gross Weight

Equipment													Soil							
Tires			Infl. Pres. Psi	Traction Device			Contact Pres. Psi		Operation		Location			Classification						
Size	Mounting			Name	Mounting		P	R	Passes Completed	Reason for Immobilization	Section No.	Unit No.	Lane No.	Remarks	Type	Classification				
	F	R			F	R										Casa-grande	Ord-nance	Class	LL	FL
Truck 251 (Continued)																				
900 x 20	S	D	70 33	None	-	-	80	43	99	End of test	7	1	1	Truck made 99 passes with- out difficulty. Dyn. read- ing at pass 31 was too low.	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	Dual high traction chains	-	S	80	43	99	End of test	7	2	1	Stuck at St.2-90 on pass 84-Clayey silt Pulled out and finished 99 passes between 1-50 and 2-70 Soft spot at 2-90 aggravated by stopping and starting.	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	Dual high traction chains	-	S	80	43	10	Stuck on pass 11	8	1	9	Truck stuck on pass 11. Mud Clayey silt covered chains completely.	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	Dual high traction chains	-	S	80	43	0	Stuck at 20 ft on first pass	8	2	9	Truck stuck on first pass	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	Dual high traction chains	-	S	80	43	4	Stuck on fifth pass	8	3	9	Truck stuck on fifth pass	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	None	-	-	80	43	0	Stuck at 50 ft on first pass	8	1	10	Truck stuck on first pass	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	None	-	-	80	43	0	Unable to reach unit 2 from unit 1 or 3	8	2	10	Truck stuck on first pass	Clayey silt	ML	A-4 No. 4	38 26 1		
900 x 20	S	D	70 33	None	-	-	80	43	0	Stuck at 20 ft on first pass	8	3	10	Truck stuck on first pass	Clayey silt	ML	A-4 No. 4	38 26 1		
Truck 255																				
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	1	1	1	Dyn. slowed truck almost to stop in units 1 and 2.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	1	2	1	Dyn. slowed truck almost to stop in units 1 and 2.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	1	3	1	Dyn. caused complete stop in unit 3 but truck could proceed when pull released	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	Canadian Jungle Track	-	T	37	47	42	Rut too deep	2	1	3	Truck alone went 42 passes o.k. Towed 165 o.k. with brakes and emergency but stalled when 165 also put in gear.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	2	1	6	Traction test only.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	3	1	3	Traction test only	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	5	1	4	Traction test only	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	6	1	10	Traction test only	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	6	2	10	Traction test only	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	6	3	10	Traction test only	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	7	1	2	Truck almost stalled on pulls Less traction with chains than without chains on truck 251, same section, lane 1.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	8	1	10	Traction test only. Chains on front wheels also.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	8	2	10	Traction test only. Chains on front wheels also.	Clayey silt	ML	A-4 No. 4	38 26 1		
14.00 x 20	S	S	25 35	High traction chains	-	T	37	47	1	End of test	8	3	10	Traction test only. Chains on front wheels also.	Clayey silt	ML	A-4 No. 4	38 26 1		

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. USA-2-1/2 T.

AT VICKSBURG, MISSISSIPPI

Weight 26,000 Pounds

Soil		Condition				Before Traffic Data										During Traffic Data										Draw Bar Pull in Lbs.	Analysis	
on	Depth Scarified	In.	Flooded	Days Drier	Test	CB - Cone Bearing WC - Water Content										Cone Bearing					Moisture							
						Depth in Inches										Depth Rut	Before Traffic	In Rut	Per- cent	3 In. Below Rut	Per- cent	In Above Rut	% in P.L.	% in P.R.				
LL	FL	PI				0	3	6	9	12	15	18	21	24	Passes in In.													
38	26	12	0	No	-	CB	82	85	-	-	-	-	-	-	1	2	83	85	+2	-	-	22	-4	-33	8,500	Truck operating on cone bearing of 85		
						WC	72	25	-	-	-	-	-	-	33	3	84	85	+1	-	-	22	-4	-33	16,700			
															99	4	85	77	-9	-	-	22	-4	-33	12,000			
38	26	12	0	No	-	CB	85	-	-	-	-	-	-	-	1	2	85	85+	0	-	-	22	-4	-33	14,000	Truck operating on cone bearing of 85		
						WC	21	-	-	-	-	-	-	-	15	5	85	85	0	-	-	22	-4	-33	15,000			
															53	7	85	75	-12	-	-	22	-4	-33	14,333			
															99	9	85	63	-26	-	-	23	-3	-25	13,583			
38	26	12	24	Yes	11	CB	15	20	34	45	54	62	68	74	80	1	7	25	43	+72	60	+25	28	2	17	7,250	Cone bearing of 43 doubtful. Mud balled up on chains	
						WC	31	29	29	30	30	30	30	30	30													
38	26	12	24	Yes	6	CB	10	19	52	85+	85+	85+	85+	85+	85+	0	-	-	-	-	-	-	-	-	-	-	No analysis	
						WC	31	28	26	26	-	-	-	-	-													
38	26	12	24	Yes	1	CB	0	7	30	58	85+	85+	85+	85+	85+	3	9	58	67	+16	95+	0	25	-1	-8	6,125	No analysis	
						WC	33	31	30	28	27	-	-	-	-													
38	26	12	24	Yes	11	CB	14	24	39	49	57	63	68	73	76	0	6	39	-	-	-	-	-	-	-	-	Stuck due to slipperiness	
						WC	33	32	31	31	31	31	31	31	31													
38	26	12	24	Yes	6	CB	11	16	22	37	66	85+	85+	85+	85+	0	-	-	-	-	-	-	-	-	-	-	No analysis	
						WC	32	29	27	24	-	-	-	-	-													
38	26	12	24	Yes	1	CB	6	8	32	64	85+	85+	85+	85+	85+	0	-	-	-	-	-	-	-	-	-	-	No analysis	
						WC	35	34	33	33	33	32	32	-	-													
38	26	12	12	Yes	11	CB	16	28	48	85+	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	8,500	No analysis
						WC	30	31	31	28	-	-	-	-	-													
38	26	12	12	Yes	6	CB	2	3	7	14	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	9,250	No analysis
						WC	34	32	29	27	-	-	-	-	-													
38	26	12	12	Yes	1	CB	4	23	29	85	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	8,500	No analysis
						WC	34	31	28	26	-	-	-	-	-													
38	26	12	12	Yes	None	CB	0	4	16	60	-	-	-	-	-	42	-	-	-	-	-	-	-	-	-	-	No analysis	
						WC	39	36	32	29	-	-	-	-	-													
38	26	12	12	Yes	None	CB	0	2	6	20	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	6,000	No analysis
						WC	37	35	33	31	-	-	-	-	-													
38	26	12	18	Yes	None	CB	0	0	1	15	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	7,125	No analysis
						WC	32	30	29	27	-	-	-	-	-													
38	26	12	24	Yes	None	CB	0	2	15	41	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	9,500	No analysis
						WC	37	34	31	29	-	-	-	-	-													
38	26	12	18	Yes	1	CB	0	5	17	46	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1,250	No analysis
						WC	43	36	30	28	-	-	-	-	-													
38	26	12	18	Yes	6	CB	27	36	51	77	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	11,000	No analysis
						WC	28	28	28	27	-	-	-	-	-													
38	26	12	18	Yes	11	CB	47	57	85+	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	8,750	No analysis
						WC	22	17	-	-	-	-	-	-	-													
38	26	12	0	No	None	CB	76	85+	-	-	-	-	-	-	-	1	-	-	85+	-	-	-	22	-4	-33	11,500	No analysis	
						WC	22	-	-	-	-	-	-	-	-													
38	26	12	24	Yes	11	CB	14	23	39	49	57	63	71	75	85+	1	54	37	-	-	-	-	-	-	-	-	6,500	No analysis
						WC	33	32	31	31	31	31	31	31	31													
38	26	12	24	Yes	6	CB	11	15	41	60	67	85+	-	-	-	1	-	-	-	-	-	-	-	-	-	-	7,500	No analysis
						WC	31	29	27	24	22	19	-	-	-													
38	26	12	24	Yes	1	CB	0	10	47	63	85+	85+	-	-	-	1	-	-	-	-	-	-	-	-	-	-	6,375	No analysis
						WC	35	34	34	33	33	32	-	-	-													

FIGURE 12 SHEET 2

TRUCK TESTS CONDUCTED AT VICKSBURG, MISSISSIPPI

6-Ton Truck - Gross Weight 35,000 Pounds

EQUIPMENT										LOCATION		SOIL										BEFORE TRAFFIC							
Tires		Inflation Pressure		Fraction Device		Calculated Contact Press. psi		Passes Completed	Reason for Immobilization	Section No.	Unit No.	Remarks	Type	Classification				Condition		Date Dry	Test	CB - Core No. WC - Water							
Size	Speed	PSI	PSI	None	Y	N	Y							N	Y	N	Y	N	Y			N	Y	N	Y	N	Y	N	Y
Truck No. 58																													
10.00 x 22	8	D	70	44	No chains	-	-	82	56	67	Truck stuck	1	1	Soil piling up behind front and rear axles. Bottom dragging	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	11	CB WC	25 30	30 30	31 30	39 29
10.00 x 22	8	D	70	44	No chains	-	-	82	56	1	Truck stuck - 1440	1	2	Bottom dragging and cutting down. Very slick	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	6	CB WC	10 13	13 13	13 29	36 29
10.00 x 22	8	D	70	44	No chains	-	-	82	56	0	Truck stuck - 2470	1	3	Bottom dragging	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	1	CB WC	0 0	0 3	3 29	24 29
10.00 x 22	8	D	70	44	No chains	-	-	82	56	1	Truck stuck - 1400	3	1	Bottom dragging. Soil piling up in front of axle.	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	None	CB WC	0 0	0 3	6 30	35 30
10.00 x 22	8	D	70	44	No chains	-	-	82	56	50	Truck stuck	7	2	Bottom dragging. Soil piling up in front of axle	Clayey silt	ML	A-4	No. 4	38	26	12	None	No	None	CB WC	64 26	85 26		
10.00 x 22	8	D	70	44	No chains	-	-	82	56	0	Truck stuck - 0410	8	1	Truck stuck with approx. 18" rut. Bottom of truck dragging	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	11	CB WC	15 34	19 31	27 28	41 28
10.00 x 22	8	D	70	44	No chains	-	-	82	56	0	No test	8	2	Unable to get truck to Unit 2	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	6	CB WC	9 31	18 29	42 27	85 27
10.00 x 22	8	D	70	44	No chains	-	-	82	56	0	Truck stuck - 2490	8	3	Bottom dragging. Approx. 18" rut	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	1	CB WC	0 36	11 34	62 32	84 30
10.00 x 22	8	D	70	44	No chains	-	-	82	56	0	Truck stuck - 0410	6	1	Soil piling up in front of axle. Bottom dragging	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	1	CB WC	0 40	0 34	10 34	49 31
10.00 x 22	8	D	70	44	No chains	-	-	82	56	0	Truck stuck - 1420	6	2	Soil piling up in front of axle & sticking to bottom of chassis. Bottom dragging	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	6	CB WC	12 33	20 33	44 32	85 29
10.00 x 22	8	D	70	44	Dual high tr. skates	-	-	82	56	2	Truck stuck - 1410	6	2	Made 2 passes with chains	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	6	CB WC	12 33	20 33	44 32	85 29
10.00 x 22	8	D	70	44	No chains	-	-	82	56	99	End of test	6	3	Truck made 99 passes without recorded difficulty	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	11	CB WC	24 31	29 30	53 29	85 27
Truck No. 265																													
10.00 x 22	8	D	70	44	None	-	-	82	56	1	Stuck at 50'	2	1	Stuck in holes made in breaking test. Hole 11" deep up to hole. None of mud in front of front wheels. Lane impassable with standard tires	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes		CB WC	0 39	0 36	13 32	49 29
10.00 x 22	8	D	70	44	Dual high tr. chains	-	-	82	56	58	Motor almost drowned out; test discontinued	2	1	On 25th pass truck beginning to cut down into hole at 1430; pull of 10,000 lb almost stalled truck. on 47th pass had motor trouble. Test continued with another truck of same weight using tires from Truck 265. 47th pass completed slowly; motor almost drowned out. Draw bar pulled on 1st & 5th passes doubtful. Test discontinued on 48th pass but traction still good	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes		CB WC	0 37	0 36	8 31	25 29
Truck No. 261																													
11.00 x 20	8	W	38	14	Good traction	-	-	90	31	1	End of test	2	1	Traction test only	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	None	CB WC	0 40	0 39	20 34	84 29
11.00 x 20	8	W	38	14	None	-	-	90	31	0	Stuck 40' from bank	3	1	Traction test only	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	None	CB WC	0 36	0 34	6 33	58 30
11.00 x 20	8	W	38	14	None	-	-	90	31	0	Stuck 5' from bank	3	1	Traction test only	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	None	CB WC	0 34	0 40	0 36	25 34
11.00 x 20	8	W	38	14	High tr. chains	-	-	90	31	1	Stalled 75' after 1st pass. Mud piled underneath.	3	1	Truck stuck on 3rd pass. Mud piled up under truck.	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	None	CB WC	0 34	0 40	0 36	25 34

NOTE: (a) Vehicle sunk to specified depth on first pass.

For abbreviations and general note see data sheet for 3-1/2-Ton Truck No. 12A-3-1/2 T.

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TRUCK TESTS CONDUCTED AT VICKSBURG, MISSISSIPPI

6-Ton Truck - Gross Weight 35,000 Pounds

Type	SOIL										BEFORE TRAFFIC DATA										DURING TRAFFIC DATA															
	Classification					Condition					CB = Cone Bearing WC = Water Content										Depth of Rate															
	Case- grain	Pub. Mo.	Ord- nance	Alter- bergs	Units	Depth Scar- ified in in.	Flooded	Days Dry- Back	Test	Depth in inches										Passes	in in.	Cone Bearing					Moisture					Draw Bar Pull	Analysis			
										0	1	6	9	12	15	18	21	In	Per- cent			Below 5 in.	Per- cent	In	Above 5 in	P.L.	P.R.									
Clayey silt	ML	A-1	No. 4	38	26	12	12	Yes	11	CB	25	30	41	59	85			1	4.7	37	46	+24	64	+31	28	2	17	10,500	Truck operated 9 passes or							
										WC	30	30	30	29	28			3	6.0	41	--	--	74	+26	--	3	25	11,000	cone bearing about 50, on							
																		5	--	--	47	--	--	--	29	3	--	--	--	--	--	cone bearing of 75 after				
																		9	8.4	54	23	-2	66	-13	28	2	17	7,000	25 passes							
																		25	10.8	75	46	-39	59	-44	29	3	25	9,000								
																		67	16.8	85+	56	-34	38	-124	30	4	33	5,000								
Clayey silt	ML	A-1	No. 4	38	26	12	12	Yes	6	CB	10	13	18	46	85+			1	12.0	85+	85+	0	--	--	--	22	-4	-13	5,000	Not consistent						
										WC	33	35	31	29																						
Clayey silt	ML	A-1	No. 4	38	26	12	12	Yes	1	CB	0	0	5	24	85			0	--	--	--	--	--	--	--	--	--	--	--	--	--	Cones bearing of 24 at 0" and				
										WC	35	34	33	29	25																	85 at 12" not sufficient				
Clayey silt	ML	A-1	No. 4	38	26	12	18	Yes	None	CB	0	0	6	35	64	85+		1	13.2	72	69	-4	85+	0	25	-1	-8	6,000	Cones bearing of 70 at 13"			not sufficient				
										WC	40	39	38	30	22																					
Clayey silt	ML	A-1	No. 4	38	26	12	None	None	None	CB	64	85+						1	3.0	85+	83	-2	85+	+913	24	-2	-17	6,000	Truck operating on cone							
										WC	26	24						7	5.9	85+	80	-6	85+	+350	26	0	0	9,300	bearing of 85+							
																		25	8.2	85+	69	-19	80	+128	25	-1	-8	10,950								
																		30	10.2	85+	71	-17	73	+43	25	-1	-8	6,500								
Clayey silt	ML	A-1	No. 4	38	26	12	24	Yes	11	CB	15	19	27	41	64	85+		0	18.0	85+	--	--	--	--	--	--	--	--	--	--	--	0	Cones bearing of 85+ at 18"			
										WC	34	31	28																			not sufficient				
Clayey silt	ML	A-1	No. 4	38	26	12	24	Yes	6	CB	9	18	42	85+				0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	No analysis			
										WC	31	29	27																							
Clayey silt	ML	A-1	No. 4	38	26	12	24	Yes	1	CB	0	11	62	85+				0	18.0	85+	--	--	--	--	--	--	--	--	--	--	--	--	Cones bearing of 85+ at 18"			
										WC	36	34	32	30																			not sufficient			
Clayey silt	ML	A-1	No. 4	38	26	12	18	Yes	1	CB	0	0	10	49	85			0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Cones bearing of 85 at 12"			
										WC	40	38	34	31	30																		not sufficient			
Clayey silt	ML	A-1	No. 4	38	26	12	18	Yes	6	CB	12	20	34	85				0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Cones bearing of 85 at 9"			
										WC	33	33	32	29																			not sufficient when surface			
																																		and was not soft		
Clayey silt	ML	A-1	No. 4	38	26	12	18	Yes	6	CB	12	20	34	85				2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Cones bearing of 95 at 9"			
										WC	33	33	32	29																			not sufficient when surface			
																																		and was not soft		
Clayey silt	ML	A-1	No. 4	38	26	12	18	Yes	11	CB	24	29	53	85				1	8.0	75	57	-24	67	-22	31	5	42	6,000	Cones bearing of 75 at 8"							
										WC	31	30	29	27				3	8.0	75	73	-3	81	-5	24	-2	-17	8,900	was sufficient							
																		9	12.0	85+	45	-47	71	-17	27	1	8	7,900								
																		25	12.0	85+	36	-58	41	-52	29	3	25	8,900								
																		99	20.0	85+	34	-60	46	-46	29	3	25	7,900								
Clayey silt	ML	A-1	No. 4	38	26	12	12	Yes		CB	0	3	13	59	85+			1	9.0	99	85+	+31	28	-67	24	-8	17	3,900	Truck stuck because of slip-							
										WC	39	36	32	29	25																		perances.			
Clayey silt	ML	A-1	No. 4	38	26	12	12	Yes		CB	0	3	8	25	85+			1	9.0	25	74	+106	83	-8	31	5	42	5,900	Truck operating on cone							
										WC	37	36	33	29	26			3	9.5	35	76	+140	72	-15	23	-3	-25	12,650	bearing of about 75. Min-							
																		5	9.6	37	75	+103	66	-22	27	1	8	7,790	imum draw bar pull 8,000 lb							
																		11	9.1	27	71	+153	64	-24	25	-1	-4	13,950								
																		24	9.0	25	86	+244			24	-2	-17	8,700								
Clayey silt	ML	A-1	No. 4	38	26	12	12	Yes	None	CB	0	0	20	85+	85+			1	(a)	--	--	--	--	--	--	--	--	--	--	--	--	8,000	No analysis			
										WC	40	39	34	29	28																					
Clayey silt	ML	A-1	No. 4	38	26	12	18	Yes	None	CB	0	0	6	58	85+			0	(a)	--	--	--	--	--	--	--	--	--	--	--	--	--	No analysis			
										WC	36	34	33	30	29																					
Clayey silt	ML	A-1	No. 4	38	26	12	24	Yes	None	CB	0	0	0	25	85	85+		0	(a)	--	--	--	--	--	--	--	--	--	--	--	--	--	No analysis			
										WC	44	40	36	34	32	33	33																			
Clayey silt	ML	A-1	No. 4	38	26	12	24	Yes	None	CB	0	0	0	25	85	85+		1	(a)	--	--	--	--	--	--	29	3	25	8,166	No analysis						
										WC	44	40	36	34	32	33	33																			

EQUIPMENT										OPERATION		LOCATION		SOIL					
Tires				Traction Device				Contact Press.		Passes Completed	Reason for Immobilization	Section No.	Unit No.	Remarks	Type	Classification			
Size	Mounting	Infl. Press. in psi	Mounting	Name	Mounting	Contact Press. in psi	Passes Completed	Casa-grande	Pub. Rte. Admin.							Ord-nance Class.	Atterberg Limits		
	F	R	F	R		F	R												
Truck No. USA 59																			
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	77	Truck stuck	1	1	Truck stuck on 77th pass. Bottom dragging & soil piling up behind front & rear axles	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	76	Truck stuck	1	2	Truck stuck on 76th pass. Bottom dragging & soil piling up on front axle	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	0	Truck stuck 2+30	1	3	Truck stuck on 1st pass. Bottom dragging	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	49	Drowned out	2	1	Truck drowned out on 49th pass. Water up to floor boards in cab	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	1	Truck stuck 1+80	3	1	Truck stuck in 1st pass. Bottom dragging & soil piling up in front of axles	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	99	End of test	7	2	Surface described as "very slick" but went 99 passes	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	0	Truck stuck 0+20	6	1	Truck stuck. Soil banking up in front of axles. Bottom dragging	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	99	End of test	6	2	Dyn. caused truck to stick on 1st pass. Pulls 1 & 3 thrown out as brake was slipping on winch	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	99	End of test	6	3	Pulls 1 & 3 thrown out as brake was slipping on winch	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	1	Truck stuck 0+30	8	1	Truck stuck on 2nd pass as chassis and axles were dragging ground	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	0	Truck stuck 1+40	8	2	Truck stuck on 1st pass	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	2	Truck stuck	8	3	Truck stuck on 3rd pass as bottom was dragging	Clayey silt	ML	A-4	No.4	38 26
10x22	S	D	70	44	Dual high tr. chains	-	S	82	56	99	Test completed	9	1	None	Clayey silt	ML	A-4	No.4	38 22

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. USA-2-1/2 T.

TESTS CONDUCTED AT VICKSBURG, MISSISSIPPI

Truck - Gross Weight 35,000 Pounds

n	BEFORE TRAFFIC DATA										DURING TRAFFIC DATA										Draw Bar Full	Analysis				
	Condition			Days Dry-back	Test	CB = Cone Bearing WC = Water Content							Depth of Rut	Cone Bearing					Moisture							
	Depth Scarified in In.					Depth in Inches								Before Traffic	In Ruts	Per-cent	3 In. Below Rut	Per-cent	In Rut	Above P.L.			% in P.R.			
	LL	PL	PI			0	3	6	9	12	15	18												21	Passee	
38	26	12	12	Yes	11	CB	21	25	33	49	85+	1	4.9	31	74	+139	75	+83	31	5	42	5,500	Truck op			
						WC	30	32	33	31		3	6.6	37	71	+92	71	+22	30	4	33	6,000	terial w			
												9	8.4	46	63	+37	63	-20	30	4	33	12,250	ing of a			
												21	9.6	57	66	+16	61	-28	30	4	33	8,500				
												76	12.0	85+	47	-45	48	-44	29	3	25	5,000				
38	26	12	12	Yes	6	CB	14	17	27	56	85+	1	7.2	39	71	+82	76	-11	29	3	25	6,100	Same as			
						WC	34	33	31	29		3	9.7	63	76	+21	85+	0	30	4	33	8,000				
												9	9.7	63	73	+16	85+	0	--	--	--	--	8,700			
												25	9.7	63	76	+21	85+	0	21	-5	-42	9,350				
												76	9.6	62	--	---	--	-	--	--	--	--	5,500			
38	26	12	12	Yes	1	CB	0	7	33	85		0	---	--	--	---	--	-	--	-	--	--	--	No analy		
						WC	37	32	28	25																
38	26	12	12	Yes	None	CB	0	3	8	25	85+	49	15.0	85+	--	---	85+	0	23	-3	-25	13,000	Truck op			
						WC	37	36	33	29	26													terial w		
38	26	12	18	Yes	None	CB	0	0	0	22	44	66	1	14.4	62	85+	+37	--	-	25	-2	-13	--	Cone be		
						WC	37	35	33	30	26	23												14" not		
38	26	12	None	No	None	CB	37	68	85+			1	4.1	74	73	-1	66	-22	25	-1	-8	6,700	Truck op			
						WC	27	25	23			5	6.2	85+	76	-11	82	-4	27	1	8	7,700	terial w			
												17	8.9	85+	72	-15	80	-6	26	0	0	10,000	ing of a			
												35	10.8	85+	63	-26	73	-14	26	0	0	10,650				
												51	11.9	85+	60	-29	70	-18	26	0	0	11,250				
												99	15.4	85+	64	-25	69	-19	26	0	0	20,000				
38	26	12	18	Yes	1	CB	0	0	21	43	63	85+	0											Cone be		
						WC	42	39	35	33	31	30												12" not		
38	26	12	18	Yes	6	CB	20	21	35	67	85+	85+	1	4.6	24	67	+179	77		27	1	8	--	Truck op		
						WC	31	30	28	28	28	28	5	9.6	73	83	+14	85+	0	28	2	17	14,500	terial w		
													25	10.8	85+	74	-13	85+	0	28	2	17	12,000	ing aro		
													51	12.6	85+	27	-68	74	-12	27	1	8				
													99	15.4	85+	64	-25	63	-26	23	-3	-25	15,000			
38	26	12	18	Yes	11	CB	20	27	44	70	85+	85+	1	8.1	60	37	-38	60	-29	29	3	25	--	Truck o		
						WC	24	25	26	26	26	26	5	7.5	56	72	+29	57	-31	29	3	25	18,500	material		
													25	9.6	75	57	-24	70	-18	29	3	25	18,000	bearing		
													51	11.7	85+	45	-47	57	-33	28	2	17	7,500			
													99	15.3	85+	56	-39	59	-31	26	0	0	21,000			
38	26	12	24	Yes	11	CB	17	20	56	80	85+	1	8.1	63	49	-22	65	-24	27	1	8	4,875	No anal			
						WC	35	30	25	24	24	2	17.4	85+	36	-58	74	-13	25	-1	-8	--				
38	26	12	24	Yes	6	CB	9	10	45	56	59	63	70	85+	1	10.2	55	67	+22	85+	+47	27	1	8	5,250	Cone b-
						WC	34	32	30	29	29	30	30	31											at 10"	
38	26	12	24	Yes	1	CB	7	5	40	58	59	76	85+	85+	1	11.1	58	67		85+	+20	26	0	0	5,500	ficient
						WC	39	35	32	30	28	26	23												Same at	
38	22	16	12	Yes	11	CB	19	22	24	24	24	31	63	85+	1	3.6	22	52	+136	61	+118	24	2	12	17,500	Cone be
						WC	26	26	25	25	24	24	23		3	5.4	24	72	+200	75	+93	24	2	12	6,500	70 adeq
														11	8.0	24	68	+183	74	+4	24	2	12	11,000		
														25	12.0	24	70	+192	64	-25	23	1	6	11,900		
														51	13.8	28	59	+111	75	-12	25	3	19	15,000		
														99	16.9	51	70	+37	80	-6	24	2	12	10,500		

FIGURE 13

Days Dry- back	BEFORE TRAFFIC DATA										DURING TRAFFIC DATA										Draw Bar Pull	Analysis	
	Test	CB = Cone Bearing WC = Water Content										Passes	Depth of Ruts	Cone Bearing				Moisture					
		Depth in Inches												Before Traffic	In Ruts	Per- cent	3 In. Below Rut	Per- cent	In Ruts	Above P.L.			4 in P.R.
		0	3	6	9	12	15	18	21														
11	CB	21	25	33	49	85+					1	4.9	31	74	+139	75	+83	31	5	42	5,500	Truck operating on ma- terial with cone bear- ing of about 70	
	WC	30	32	33	31						3	6.6	37	71	+92	71	+22	30	4	33	6,000		
											9	8.4	46	63	+37	63	-20	30	4	33	12,250		
											21	9.6	57	66	+16	61	-28	30	4	33	8,500		
											76	12.0	85+	47	-45	48	-44	29	3	25	5,000		
6	CB	14	17	27	56	85+					1	7.2	39	71	+82	76	-11	29	3	25	6,100	Same as above	
	WC	34	33	31	29						3	9.7	63	76	+21	85+	0	30	4	33	8,000		
											9	9.7	63	73	+16	85+	0	--	--	--	8,700		
											25	9.7	63	76	+21	85+	0	21	-5	-42	9,350		
											76	9.6	62	--	---	--	--	--	--	--	5,500		
1	CB	0	7	33	85						0	---	--	--	---	--	--	--	--	--	--	No analysis	
	WC	37	32	28	25																		
None	CB	0	3	8	25	85+					49	15.0	85+	--	---	85+	0	23	-3	-25	13,000	Truck operating on ma- terial with cone bear- ing of 35+	
	WC	37	36	33	29	26																	
None	CB	0	0	0	22	44	66				1	14.4	62	85+	+37	--	--	25	-2	-13	--	Cone bearing of 62 at 14" not sufficient	
	WC	37	35	33	30	26	23																
None	CB	37	68	85+							1	4.1	74	73	-1	66	-22	25	-1	-8	6,700	Truck operating on ma- terial with cone bear- ing of about 60	
	WC	27	25	23							5	6.2	85+	76	-11	82	-4	27	1	8	7,700		
											17	8.9	85+	72	-15	80	-6	26	0	0	10,000		
											35	10.8	85+	63	-26	73	-14	26	0	0	10,650		
											51	11.9	85+	60	-29	70	-18	26	0	0	11,250		
											99	15.4	85+	64	-25	69	-19	26	0	0	20,000		
1	CB	0	0	21	43	63	85+				0											Cone bearing of 60 at 12" not sufficient	
	WC	42	39	35	33	31	30																
6	CB	20	21	35	67	85+	85+				1	4.6	24	67	+179	77		27	1	8	--	Truck operating on ma- terial with cone bear- ing around 70	
	WC	31	30	28	28	28	28				5	9.6	73	83	+14	85+	0	28	2	17	14,500		
											25	10.8	85+	74	-13	85+	0	28	2	17	12,000		
											51	12.6	85+	27	-68	74	-12	27	1	8			
											99	15.4	85+	64	-25	63	-26	23	-3	-25	15,000		
11	CB	20	27	44	70	85+	85+				1	8.1	60	37	-38	60	-29	29	3	25	--	Truck operating on material with cone bearing around 60	
	WC	24	25	26	26	26	26				5	7.5	56	72	+29	57	-31	29	3	25	16,500		
											25	9.6	75	57	-24	70	-18	29	3	25	18,000		
											51	11.7	85+	45	-47	57	-33	28	2	17	7,500		
											99	15.3	85+	56	-39	59	-31	26	0	0	21,000		
11	CB	17	20	56	80	85+					1	8.1	63	49	-22	65	-24	27	1	8	4,875	No analysis	
	WC	35	30	25	24	24					2	17.4	85+	36	-58	74	-13	25	-1	-8	--		
6	CB	9	10	45	56	59	63	70	85+		1	10.2	55	67	+22	85+	+47	27	1	8	5,250	Cone bearing about 60 at 10" depth. At suf- ficient	
	WC	34	32	30	29	29	30	30	31														
1	CB	7	5	40	58	59	76	85+	85+		1	11.1	58	67		85+	+20	26	0	0	5,500	Same at 11" depth	
	WC	39	35	32	30	28	26	23															
11	CB	19	22	24	24	24	31	63	85+		1	3.6	22	52	+136	61	+118	24	2	12	17,500	Cone bearing of about 70 adequate	
	WC	26	26	25	25	24	24	23			3	5.4	24	72	+200	75	+93	24	2	12	6,500		
											11	8.0	24	68	+183	74	+4	24	2	12	11,000		
											25	12.0	24	70	+192	64	-25	23	1	6	11,500		
											51	13.8	28	59	+111	75	-12	25	3	19	13,000		
											99	16.9	51	70	+37	80	-6	24	2	12	10,500		

FIGURE 13 SHEET 2

TRUCK TESTS CONDUCTED AT VICKSBURG, MISSISSIPPI

6-Ton Truck - Gross Weight 35,000 Pounds

EQUIPMENT										LOCATION		SOIL													
Tires				Traction Device				Contact		OPERATION		LOCATION		Classification						Condition					
Size	Type	S	D	Infl.	Press.	in psi	Mount- ing	Press.	in psi	Passes Com- pleted	Reason for Immobilization	Sec- tion No.	Unit No.	Remarks	Type	Case- grande	Pub. Rds. Admin.	Ord- nance Class.	Atterberg Limits			Depth Scari- fied in in.	Flooded	Dry Dec	
																			LL	PL	PI				
Truck No. USA 59 (Continued)																									
10x22	S	D	70	44	Dual high	-	S	82	56	2	Truck stuck	9	2	Stuck at 1+40 Bottom dragging	Clayey silt	ML	A-4	No. 4	38	22	16	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	0	Truck stuck	9	3	Truck stuck about 10' from bank	Clayey silt	ML	A-4	No. 4	38	22	16	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	99	Test completed	10	1	Standard tires	Clayey silt	ML	A-4	No. 4	38	22	16	18	Yes	11	
10x22	S	D	70	44	Dual high	-	S	82	56	99	Test completed	10	2	Standard tires	Clayey silt	ML	A-4	No. 4	38	22	16	18	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	0	Truck stuck	10	3	Stuck at 2+50. Soil banking up in front of axles & under bottom, also balling up on wheels, reducing effectiveness of chains	Clayey silt	ML	A-4	No. 4	38	22	16	18	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	12	End of test	11	1	Apparently could have made 100 passes. Chains were ineffective due to mud balling up on wheels	Clayey silt	ML	A-4	No. 4	38	22	16	12	Yes	11	
10x22	S	D	70	44	Dual high	-	S	82	56	12	End of test	11	2	Same as above	Clayey silt	ML	A-4	No. 4	38	22	16	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	12	End of test	11	3	Same as above	Clayey silt	ML	A-4	No. 4	38	22	16	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	9%	End of test	12	-	None	Clayey silt	ML	A-4	No. 4	38	22	16	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	0	Truck stuck	13	-	Truck stuck 0+20. Mud balling up on wheels, banking up in front & under truck	Clayey silt	ML	A-4	No. 4	38	22	16	18	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	0	Truck stuck	14	-	Same as above	Clayey silt	ML	A-4	No. 4	38	22	16	24	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	21	End of test	15	-	7% slope. South side	Clayey silt	CL	A-7	No. 2	48	22	26	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	20	End of test with winch	16	-	0% slope	Clayey silt	CL	A-7	No. 2	48	22	26	12	Yes		
10x22	S	D	70	44	Dual high	-	S	82	56	11	Truck stuck	17	-	3-1/2% slope. East side. Truck stuck on 12th pass 15' from bank. Soil piling up under truck & banking in front of axles. Bottom dragging. Soil balling upon wheels causing chains to become ineffective	Clayey silt	CL	A-7	No. 2	48	22	26	12	Yes		

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. USA-2-1/2 T.

7

OSG
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OSG, MISSISSIPPI

35,000 Pounds

Condition	BEFORE TRAFFIC DATA										DURING TRAFFIC DATA										Draw Bar Pull	Analysis			
	Days Dry-back	Test	CB = Cone Bearing WC = Water Content										Passes	Depth of Ruts	Cone Bearing				Moisture						
			Depth in Inches												Before Traffic	In Ruts	Per-cent	3 in. Below Rut	Per-cent	In Ruts			Above P.L.	3 in P.R.	
			0	3	6	9	12	15	18	21															
Flooded																									
Yes	6	CB	15	17	22	33	67	85+			1	10.2	47	79	+68	85+	+20	27	5	31					No analysis
		WC	29	29	30	29	28																		
Yes	1	CB	0	0	3	11	26	58	85+																Cone bearing of 58 at 15" not adequate
		WC	38	34	30	30	29	28	27																
Yes	11	CB	3	4	6	10	41	85+			1	10.2	15	85+	+466	--	--	21	-1	-6	7,000				Cone bearing of 85+ adequate
		WC	27	27	28	26	24	21			5			85+				19	-3	-19	4,500				
											25	11.4	25	85+	+240			20	-2	-12	6,500				
											50	12.0	41	85+	+107			22	0	0	6,500				
											99	12.0	41	85+	+107			19	-3	-19	7,875				
Yes	6	CB	0	3	10	30	85+				1	8.4	23	85+	+248			19	-3	-19	6,000				Cone bearing of 85+ Adequate
		WC	27	29	31	28	25				5	9.0	30	85+	+183			20	-2	-12	6,000				
											25	9.0	30	85+	+153			19	-3	-19	7,000				
											50	15.0	85+	85+	0			18	-4	-25	7,500				
											99	14.3	85+	85+	0			19	-4	-25	8,250				
Yes	1	CB	0	0	0	4	16	54	85+		0														Cone bearing of 54 at 15" not adequate
		WC	30	29	28	27	25	25	24																
Yes	11	CB	16	45	85+						1	6.3	85+	85+	0			20	-2	-13	6,500				Cone bearing of 85+ adequate
		WC	23	23	23						5	8.4	85+	85+	0			19	-3	-19	7,000				
											12	9.0	85+	85+	0			19	-3	-19	5,500				
Yes	6	CB	0	0	27	85+					1	9.0	85+	85+	0			22	0	0	9,000				Same as above
		WC	22	22	23	23					5	10.2	85+	85+	0			22	0	0	7,500				
											12	11.4	85+	85+	0			22	0	0	7,250				
Yes	1	CB	0	0	50	85+					1	12.0	85+	85+	0			22	0	0	8,000				Same as above
		WC	35	33	31	29					5	12.3	85+	85+	0			21	-1	-6	7,000				
											12	12.3	85+	85+	0			21	-1	-6	5,000				
Yes	0	CB	0	21	42	63	85+				1	6.9	48	82	+71	85+	+23	29	+7	43	12,500				Same as above
		WC	36	31	26	25					5	11.7	83	85+	+2			30	+8	50	14,250				
											25	14.7	85+	85+	0			27	+5	31	9,750				
											51	18.6	85+	85+	0			26	+4	25					
											99	22.3	85+	85+	0			25	+3	19	2,500				
Yes	0	CB	0	30	80	85+					0														No analysis
		WC	33	29	25																				
Yes	0	CB	0	6	30	85+					0														No analysis
		WC	34	32	31	29																			
Yes	1	CB	0	5	18	53	85+				1	3.2	5	85+	+1600			26	4	25	3,500				Cone bearing of 85+ adequate
		WC	37	37	36	24					3	6.0	18	85+	+372			25	3	19	3,000				
											9	8.4	45	85+	+89			26	4	25	3,500				
											11	8.4	45	85+	+89			26	4	25	5,500				
											19	9.5	60	70	+17	85+	0	28	6	38	10,000				
											21	11.3	82	83	+1	85+	0	25	3	19	9,000				
Yes	1	CB	2	20	85+						2	9.0	85+	69	-19	85+	0	26	4	25	6,500				Same as above
		WC	33	29	24						4	9.6	85+	76	-10	85+	0	25	3	19	6,000				
											10	10.8	85+	85+	0			25	3	19	12,000				
											12	12.0	85+	85+	0			25	3	19	12,500				
											18	12.6	85+	80	-6	85+	0	26	4	25	10,500				
											20	13.8	85+	83	-2	85+	0	25	3	19	12,000				
Yes	1	CB	2	20	50	85+					1	9.0	85+	73	-14	85+	0	23	1	6	6,500				Same as above
		WC	33	33	34	34					3	10.8	85+	67	-21	85+	0	26	4	25	10,000				
											9	15.0	85+	63	-26	82	0	24	2	13	7,500				

FIGURE 13 SHEET 3

TRACTORS TESTED AT VICKSBURG, MISSISSIPPI

D-8 - Gross Weight 44,000 Pounds

Tractor				EQUIPMENT				OPERATION		LOCATION		SOIL										REMARKS					
Type	Extens-ions	Gross Weight Pounds	C't'ct Press. psi	Train		Gross Weight Pounds	C't'ct Press. psi	Passes Com-pleted	Reason for Im-mobilization	Sec-tion	Unit	Remarks	Type	Classification				Condition		Days Dry-back Test	BEFORE						
				Type	Load Pounds									Casa-grande	Pub. Rpt. Admin.	Ord-nance Class.	Atterberg Limits	Depth Scarified in in.	Flooded		CB WC	Comp. Mat. Dept.					
Tractor No. D-8																											
D-8	None	44,000	10.2	Athey wagon (2)	24,000	40,000	7.5	25	End of test	1	1	None	Clayey silt	ML	A-4	No.4	26	12	12	Yes	11	CB WC	25 31	30 30	44 44	80 29	
D-8	None	44,000	10.2	Athey wagon (2)	24,000	40,000	7.5	25	End of test	1	2	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	6	CB WC	23 31	24 29	33 24	55 --
D-8	None	44,000	10.2	Athey wagon (2)	24,000	40,000	7.5	25	End of test	1	2	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	1	CB WC	4 37	7 32	13 28	32 26
D-8	None	44,000	10.2	None	--	--	---	25	End of test	1	1	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	11	CB WC	30 27	33 29	44 31	69 30
D-8	None	44,000	10.2	None	--	--	---	25	End of test	1	2	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	6	CB WC	23 30	24 30	31 28	58 30
D-8	None	44,000	10.2	None	--	--	---	25	End of test	1	3	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	1	CB WC	2 35	4 32	16 30	39 29
D-8	None	44,000	10.2	Athey wagon (2)	24,000	40,000	7.5	25	End of test	2	1	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	0	CB WC	0 40	0 38	0 33	0 31
D-8	None	44,000	10.2	None	--	--	---	25	End of test	2	2	None	Clayey silt	ML	A-4	No.4	38	26	12	12	Yes	0	CB WC	0 42	0 38	0 35	0 32
D-8	None	44,000	10.2	None	--	--	---	25	End of test	3	1	Evident that could complete 100 passes. Test stopped at 25	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	0	CB WC	0 38	0 34	0 31	0 30
D-8	None	44,000	10.2	Athey wagon (2)	24,000	40,000	7.5	25	End of test	3	1	Tracked satisfactorily for 25 passes. Mud washing out of tracks on tractor. Readings at 1 & 5 passes N.G.	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	0	CB WC	0 35	0 32	0 28	0 25
D-8	Yes	44,000	3.7	None	--	--	---	25	End of test	5	2	None	Clayey silt	ML	A-4	No.4	38	26	12	24	Yes	0	CB WC	0 38	0 35	0 32	0 30
D-8	Yes	44,000	3.7	Mud sled (3 tons on sled)	6,000	8,000	0.5	25	End of test	5	1	Dym. pulls from sled too small to record. No rutting effect after 1st pull, so testing stopped at 25 trips	Clayey silt	ML	A-4	No.4	38	26	12	24	Yes	0	CB WC	0 40	0 38	0 36	0 34
D-8	Yes	44,000	3.7	None	--	--	---	25	End of test	6	1	25 passes satisfactory. 2 extension boards pulled off after 25 passes. Considerable mud collected on extensions during test	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	1	CB WC	0 35	0 33	0 32	0 31
D-8	Yes	44,000	3.7	None	--	--	---	25	End of test	6	2	Same as unit 1 above	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	6	CB WC	13 38	18 36	26 34	43 31
D-8	Yes	44,000	3.7	None	--	--	---	25	End of test	6	3	Same as unit 1 above	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	11	CB WC	16 33	18 33	29 33	58 29
D-8	Yes	44,000	3.7	Athey wagons with extensions (2)	24,000	40,000	4.2	0	See note	6	1	Mud piled up in extensions & tracks slipped. Extensions on 1st wagon track cocked up against body bed, caught & tracks could not turn	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	1	CB WC	11 31	10 30	15 28	48 28
D-8	Yes	44,000	3.7	Athey wagons (2) with extensions	24,000	40,000	4.2	0	See note	6	2	Same as above	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	6	CB WC	11 34	12 32	14 30	40 28
D-8	Yes	44,000	3.7	Athey wagons (2) with extensions	24,000	40,000	4.2	0	See note	6	3	Same as above	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	11	CB WC	14 30	16 28	20 27	37 27
D-8	Yes	44,000	3.7	Mud sled	6,000	8,000	0.5	25	End of test	6	1	None	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	11	CB WC	14 37	19 34	26 31	50 31
D-8	Yes	44,000	3.7	Mud sled	6,000	8,000	0.5	25	End of test	6	2	None	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	6	CB WC	18 32	21 29	29 25	65 21
D-8	Yes	44,000	3.7	Mud sled	6,000	8,000	0.5	25	End of test	6	3	None	Clayey silt	ML	A-4	No.4	38	26	12	18	Yes	1	CB WC	18 35	32 33	57 32	61 30

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. U24-2-1/2 T.

TRACTORS TESTED AT VICKSBURG, MISSISSIPPI

D-8 - Gross Weight 44,000 Pounds

Type	SOIL					Condition	Days Dry-back	Test	BEFORE TRAFFIC DATA																DURING TRAFFIC DATA										Draw Bar Resistance	Draw Bar Resistance	Analysis																																																																																																																																																										
	Classification	Cane-Grade	Pub. No.	Ordnance	Atterberg Limits				Depth Scarified	Flooded	CB WC	Cone Bearing	Water Content	Depth in Inches	Passes	In In.	Before Traffic	In Rut	Per cent	3 In. Below Rut	Per cent	In Rut	Moisture	5 Above P.L.	1 in P.L.	Draw Bar Pull of Tractor	Draw Bar Resistance																																																																																																																																																																				
Clayey silt	ML	A-4	No. 4	26	12	12	Yes	11	CB 26 30 44 80 85+ WC 31 30 30 29 --	1 1.5 26 28 0 35 -8 30 4 33 20,000 -- 5 1.5 28 28 0 40 +5 33 7 58 20,000 -- 25 3.5 31 24 -23 34 -31 32 6 50 17,000 --	1 5.5 31 12 -63 32 -48 34 8 67 12,000 2,000 5 8.0 50 16 -68 59 -24 32 6 50 15,000 -- 25 9.0 50 24 -52 85+ 49 30 4 33 13,000 2,000	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	1	CB 4 7 13 32 80 85+ WC 37 32 28 26 25 --	1 6.0 13 10 -23 39 +22 30 4 33 15,000 -- 5 6.0 13 12 -8 31 -3 33 7 58 15,000 -- 25 5.6 12 17 +42 44 +52 33 7 58 15,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	11	CB 30 33 44 69 85+ WC 27 29 31 30 30 28	1 4.0 37 47 +27 50 -4 33 7 58 20,000 -- 5 4.0 37 46 +24 66 +27 29 3 25 20,000 -- 25 7.0 52 46 -12 76 +3 23 -3 25 18,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	6	CB 23 24 31 68 85+ WC 30 30 28 30 29 29	1 7.0 42 22 -18 70 -5 31 5 42 14,000 -- 5 6.0 31 72 +132 85+ +25 28 2 17 15,000 -- 25 7.0 42 85 +102 85+ +15 31 5 42 15,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	1	CB 2 4 16 39 79 85+ WC 35 32 30 29 29	1 8.0 24 85+ +255 85+ +63 23 -3 -25 11,000 -- 5 10.0 52 85+ +64 23 -3 -25 12,000 -- 25 7.0 24 85+ +255 85+ +63 22 -4 -33 13,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	0	CB 0 0 0 8 45 83 85+ WC 40 38 33 31 29 28 --	1 12.0 45 74 +64 85+ 44 26 0 0 15,500 -- 5 14.0 70 81 416 -- - 23 -3 -25 23,500 -- 25 18.0 85+ 81 -5 -- - 25 -1 -48 16,500 --	Clayey silt	ML	A-4	No. 4	38	26	12	12	Yes	0	CB 0 0 0 9 20 65 85+ WC 42 38 35 32 29 28 24	1 14.0 50 85 +70 -- - 26 0 0 14,000 -- 5 16.0 72 85 +18 -- - 19 -7 -58 10,000 -- 25 16.0 72 63 -13 85+ 0 27 1 8 --	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	0	CB 0 3 8 19 43 68 85+ WC 38 34 31 30 29 28 --	1 14.0 60 85 +42 -- - 27 1 8 20,000 -- 5 14.0 60 85 +42 85+ 29 3 25 18,000 -- 25 16.0 74 85 +15 -- - 25 -1 -8 --	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	0	CB 0 0 3 15 48 85 WC 35 32 28 25 28 29	1 9.0 15 85 +214 85+ +77 29 3 25 9,000 11,000 5 13.0 60 85 +42 -- -- 29 3 25 9,000 9,000 25 14.0 72 85 +18 85+ 0 28 2 17 13,500 --	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	0	CB 0 0 12 30 49 61 70 78 85 WC 38 38 35 32 30 29 28 27 26	1 7.0 18 28 +56 62 +72 35 9 75 18,500 -- 5 10.0 36 55 +53 76 +43 35 9 75 20,000 -- 25 11.0 42 5 -98 -- -- 35 9 75 25,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	24	Yes	0	CB 0 0 25 39 48 54 58 63 70 WC 40 38 36 34 33 32 31 30 29	1 11.0 45 23 -49 41 -21 29 3 25 18,800 700 5 9.0 39 42 -8 53 +10 29 3 25 20,800 700 6 13.0 50 46 -8 56 0 30 4 33 18,000 700 25 15.0 54 46 +15 45 -22 30 4 33 --	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	1	CB 0 0 11 37 64 85+ WC 35 33 34 31 31 30	1 11.0 55 85 455 -- -- 32 6 50 13,000 -- 5 14.0 78 74 -5 85+ 0 28 2 17 15,000 -- 25 14.0 78 85 49 -- -- 24 -2 -17 21,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	6	CB 13 18 26 43 85+ WC 38 36 34 31 29	1 9.0 43 43 0 71 -16 26 0 0 20,000 -- 5 11.0 64 27 -58 60 -29 32 6 50 19,500 -- 25 12.0 85+ 75 -12 85 0 28 2 17 21,500 --	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	11	CB 16 18 29 58 85+ WC 33 33 33 29 25	1 9.0 58 35 -40 60 -31 34 8 67 19,000 -- 5 10.0 68 85 +25 -- -- 23 -3 -25 21,000 -- 25 11.0 78 63 -19 85+ 0 28 2 17 23,000 --	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	1	CB 11 10 15 48 80 85+ WC 31 30 28 28 -- --	0 9.0 48 22 -54 56 -30 32 6 50 11,000 2,000 5 4.0 24 18 -25 21 -45 30 4 33 18,800 8,800 25 9.0 65 21 -68 39 -54 29 3 25 21,800 800	Clayey silt	ML	A-4	No. 4	38	26	12	18	Yes	6	CB 11 12 14 40 68 85+ WC 34 32 30 28 26 --	0 --

FIGURE 14 SHEET 1

Equipment										Soil									
Tractor				Train				Operation		Location		Remarks	Type	Classification					
Type	Extensions	Gross Weight Lbs	Contact Pres. Psi	Type	Load Lbs	Gross Weight Lbs	Contact Pres. Psi	Passes Completed	Reason for Immobilization	Sect. No.	Unit No.			Cases- grande	Ord-nances	PRA	Class	LL	
D-8	Yes	44,000	3.7	None	-	-	-	0	Traction test	8	1	Due to hard condition traffic could continue indefinitely.	Clayey silt	ML	A-4	No. 4	38		
D-8	Yes	44,000	3.7	None	-	-	-	99	End of test	8	2	Tracking stopped at 99 trips. Maximum depth of ruts obtained, 16 inches.	Clayey silt	ML	A-4	No. 4	38		
D-8	Yes	44,000	3.7	None	-	-	-	99	End of test	8	3	Due to the excessive amount of mud that collects inside of the extensions, three springs were broken.	Clayey silt	ML	A-4	No. 4	38		
D-8	Yes	44,000	3.7	Athey wagons (2) with extensions	24,000	40,000	4.2	1	End of test	8	1	After 1 pass test was stopped due to heavy pull.	Clayey silt	ML	A-4	No. 4	38		
D-8	Yes	44,000	3.7	Athey wagons (2) with extensions	24,000	40,000	4.2	60	Stuck on pass 61	8	2	Athey wagon stuck and bed was pulled off tracks pulling train out of mud.	Clayey silt	ML	A-4	No. 4	38		
D-8	Yes	44,000	3.7	Athey wagons (2) with extensions	24,000	40,000	4.2	60	Stuck on pass 61	8	3	Stuck on pass 61 with one Athey wagon.	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	25	End of test	9	1	Evident that could make 100 passes in unit 1. Ruts building up in unit 1.	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	25	Stuck on pass 25	9	2	Progress very slow as mud stops track rollers from turning and must be cleaned out about every 4 passes.	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	1	End of test	9	3	Test discontinued in unit 3 because of lack of time and broken dynamometers.	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	0	Stuck at 80 ft on pass 1	10	1	Unable to reach unit 2. Mud completely filled cleats affording no traction.	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	11	End of test	11	1	None	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	11	End of test	11	2	None	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	50	Test discontinued	14	1	Dyn. broke on first pull. No data after pass 1. Doubtful whether tractor could make 100 passes (75-).	Clayey silt	ML	A-4	No. 4	38		
D-8	None	44,000	10.2	None	-	-	-	11	End of test	15	1	7 per cent slope section	Silty clay	CL	A-7	No. 2	48		
D-8	None	44,000	10.2	None	-	-	-	11	End of test	16	1	Level section, 0 per cent slope	Silty clay	CL	A-7	No. 2	48		
D-8	None	44,000	10.2	None	-	-	-	11	End of test	17	1	3-1/2 per cent slope section	Silty clay	CL	A-7	No. 2	48		

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. USA-2-1/2 T.

TESTED AT VICKSBURG, MISSISSIPPI

Test Weight 44,000 Pounds

Condition				Before Traffic Data										During Traffic Data										Drawbar Pull of Tractor	Drawbar Resistance of Tractor	Analysis
PI	In.	Flooded	Days Dried Back	Test	CB - Cone Bearing WC - Water Content										Depth of Rut In.	Cone Bearing				Moisture						
					Depth in Inches											Before Traffic	In Ruts	Per-Cent	3 In. Below Rut	Per-Cent	In Ruts	Above FL	% In FR			
					0	3	6	9	12	15	18	21	24	Passee												
12	24	Yes	10	CB	34	48	85+							1	0	34	33	- 3	-		28			25,000	-	Operating on cone bearing of about 35
				WC	25	26	28																			
12	24	Yes	5	CB	11	15	35	50	59	66	73	80	85+	-	0	11	17	+55	-		32	6	50	22,500	-	Operating on cone bearing of around 15
				WC	31	30	29	28	28	27	27	-	-	-	6	35	14	-60	-		32	6	50	24,500	-	
														99	12	59	15	-75	-		29	3	25	21,500	-	
															16	75	15	-80	-		31	5	42	23,500	-	
12	24	Yes	1	CB	0	0	31	65	85+					1	6	31	32	+ 3	-		27	1	8	21,500	-	Operating on cone bearing of around 30. Mud sticky in treads
				WC	36	34	31	28	26					12	12	65	32	-51	-		28	1	8	24,000	-	
														51	18	54	14	-84	-		29	3	25	22,500	-	
														99	23	85+	14	-84	-		30	4	33	15,500	-	
12	24	Yes	10	CB	7	30	61	85+						1	4	38	61	+61	65	+23	24	-2	-17	31,000	-	
				WC	27	28	28	28																		
12	24	Yes	5	CB	15	22	40	85+						1	6	40	38	- 5	77	- 9	28	2	17	17,500	5,000	Operating on cone bearing of around 40
				WC	28	28	27	27						11	9	85+	32	-62	70	-18	19	-7	-58	15,000	9,500	
														23	11	85+	18	-79	55	-35	30	-	33	20,000	1,500	
														41	15	85+	12	-86	44	-48	33	7	58	10,000	13,500	
														60	14	85+	-	-	-	-	-	-	-	-	-	-
12	24	Yes	1	CB	0	9	23	50	85+					1	7	30	33	+10	75	+27	26	0	0	8,000	13,500	Operating on cone bearing of around 30 and greater
				WC	35	31	28	27	25					11	11	73	25	-66	63	-26	28	2	17	17,000	7,000	
														23	12	85+	28	-67	69	-19	30	4	33	15,000	7,500	
														41	16	85+	14	-84	45	-47	30	4	33	9,000	6,500	
														60	19	85+	15	-83	23	-73	30	4	33	-	-	-
16	24	Yes	11	CB	11	16	25	48	85+					1	7	33	52	+54	72	+44	23	1	6	13,000	-	Operating on cone bearing of around 30 to 50
				WC	29	26	24	22	19					5	7	33	85	+158	85	+70	19	-3	-19	15,200	-	
														25	8	40	69	+70	75	+17	22	0	0	17,000	-	
16	24	Yes	6	CB	12	12	18	28	53	85+				1	8	25	77	+208	85+	+89	24	2	13	12,500	-	Operating on cone bearing of around 60 to 70. Mud balling up in rollers.
				WC	28	28	29	26	23	-				5	11	41	66	+61	78	0	24	2	13	11,500	-	
														25	11	41	36	-12	73	- 6	24	2	13	11,000	-	
16	24	Yes	1	CB	9	14	23	38	56	75	85+			0	11	50	77	+54	81	+17	28	6	38	12,000	-	Operating on cone bearing of 50 and greater.
				WC	31	30	30	29	28	27	26															
16	18	Yes	11	CB	14	15	20	42	76	85+				0	11	66	77	+17	85+	+ 4	21	-1	- 6	-	-	Mud filled cleats.
				WC	31	29	27	25	24	22																
16	12	Yes	11	CB	25	27	38	85+						1	7	48	67	+48	83	- 3	24	2	13	13,000	-	Operating on cone bearing of 85
				WC	26	25	24	23						5	8	85+	85+	0			21	-1	- 6	20,000	-	
														11	8	85+	85+	0			19	-3	-19	15,500	-	
16	12	Yes	6	CB	6	10	25	56	85+					1	8	45	81	+80	85+	+13	26	4	25	17,500	-	Operating on cone bearing of 85
				WC	33	27	21	21	22					5	13	85+	85+	0			24	2	13	14,700	-	
														11	12	85+	85+	0			21	-1	- 6	21,000	-	
16	24	Yes	0	CB	5	12	36	41	46	51	85+			1	12	46	75	+63	85+	+67	25	3	19	14,000	-	Operating on cone bearing of 85
				WC	31	31	32	32	32	30	28															
26	12	Yes	1	CB	15	37	85+							1	9	85+	71	-17	82	- 4	23	1	4	11,000	-	Operating on cone bearing of 85
				WC	25	29	25							5	8	85+	70	-18	85+	0	26	4	15	17,500	-	
														11	-	-	99	-	64	-	26	4	15	-	-	
26	12	Yes	1	CB	11	17	30	85+						1	7	38	85+	+124			24	2	8	12,000	-	Operating on cone bearing of 85
				WC	34	30	26	-						5	8	90	85+	+70			25	3	12	14,500	-	
														11	8	90	85+	+70			24	2	8	19,500	-	
26	12	Yes	1	CB	12	15	34	85+						1	6	34	78	+129	83	- 2	26	4	15	11,000	-	Operating on cone bearing of 85
				WC	33	31	30	27						5	8	67	82	+22	85+	0	24	2	8	17,500	-	
														11	7	90	78	85+	85+	0	26	4	15	23,500	-	

FIGURE 14 SHEET 2

Test No.	EQUIPMENT									OPERATION		LOCATION			Remarks	CLASSIFICATION						
	TRACTOR			Contact Pres. psi	Type	WHALE			Passes Completed	Reason for Immobilization	Dist. So.	Unit No.	Line No.	Type		Coarsegrain	FRA	OF FINES			LT	PT
	Type	Extension	Gross Wt Lbs			Load Lbs	Gross Wt Lbs	Contact Pres. psi										Reason for Immobilization	Dist. So.	Unit No.		
D-7 Special	None		34,800	4.8	Sled	6,000	8,000	.5	26	End of test	6	1	4	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	Sled	6,000	8,000	.5	26	End of test	6	2	4	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	Sled	6,000	8,000	.5	26	End of test	6	3	4	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	Without sled				25	End of test	6	1	4	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	Without sled				25	End of test	6	2	4	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	Without sled				25	End of test	6	3	4	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	With sled	6,000	8,000	.8	26	End of test	5	1	8	None	Clayey silt	ML	AL	No. 4	50			
D-7 Special	None		34,800	4.8	Without sled				25	End of test	5	1	8	None	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	8 Athey engine	12,000	20,000	7.5	25	End of test	1	1	11	Test stopped at 25 passes. Evident that 99 could be made.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	8 Athey engine	12,000	20,000	7.5	25	End of test	1	2	11	Evident 99 passes could be made.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	8 Athey engine	10,000	20,000	7.5	0	Tractor stuck on first pass	1	3	11	Stuck on first pass at 8 + 25. Had filled cloths - no traction.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	None				25	End of test	1	1	10	Evident 99 passes could be made.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	None				25	End of test	1	2	12	Test stopped at 25 passes. Evident 99 passes could be made.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	None				25	End of test	1	3	12	Evident 99 passes could be made.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	None				25	End of test	0	1	7	Test stopped at 25 passes.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	None				0	Tractor stuck on first pass	0	1	9	Stuck at Station 1 + 05 on first pass. Had filled tracks on traction.	Clayey silt	ML	AL	No. 4	50			
D-7	None		25,600	6.3	None				25	End of test	3	1	9		Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	8.5	None				99	End of test	3	1	1	Stuck on 4" on first pass. Two extension boards broken on each side of tractor.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	2.5	8 Athey engine	12,000	20,000	4.2	2	Stuck on third pass	3	1	8	Stuck on third pass at 8 + 40. Stuck at 0 + 40, 4th deep. The ext. tore off engine.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	2.5	None				0	Test stopped on first pass	0	1-2	1	Test stopped on first pass. Pull of 25,000 developed.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	8.3	None				99	End of test	0	2-4	1	Had collected inside of extension. Caused 4 extension board springs and 3 boards to break.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	2.3	None				51	End of test	0	3-5	1	Evident 99 passes could be made. Pull on 12 passes may be 10+ accurate.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	8.5	2 Athey engine	12,000	20,000	4.2	97	End of test	0	1	3	Test stopped as pull of 25,000 developed.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	2.3	2 Athey engine	12,000	20,000	4.2	51	End of test	0	2	3	Test stopped as pull of 25,000 developed.	Clayey silt	ML	AL	No. 4	50			
D-7	Yes		25,600	2.5	2 Athey engine	12,000	20,000	4.2	51	End of test	0	3	3	Test stopped as pull of 25,000 developed.	Clayey silt	ML	AL	No. 4	50			

NOTE: For observations and general notes see data sheet for 3-1/2-4-5 Tractor No. 314-3-1/2 7.

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TESTED AT VICKSBURG, MISSISSIPPI

Gross Weight 23,600 Pounds
 41 - Gross Weight 34,800 Pounds

L	PL	PI	Depth Soarified Inches	Flooded	Days Dry Week	Test	Before Traffic Data										During Traffic Data										Drum Pull lbs	Drum Resistance of Tire lbs	Analysis		
							CS - Core Bearing WC - Water Contents										Core Bearing														
							Depth in inches										Rate	Per Cent	Below	Per Cent	Below	Rate	Per Cent	Below	Rate	Per Cent				Below	
							0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				20	21
30	26	12	18"	Yes	1	CB	3	9	10	14	80	85	85				2	1.8	37	13	-40			34	8	67					
						WC	41	38	36	33	31	30	30				6	10.2	30	37	-23			35	9	75					
																	25	10.2	30	11	-63	17	-79	33	7	38	2,500				
30	26	12	18"	Yes	6	CB	20	22	24	33	68	85	85				2	3.0	20	12	-40			33	7	58	500				
						WC	41	38	36	33	31	31	30				6	5.4	23	24	-4			32	6	50					
																	26	8.4	30	14	-53			31	5	42	4,500				
30	26	12	18"	Yes	11	CB	25	32	42	62	82	85	85				2	1.2	27	38	-60			30	4	33	750				
						WC	31	33	34	32	31	29					6	2.4	30	12	-73	18	-47	28	2	17					
																	26	3.6	33	21			32	6	50	2,250					
30	26	12	18"	Yes	1	CB	3	9	10	14	80	85	85				1	6.6	15	15	0	47	7	34	8	67	11,000				
						WC	41	38	36	33	31	30	30				5	12.0	80	37	-50	60	-29	35	9	75	10,000				
																	25	10.2	80	18	-79	29	-65	33	7	58	2,500				
30	26	12	18"	Yes	6	CB	20	22	24	33	68	85	85				1	4.2	22	12	-45	17	-37	33	7	58	20,000				
						WC	41	38	36	33	31	31	30				9	4.2	22	24	-10	38	44	32	6	50	12,000				
																	25	7.2	26	14	-46	34	0	31	5	42	9,300				
30	26	12	18"	Yes	11	CB	25	32	42	62	82	85	85				1	1.8	28	38	-36	50	28	30	4	33	14,000				
						WC	31	33	34	32	31	29					5	2.4	30	42	-30	50	28	2	17	13,000					
																	25	3.6	33	21	-36	44	-8	32	6	50	11,000				
30	26	12	24"	Yes	0	CB	23	36	61	55	65	85	85				2	10.2	58	15	-74	46	-36	32	6	50	700				
						WC	29	30	31	32	33	34					6	11.4	61	17	-72	53	-32	34	8	67	700				
																	26	12.4	76	30	-61			34	8	67	700				
30	26	12	24"	Yes	0	CB	23	36	61	55	65	85	85				1	7.8	58	22	-62	44	-77	32	6	50	17,000				
						WC	29	30	31	32	33	34					5	10.8	58	16	-72	47	-76	34	8	67	3,750				
																	25	13.2	63	30	-52	46		34	8	67	700				
30	26	12	12"	Yes	11	CB	36	34	42	57	74	85	85				1	1.8	35	49	-28	59	-21	29	3	25	20,000				
						WC	28	27	38	31	30	28					9	6.0	42	40	-5	57	-2	30	4	33	20,000				
																	25	9.6	61	46	-25	82	-4	28	2	17	20,000	4,000			
30	26	12	12"	Yes	6	CB	19	23	25	72	85	85	85				1	6.0	20	55	-117	85	-21	28	2	17	11,000				
						WC	30	30	31	30	29	29					9	7.2	72	28	-61	39	-34	29	3	25	11,000				
																	25	10.2	85	74	-12	85	0	29	3	25	13,000				
30	26	12	12"	Yes	1	CB	0	7	16	41	85	85	85				0														
						WC	32	32	32	31	30																				
30	26	12	12"	Yes	11	CB	28	33	60	85	85	85	85				1	4.8	50	30	-40	56	-29	30	4	33	20,000				
						WC	28	29	29	29							5	3.6	39	31	-21	56	-40	31	3	25	20,000				
																	25	7.2	71	54	-23	80	-6	31	3	25	20,000				
30	26	12	12"	Yes	6	CB	20	24	38	70	85	85	85				1	6.0	38	19	-50	44	-13	34	8	66					
						WC	34	33	33	30							3	8.5	44	30	-53	68	-3	29	3	25	11,000				
																	25	10.8	85	53	-35	63	-25	32	6	50	13,000				
30	26	12	12"	Yes	1	CB	0	8	12	44	85	85	85				1	9.6	50	85	-41	85	0	30	4	33	10,000				
						WC	39	34	30	20							5	12.1	85	75	-10	85	0	30	4	33	10,500				
																	25	12.0	85	77	-9	85	0	27	1	8	11,000				
30	26	12	12"	Yes	0	CB	0	0	0	5	43	85	85				1	10.8	16	85	-430	85	-47	20	-4	-50	5,000				
						WC	38	38	34	28							5	13.8	59	78	-32	85	0	27	1	8	8,000				
																	25	16.8	85	85	0	85	0	25	-1	-8	17,000				
30	26	12	12"	Yes	0	CB	0	0	0	28	60	85	85				1	11.4	30	85	-41	85	-9	34	-2	-17	4,000				
						WC	43	39	39	30	32																				
30	26	12	18"	Yes	0	CB	0	1	5	17	31	61	85				1	12.6	37	85	-130	85	-17	30	4	33	8,000				
						WC	33	31	28	26	26	26					25	12.6	37	85	-130	85	-17	30	4	33	11,000				
30	26	12	24"	Yes	0	CB	0	0	13	13	34	39	32	24	38		1	8.4	27	23	-35	53	-85	29	3	25	31,000				
						WC	38	38	26	26	26	27	27	28	28		17	11.4	34	40	-77	81	-107	29	3	25	24,000				
																	49	17.4	33	45	-97	78	-167	29	2	17	28,000				
																	99	26	48	73	-52	85	-21	29	3	25	41,000				
30	26	12	24"	Yes	0	CB	0	0	27	51	66	85	85	85	85		1	11.4	62	28	-35	60	-89	30	4	33	31,000	6,250			
						WC	39	35	38	31	30	30	30	30			3	14.0	85	52	-39										

TRUCK TESTS CONDUCTED AT CAMP HULEN, TEXAS

2-1/2-Ton Truck - Gross Weight 14,500 Pounds
4-Ton Truck - Gross Weight 26,000 Pounds
6-Ton Truck - Gross Weight 35,000 Pounds

EQUIPMENT										OPERATION										Before Traffic										After Traffic					
Tires			Traction Device			Contact			Passes			Reason for Immobilization	Lane	Type	Flooded	Depth Strata	Classification			Variation of Cone Bearing (CB) and Moisture Content (MC) with Depth in Inches										Depth of Rut	Moisture Content				
Size	Inf. Pres.	Max. Pres.	Name	Mount- Pres.	Max. Pres.	Passes	Completed	Case	Grade	Force	1-1						1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12	1-13	1-14			1-15	1-16	Page	In.
2-1/2-TON 6 x 6 - GROSS WEIGHT WITH 2-1/2-TON LOAD = 14,500 LBS																																			
14	7.50 x 20 S	D 15 9	None	-	-	23 17	6	Insufficient traction.	11	Silty clay Sandy clay Red clay	Yes	0-6 6-9 9-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 20 40 70 64 52 50 - MC 38 30 24 28 33 34 -	1 6	3 8	4 8	4 8	4 8	4 8	4 8	4 8	4 8	4 8	4 8	4 8	4 8				
12	7.50 x 20 S	D 58 18	None	-	-	66 26	1/3	Insufficient traction.	10	Silty clay Sandy clay Red clay	Yes	0-5 5-12 12-30	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 20 60 90+ 74 60 52 - MC 36 32 25 24 28 34 -	1	8	8	8	8	8	8	8	8	8	8	8	8	8			
64	7.50 x 20 S	D 58 18	Standard chains	S	D	66 26	100	Not immobilized.	12	Silty sand Silty clay Sandy clay Red clay	No	0-3 3-6 6-11 11-30+	ML CL CL CH	A-4 Class 3 A-7 Class 3 A-7 Class 3 A-7 Class 3	27 42 36 50	17 18 18 20	10 24 18 30	CB 30 69 87 50 68 68 87 MC 24 23 20 25 28 30 28	1 10 50 100	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12	6 8 10 12					
68	7.50 x 20 S	D 58 18	Standard chains	S	D	66 26	24	Insufficient traction, ruts too deep.	12	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 3 48 90 80 67 67 76 MC 30 24 27 26 26 29 32	1 6 12 24	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12	6 7 7 12					
2	10.90 x 18 S	S 21 21	High traction chains	S	Y	31 31	10	Insufficient traction, ruts too deep.	34	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 4 28 52 73 62 69 80 MC 44 32 25 26 30 32 34	1 4 12 10	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20	7 12 20				
21	10.90 x 18 S	S 21 21	Canadian Jungle Truck, rear. High traction chains, front.	S	Y	31 31	21	Insufficient traction, ruts too deep.	6	Silty sand Silty clay Sandy clay Red clay	Yes	0-5 5-11 11-30+	ML CL CL CH	A-4 Class 3 A-7 Class 3 A-7 Class 3 A-7 Class 3	27 42 36 50	17 18 18 20	10 24 18 30	CB 12 50 75 66 42 40 40 MC 44 31 29 28 30 39 39	1 6 12 12	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14	5 6 7 14				
19	7.50 x 20 S	D 58 18	Standard chains	S	Y	66 26	12	Insufficient traction, ruts too deep.	7	Silty clay Sandy clay Red clay	Yes	0-5 5-12 12-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 14 80 80 45 55 84 70 MC 38 32 28 28 32 32 32	1 6 12 14	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15	6 12 15				
18A	7.50 x 20 S	D 58 18	High traction chains	S	Y	66 26	6	Insufficient traction.	7						Same as Lane 7 above										1 6	5 12	5 12	5 12	5 12	5 12	5 12	5 12	5 12	5 12	5 12
4-TON 6 x 6 - GROSS WEIGHT WITH 4-TON LOAD = 26,000 LBS																																			
7	14.00 x 20 S	S 18 25	None	-	-	30 37	60	Insufficient traction, ruts too deep.	12	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 3 48 90 80 67 67 76 MC 30 24 27 26 26 29 32	1 10 24 50	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16	3 14 16 16					
9	14.00 x 20 S	S 18 25	None	-	-	30 37	6	Insufficient traction, ruts too deep.	11	Silty clay Sandy clay Red clay	Yes	0-6 6-9 9-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 20 40 70 64 52 50 - MC 38 30 24 28 33 35	1 6 7	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12	6 12 12				
10	14.00 x 20 S	S 7 7	None	-	-	19 19	25	Insufficient traction, ruts too deep.	10	Silty clay Sandy clay Red clay	Yes	0-5 5-12 12-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 20 60 90+ 74 60 52 - MC 36 32 25 24 28 34	1 10 25	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15	3 5 15				
15	9.00 x 20 S	D 52 25	None	-	-	62 35	1/3	Insufficient traction.	11						Same as Lane 11 above										1/3	7	7	7	7	7	7	7	7	7	7
16	9.00 x 20 S	D 18 13	None	-	-	28 23	5	Insufficient traction, ruts too deep.	11						Same as Lane 11 above										1 4	5 11	5 11	5 11	5 11	5 11	5 11	5 11	5 11	5 11	5 11
20	9.00 x 20 S	D 52 25	High traction chains	S		62 35	4	Insufficient traction, ruts too deep.	6						Same as Lane 6 above										1 4	5 13	5 13	5 13	5 13	5 13	5 13	5 13	5 13	5 13	5 13
1	14.00 x 20 S	S 18 25	High traction chains	S	Y	30 37	27	Insufficient traction, ruts too deep.	34						Same as Lane 34 above										1 7 27	9 17 19	9 17 19	9 17 19	9 17 19	9 17 19	9 17 19	9 17 19	9 17 19	9 17 19	9 17 19
6	9.00 x 20 D	D 18 25	Calsonet-Watons	S	Y	30 37	6	Slippage between tires and traction device.	11						Same as Lane 11 above										1 4	6 11	6 11	6 11	6 11	6 11	6 11	6 11	6 11	6 11	6 11
6-TON 6 x 6 - GROSS WEIGHT WITH 6-TON LOAD = 35,000 LBS																																			
11	14.00 x 20 S	D 27 15	None	-	-	39 37	6	Insufficient traction.	10						Same as Lane 10 above										1 6	5 11	5 11	5 11	5 11	5 11	5 11	5 11	5 11	5 11	5 11
17	10.00 x 22 S	D 22 11	None	-	-	34 23	11	Insufficient traction, ruts too deep.	9	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24 18 30	CB 7 70 76 77 29 27 68 MC 38 27 23 28 32 34 36	1 12	3 13	3 13	3 13	3 13	3 13	3 13	3 13	3 13	3 13	3 13	3 13	3 13	3 13			
13	10.00 x 22 S	S 66 32	None	-	-	78 44	1/3	Front wheels bogged down.	10						Same as Lane 10 above										1	14	14	14	14	14	14	14	14	14	14
5	10.00 x 22 S	D 66 32	High traction chains	S	D	78 44	6	Insufficient traction.	12						Same as Lane 12, Test 64 above										1 5	11 12	11 12	11 12	11 12	11 12	11 12	11 12	11 12	11 12	11 12
3	10.00 x 22 S	D 66 32	High traction chains	S	D	78 44	1	Insufficient traction.	34						Same as Lane 34 above										1	11	11	11	11	11	11	11	11	11	11
44	14.00 x 20 S	D 27 15	High traction chains on outside dual only	S	Y	39 27	100	Not immobil.	12						Same as Lane 12, Test 64 above										1 10 25 100	7 13 13 13	7 13 13 13	7 13 13 13	7 13 13 13	7 13 13 13	7 13 13 13	7 13 13 13	7 13 13 13	7 13 13 13	
48	Same as Test 44 except in flooded part of lane						100	Not immobilized.	12						Same as Lane 12, Test 68 above										1 20 29 50 100	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	5 13 16 19 23	
22	14.00 x 20 S	D 27 15	High traction chains on outside dual only	S	Y	39 27	17	Insufficient traction, ruts too deep.	6						Same as Lane 6 above										1 6 13 12	4 13 15	4 13 15	4 13 15	4 13 15	4 13 15	4 13 15	4 13 15	4 13 15	4 13 15	4 13 15

NOTE: For abbreviations and general note see data sheet for 2-1/2-Ton Truck No. ULS-2-1/2 T.

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TRUCK TESTS CONDUCTED AT CAMP MULEN, TEXAS

2-1/2-Ton Truck - Gross Weight 16,600 Pounds
4-Ton Truck - Gross Weight 26,000 Pounds
6-Ton Truck - Gross Weight 35,000 Pounds

Utilization	Lane	Type	Flooded	Depth Strata In.	Classification Case- granda Ord- pance	L.H.	P.H.	P.L.	Before Traffic										During Traffic					Draw- bar Pull lbs	Analysis
									Variation of Cone Bearing (CB) and Moisture Content (MC) with Depth in Inches										Pass	In.	Cone Bearing Before In Traffic	Moisture Content In Full			
									Test	0	3	6	9	12	15	18	21	24							
Station.	11	Silty clay Sandy clay Red clay	Yes	0-6 6-9 9-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 20 MC 38	40 30	70 24	64 28	52 33	50 34	-	1 6	3 8	40 64	56 + 40 28 - 55	22 25	1,000 0	Cone bearing. A cone bearing of about 60 and greater (in the rut after tracking) was furnishing support for the 2-1/2-ton truck for a limited number of passes.		
Station.	10	Silty clay Sandy clay Red clay	Yes	0-5 5-12 12-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 20 MC 36	60 32	90+ 25	74 24	60 28	52 34	-	1 10	8 12	84 67	45 - 46 50 - 25	21 33	0	Slipperiness. For rubber tires without traction devices, a moisture content of 3% and more above the plastic limit was so slippery that little or no drawbar was developed. For rubber tires with traction devices, moisture contents as high as 15% above the plastic limit apparently did not affect the drawbar pull.		
Station.	12	Silty sand Silty clay Sandy clay Red clay	No	0-3 3-6 6-11 11-30+	ML CL CL CH	A-4 Class 3 A-7 Class 3 A-7 Class 3 A-7 Class 3	27 42 36 50	17 18 18 20	10	CB 30 MC 24	69 24	87 20	87 25	68 28	68 30	87 28	1 100	6 10	87 50	55 - 37 50 - 25	22 33	4,250 3,500 7,000 7,500	Stickiness. Stickiness did not develop. The average moisture content was 14% below the liquid limit.		
Station.	12	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 3 MC 30	48 24	90 27	80 26	67 26	67 29	76 32	1 12	6 7	90 86	68 - 42 63 - 27	23 24	4,500 4,750 4,500	Effect of rut- petitions. The cone bearing in the ruts averaged 40% less than the cone bearing at a comparable depth prior to traffic.		
Station.	3A	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 4 MC 44	28 32	52 25	73 26	62 30	69 32	80 34	1 10	7 12	60 62	32 - 47 30 - 53	27 29	4,500 4,000 3,000			
Station.	6	Silty sand Sandy clay Red clay	Yes	0-5 5-11 11-30+	ML CL CH	A-4 Class 3 A-7 Class 3 A-7 Class 3	27 36 50	17 18 20	10	CB 12 MC 44	50 31	75 29	66 28	42 30	40 39	40 39	1 12	5 14	75 40	42 - 44 50 - 33	25 30	2,100 2,100 1,000			
Station.	7	Silty clay Sandy clay Red clay	Yes	0-5 5-12 12-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 14 MC 38	80 32	80 28	45 28	55 32	84 32	70 32	1 14	6 15	80 84	55 - 44 30 - 45	24 33	2,000 1,000 0			
Station.	7	Same as Lane 7 above								1 6	5 12	86 55	70 - 18 30 - 45	22 24	3,000 0										
Station.	12	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 3 MC 30	48 30	70 24	60 27	67 26	67 29	76 32	1 10	3 14	48 68	70 + 46 64 - 38	22 26	3,750 2,500 2,200	Cone bearing. A cone bearing of about 50 and greater (in the rut after tracking) was furnishing support for a limited number of passes.		
Station.	11	Silty clay Sandy clay Red clay	Yes	0-6 6-9 9-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 20 MC 38	40 30	70 24	64 28	52 33	50 35	-	1 7	6 12	70 52	37 - 57 30 - 42	24 23	2,500 1,000 0	Slipperiness. Rubber tires without traction devices developed a small amount of drawbar pull where the moisture content was as high as 6% above the plastic limit. Rubber tires with traction devices developed some drawbar where the moisture content was 12% above the plastic limit. No stickiness developed. The average moisture content was 16% below the liquid limit.		
Station.	10	Silty clay Sandy clay Red clay	Yes	0-5 5-12 12-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 20 MC 36	60 32	90+ 25	74 24	60 28	52 34	-	1 25	3 15	60 52	82 + 27 68 - 24	24 23	3,000 2,000 0	Stickiness. The cone bearing in the ruts averaged 36% less than the cone bearing at a comparable depth prior to traffic.		
Station.	11	Same as Lane 11 above								1 5	7 11	70 58	30 - 57 16 - 80	23 23	0										
Station.	11	Same as Lane 11 above								1 5	4 11	52 58	72 + 36 16 - 80	21 23	2,000 0										
Station.	6	Same as Lane 6 above								1 4	5 13	75 40	85 + 7 25 - 37	22 34	2,750 0										
Station.	3A	Same as Lane 3A above								1 7	9 17	73 77	45 - 38 66 - 40	32 31	4,500 4,400										
Station.	11	Same as Lane 11 above								1 6	6 11	70 60	66 - 23 60	23 31	4,500 0										
Station.	10	Same as Lane 10 above								1 6	5 11	90+ 60	28 - 69 16 - 73	20 29	4,000 0										
Station.	9	Silty clay Sandy clay Red clay	Yes	0-6 6-11 11-30+	CL CL CH	A-7 Class 3 A-7 Class 3 A-7 Class 3	42 36 50	18 18 20	24	CB 7 MC 38	70 27	76 23	57 38	27 32	27 34	68 36	1 12	3 10	70 58	45 - 50 40 - 30	19 22	3,000 4,000 0	Stickiness. Moisture contents 6 and 9% above the plastic limit produced a condition which was so slippery that rubber tires without traction devices could not develop appreciable drawbar. Rubber tires with traction devices developed appreciable drawbar where there were moisture contents as high as 15% above the plastic limit.		
Station.	10	Same as Lane 10 above								1 5	4 12	76 67	36 - 53 49 - 27	22 33	5,000 8,750										
Station.	12	Same as Lane 12, Test 64 above								1 10	11 11	64 61	34 - 47 40 - 35	30 38	0 5,800										
Station.	3A	Same as Lane 3A above								1 25	7 13	73 61	22 - 70 45 - 26	30 39	4,750 7,000										
Station.	12	Same as Lane 12, Test 64 above								100 100	13 13	61 61	68 - 21 28 - 54	36 30	8,400 10,750										
Station.	12	Same as Lane 12, Test 68 above								1 10	5 13	72 68	60 - 17 66 - 13	21 35	7,000 7,300										
Station.	6	Same as Lane 6 above								1 12	4 15	68 60	33 - 51 31 - 24	27 33	3,000 3,000										

Truck No. 284-2-1/2 T.

Test	EQUIPMENT								OPERATION					Soil Type	Dep Str I
	Tractor				Train				Passes Completed	Reason for Immobilization	Lane	Flooded			
	Type	Extensions	Gross Weight Lbs	Contact Pres. Psi	Type	Load Lbs	Gross Weight Lbs	Contact Pres. Psi							
<u>TRACTORS ALONE</u>															
1	Spec. D-7	None	34,800	4.8	None	-	-	-	100	Not immobilized	1	Yes	Silty clay 0- Sandy clay 6- Red clay 11-		
2	D-8	60-in. wooden	44,000	3.7	None	-	-	-	-	Drawbar tests only	1				
9	TD-14	60-in. wooden	21,600	2.3	None	-	-	-	100	Not immobilized	2	Yes	Silty clay 0- Sandy clay 7- Red clay 11-		
10	D-7	60-in. wooden on every other plate	23,600	2.5	None	-	-	-	50	Not immobilized	2				
<u>TRACTORS WITH ATHEY WAGONS</u>															
3	Spec. D-7	None	34,800	4.8	Two 6-Ton Athey Wagons	14,400 each	22,400 each	8.2	5	Tracks on wagons quit turning, tractor stuck on pass 6	1				
5	D-7	60-in. wooden	23,600	2.5	Two 6-Ton Athey Wagons	14,400 each	22,400 each	8.2	49	Train stuck in soft spot (old ditch) on pass 50	1				
7	D-8	60-in. wooden	44,000	3.7	Two 6-Ton Athey Wagons	14,400 each	22,400 each	8.2	21	Tracks on wagons skidded on pass 22, tractor stuck	3		Silty clay 0- Sandy clay 6- Red clay 11-		
8	Spec. D-7	None	34,800	4.8	Two 6-Ton Athey Wagons	12,000 each	20,000 each	7.5	0	Tracks on wagons skidded on pass 1, tractor stuck	3				
11	D-8	60-in. wooden	44,000	3.7	Two 6-Ton Athey Wagons with 60-in. extensions on every other plate	12,000 each	20,000 each	7.5	16	Mired down and stuck on pass 17	3				
<u>TRACTOR WITH MUD SLED</u>															
6	Spec. D-7	None	34,800	4.8	Two Engineer Board Mud Sleds	6,000 each	7,850 each	0.6	12	Cable hitch broke, passes could have continued	3				

NOTES:

- (a) Drawbar tests made at one end of lane prior to repetitions.
 (b) In old ditch where train was stuck.

For abbreviations and general notes see data sheet for 2-1/2-Ton Truck No. USA-2-1/2 T.

Tractors Alone
Tractors with Athey Wagons
Tractor with Mud Sled

[illegible]

Before Traffic										TRAFFIC DATA							ANALYSIS	
Variation of Cone Bearing (CB) and Moisture Content (WC) with Depth in Inches										Depth of Rut	Cone Bearing			Moisture Content	Draw-bar Pull			
P.I.	Test	0	3	6	9	12	15	18	Pass	In.	Traffic	Rut	In Per Cent	in Rut	Lbs			
24	CB	6	15	23	28	31	33	40	1	3	15	20 + 33	6	In. water in	7,750	<u>Cone bearing.</u>	Spec. D-7 tractor and D-7, D-8, and TD-14 tractors operated on material with cone bearing of 15 to 60 for more than 25 passes.	
									9	5	20	25 + 25	ruts					
									25	7	24	32 + 33						
									50	9	28	38 + 36						
18	WC	43	36	30	28	33	37	40	100	11	30	40 + 33				<u>Slipperiness.</u>	Slipperiness was not a problem. In several cases tractors were operating with water in ruts, but grousers or extensions were effective in cutting through to firm material.	
30																<u>Stickiness.</u>	Stickiness did not develop. Average moisture content in rut was above the liquid limit as in areas where water was in ruts.	
24	CB	8	17	30	40	50	60	68	(a)	7	34	36 + 6	6	"	21,000	<u>Effect of repetitions.</u>	First few repetitions do not produce appreciable change. Additional repetitions produce appreciable decrease in cone bearing. In one test there was considerable increase.	
									1	3	17	18 + 6						
									10	7	34	18 - 47						
									25	12	50	20 - 60						
18	WC	37	30	26	25	30	31	32	50	7	34	25 - 29						
30									100	8	38	22 - 42						
24	CB	5	29	52	62	70	80	90+	1	3	29	18 - 31	6	In. water in	21,000	<u>Cone bearing.</u>	Cone bearing of 15 and more apparently furnishes support for Athey wagons. Operation is not dependent entirely on support, however.	
									12	6	56	23 - 59	ruts					
									22	13	73	25 - 66						
									1	7	60	- -	"					
18	WC	44	32	25	26	30	32	33	10	10	65	17 - 74	-			<u>Slipperiness and stickiness.</u>	Conditions were such that some mud stuck to the tracks of the Athey wagons causing them to bind. Mud in the ruts was slippery enough for the tracks without extensions to slide rather than turn. Tracks with extensions did not have this difficulty. Average moisture content where surface water existed was 13% above the plastic limit and 12% below the liquid limit.	
30									17	12	70	15 - 78	32			<u>Effect of repetitions.</u>	Repetitions of traffic with the Athey wagons and tractors reduced the cone bearing in the ruts an average of 44%.	
24	CB	5	29	52	62	70	80	90+	In tractor ruts						21,000	<u>Cone bearing.</u>	Mud sleds will operate on a material with a cone bearing of 5 to 10.	
									1	1	10	7 - 30	2	In. water on				
									10	4	36	16 - 55	surface					
									Where mud sled operated									
18	WC	44	32	25	26	30	32	33	1	0	5	7 + 40	2	In. water on	21,000	<u>Slipperiness.</u>	Slipperiness is an asset.	
30									10	1	10	13 + 33	surface					
24	CB	5	29	52	62	70	80	90+	In tractor ruts						21,000	<u>Stickiness.</u>	No analysis.	
									1	1	10	7 - 30	2	In. water on				
									10	4	36	16 - 55	surface					
									Where mud sled operated									
18	WC	44	32	25	26	30	32	33	1	0	5	7 + 40	2	In. water on	21,000	<u>Effect of repetitions.</u>	No analysis.	
30									10	1	10	13 + 33	surface					

FIGURE 17

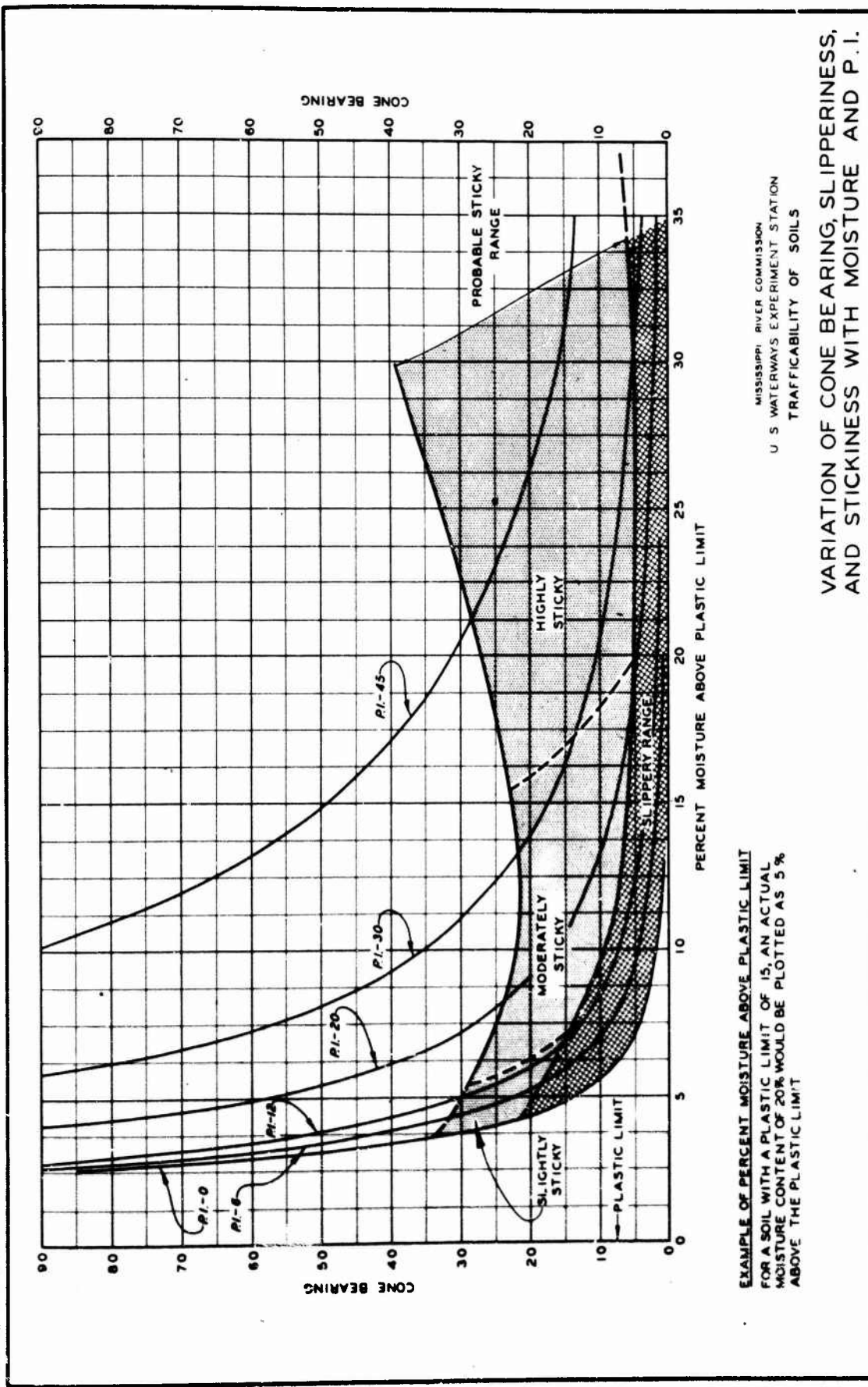


FIGURE 18

MOBILITY OF STANDARD MILITARY

Based on Limited Operation (Approximate)

Soil Classification	Typical Names of Soils in Group	Liquid Limit	Plastic Range (PI)	Percent Moisture above Plastic Limit producing Min. Cone Bearing Indicated	Approximate Cone Bearing within 10 Inches of Ground Surface	Sticky
COARSE-GRAINED						
Gravel & gravelly soils GW, GC, GP	Well graded gravel & gravel-sand mixtures, little or no fines, well graded gravel-sand-clay mixtures excellent binder, poorly graded gravel & gravel-sand mixtures little or no fines	Not significant	Not significant	Not significant	80+	No
GF	Gravel with fines, very silty gravel, clayey gravel, poorly graded gravel-sand-clay mixtures	Plasticity must be determined for material passing 40-mesh screen. Detrimental only when PI exceeds 6.			50-80 35-50 15-35	May be slightly "
Sands & sandy soils SW, SC, SP, SF	Well graded sands & gravelly sands, little or no fines, well graded sand-clay mixtures excellent binder, poorly graded sands little or no fines, cohesionless sands with fines	Not significant	Not significant	Moist to saturated Dry	Not applicable Not applicable, loose	May be slightly
SF	Sands with fines, very silty sands	20-30	6-15	2-4 3-6 6-9	50-80 35-50 15-35	May be slightly "
FINE-GRAINED						
Feebly plastic ML, CL, MH, Pt	Silts & very fine sands, sandy clays, silty clays, lean clays, peats	Not significant	0-6	0-2 2-4 4-6	50-80 35-50 15-35	No Slightly Slightly
Moderately plastic soils ML, CL, OL, MH	Organic & inorganic silts, sandy clays, lean clays, silty clays	25-60	6-12	2-4 3-6 6-9	50-80 35-50 15-35	No Slightly Moderately
Plastic soils CL, OL, OH	Organic and inorganic clays, silty clays, lean clays	30-60	12-20	2-6 3-8 6-12	50-80 35-50 15-35	No Slightly Moderately
Highly plastic soils CH, OH	Organic & inorganic clays	40-70	20-30	4-10 6-12 8-24	50-80 35-50 15-35	No No Mod.-highly
Very highly plastic soil CH	Clay	50+	30+	8-20 12-25 20-40	50-80 35-50 15-35	No Moderately Highly

- NOTES:
- Where mud above firm layer has a cone bearing value of less than about 15, vehicles may operate at depths equal to 2.
 - All conditions above the plastic limit are slippery for rubber tires. Statements pertaining to slipperiness apply.
 - For cone bearing values less than about 15, bridging or roadways are required. See Appendix D for equipment class.
 - Applies to crawler tractors and trucks which were the basis of estimate.
 - Vehicles alone without any towed equipment, assuming adequate power to cause slipping of tracks or wheels.
 - Cone bearing values are given adjective classifications as follows: 0-5 = fluid; 15-35 = very soft; 35-50 = soft;

1

MILITARY VEHICLES ON MAJOR SOIL TYPES

ration (Approximately 25 Passes) Over Muddy Terrain

Sticky	Slippery ² for Equipment that can Operate	Class of Equipment ³ that can Operate			Estimated Draw Bar ⁴ Ratio to Total Weight of Vehicle			Maximum Slope Vehicle ⁵ can Traverse - in Percent			Remarks
					Type			Type			
		Good	Doubtful	No-Go	A	B	C	A	B	C	
		<u>COARSE-GRAINED MATERIALS</u>									
No	No	ABCDE	-	-	Estimated to be equal to or higher than values listed below for low PI materials.			Not considered as mud. Highly stable under tions.			
be ghtly	No	ABCD		E	Estimated to be equal to or higher than values listed below for low PI materials.			In general, vehicles without traction device operate on this material. Considered as very unlikely condition.			
	No	AB	CD	E							
	No	A	B	CDE							
be ghtly	No	AB D*	C	-	Estimated to be equal to or higher than values listed below for low PI materials.			* For trucks with low-pressure tires only.			
		A D*	B	CE							
be ghtly	No	ABC	D	E	Estimated to be equal to or higher than values listed below for low PI materials.			Sands with fines having little or no plasticity be included in SW, SC, SP group.			
	No	AB	C	DE							
	Slightly	A	B	CDE							
<u>FINE-GRAINED MATERIALS</u>											
No	No	ABC	D	E	0.7	0.5	0.3	55	40	25	
ghtly	Slightly	AB	C	DE	0.6	0.4	-	50	30	-	
ghtly	Slightly	A	B	CDE	0.4	-	-	30	-	-	
No	No	ABC	D	E	0.6	0.4	0.2	50	30	15	
ghtly	No	AB	C	DE	0.5	0.3	-	40	25	-	
erately	No	A	B	CDE	0.3	-	-	25	-	-	
No	No	ABC	D	E	0.5	0.4	0.1	40	30	10	
ghtly	No	AB	C	DE	0.4	0.3	-	30	25	-	
erately	No	A	B	CDE	0.2	-	-	15	-	-	
No	No	ABC	D	E	0.4	0.3	0.1	30	25	10	
No	No	AB	C	DE	0.3	0.2	-	25	15	-	
-highly	No	A	B	CDE	0.2	-	-	15	-	-	Sticky condition both on bottom & overlying mobilize equipment.
No	No	ABC	D	E	0.3	0.2	0.05	25	15	5	
erately	No	AB	C	DE	0.2	0.1	-	15	10	-	Same as above.
ly	No	A	B	CDE	0.1	-	-	10	-	-	Probable that sticky condition will immobilize

be equal to and slightly greater than the ground clearance.
ness apply only to track type vehicles with cleats or extensions and wheel vehicles with chains.
ment classification.

50 - soft; 50-80 - stiff; and 80- - firm bottom.

2

VEHICLES ON MAJOR SOIL TYPES

5 Passes) Over Muddy Terrain

Class of Equipment ³ that can Operate			Estimated Draw Bar ⁴ Ratio to Total Weight of Vehicle			Maximum Slope Vehicle ⁵ can Traverse - in Percent			Remarks
Good	Doubtful	No-Go	Type			Vert. rise, ft Horiz. dist., ft x 100			
			A	B	C	A	B	C	

RIALS

ABCDE	-	-	Estimated to be equal to or higher than values listed below for low PI materials.			Not considered as mud. Highly stable under all conditions.		
ABCD		E	Estimated to be equal to or higher than values listed below for low PI materials.			In general, vehicles without traction devices can operate on this material. Considered as very unlikely condition.		
AB	CD	E						
A	B	CDE						
AB D*	C	-	Estimated to be equal to or higher than values listed below for low PI materials.			* For trucks with low-pressure tires only.		
A D*	B	CE				* For trucks with low-pressure tires only.		
ABC	D	E	Estimated to be equal to or higher than values listed below for low PI materials.			Sands with fines having little or no plasticity should be included in SW, SC, SP group.		
AB	C	DE						
A	B	CDE						

LS

ABC	D	E	0.7	0.5	0.3	55	40	25	
AB	C	DE	0.6	0.4	-	50	30	-	
A	B	CDE	0.4	-	-	30	-	-	
ABC	D	E	0.6	0.4	0.2	50	30	15	
AB	C	DE	0.5	0.3	-	40	25	-	
A	B	CDE	0.3	-	-	25	-	-	
ABC	D	E	0.5	0.4	0.1	40	30	10	
AB	C	DE	0.4	0.3	-	30	25	-	
A	B	CDE	0.2	-	-	15	-	-	
ABC	D	E	0.4	0.3	0.1	30	25	10	
AB	C	DE	0.3	0.2	-	25	15	-	
A	B	CDE	0.2	-	-	15	-	-	
ABC	D	E	0.3	0.2	0.05	25	15	5	Sticky condition both on bottom & overlying mud may immobilize equipment.
AB	C	DE	0.2	0.1	-	15	10	-	
A	B	CDE	0.1	-	-	10	-	-	
Same as above.									
Probable that sticky condition will immobilize equipment.									

greater than the ground clearance.

* type vehicles with cleats or extensions and wheel vehicles with chains.

; and 80- = firm bottom.

FIGURE 19

APPENDIX

APPENDIX A

CLASSIFICATION SYSTEMS

1. This appendix presents summaries of classification systems in use by the Corps of Engineers, the Public Roads Administration, and the Ordnance Department. The summaries are shown on figures as follows:

Figure 1A, Corps of Engineers (Casagrande) Classification.

Figure 2A, Public Roads Administration Classification.

Figure 3A, Ordnance Department Classification.

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Group	A-1	A-2		A-3	A-4	A-5	A-6	A-7	A-8
		Friable	Plastic						
General stability properties.	Highly stable at all times.	Stable when dry; may ravel.	Good stable material.	Ideal support when confined.	Satisfactory when dry; loss of stability when wet or by frost action.	Difficult to compact; stability doubtful.	Good stability when properly compacted.	Good stability when properly compacted.	Incappable of support.
Physical constants:									
Internal friction.....	High.....	High.....	High.....	High.....	Variable.....	Variable.....	Low.....	Low.....	Low.....
Cohesion.....	do.....	Low.....	do.....	None.....	do.....	do.....	High.....	High.....	Do.....
Shrinkage.....	Not detrimental.	Not significant.	Detrimental when poorly graded.	Not significant.	do.....	Variable.....	Detrimental.	Detrimental.	Detrimental.
Expansion.....	None.....	None.....	Some.....	Slight.....	do.....	High.....	High.....	do.....	Do.....
Capillary.....	do.....	do.....	do.....	do.....	Detrimental.	do.....	do.....	do.....	Do.....
Elasticity.....	do.....	do.....	do.....	None.....	Variable.....	Detrimental.	None.....	do.....	Do.....
Textural classification:									
General grading.....	Uniformly graded; coarse-fine excellent binder.	Poor grading; poor binder.	Poor grading; inferior binder.	Coarse material only; no binder.	Fine sand cohesionless silt and friable clay.	Micaceous and diatomaceous.	Deflocculated cohesive clays.	Drainable flocculated clays.	Peat and muck.
Approximate limits:									
Sand..... percent.....	70-85.....	55-80.....	55-80.....	75-100.....	55 (maximum).....	55 (maximum).....	55 (maximum).....	55 (maximum).....	55 (maximum).....
Silt..... do.....	10-20.....	0-45.....	0-45.....	(?).....	High.....	Medium.....	Medium.....	Medium.....	No. significant.....
Clay..... do.....	5-10.....	0-45.....	0-45.....	(?).....	Low.....	Low.....	30 (minimum).....	30 (minimum).....	Do.....
Physical characteristics:									
Liquid limit.....	14-35.....	35 (maximum).....	35 (maximum).....	NP ¹	20-45.....	35 (minimum).....	35 (minimum).....	35 (minimum).....	35-400.....
Plasticity Index.....	4-6.....	NP-3 ²	3-15.....	NP ¹	0-15.....	0-60.....	18 (minimum).....	12 (minimum).....	0-60.....
Field moisture equivalent.....	Not essential.	Not essential.	Not essential.	Not essential.	30 (maximum).....	30-120.....	50 (maximum).....	30-100.....	30-400.....
Centrifuge moisture equivalent.....	15 (maximum).....	12-25.....	25 (maximum).....	12 (maximum).....	Not essential.	Not essential.	Not essential.	Not essential.	Not essential.
Shrinkage limit.....	14-20.....	15-25.....	25 (maximum).....	Not essential.	20-30.....	30-120.....	6-14.....	10-30.....	30-120.....
Shrinkage ratio.....	1.7-1.9.....	1.7-1.9.....	1.7-1.9.....	do.....	1.5-1.7.....	0.7-1.5.....	1.7-2.9.....	1.7-2.9.....	0.3-1.4.....
Volume change.....	0-10.....	0-6.....	0-16.....	None.....	0-16.....	0-16.....	17 (minimum).....	17 (minimum).....	4-200.....
Linear shrinkage.....	0-3.....	0-3.....	0-4.....	do.....	0-4.....	0-4.....	5 (minimum).....	5 (minimum).....	1-30.....
Compaction characteristics:									
Maximum dry weight, pounds per cubic foot.....	130 (minimum).....	120-130.....	120-130.....	120-130.....	110-120.....	80-100.....	80-110.....	80-110.....	90 (maximum).....
Optimum moisture, percentage of dry weight (approximate).....	9.....	9-12.....	9-12.....	9-12.....	12-17.....	22-30.....	17-28.....	17-28.....	
Maximum field compaction required, percentage of maximum dry weight, pounds per cubic foot.....	90.....	90.....	90.....	90.....	95.....	100.....	100.....	100.....	Waste.....
Rating for fills 50 feet or less in height.....	Excellent.....	Good.....	Good.....	Good.....	Good to poor.....	Poor to very poor.....	Fair to poor.....	Fair to poor.....	Unsatisfactory.....
Rating for fills more than 50 feet in height.....	Good.....	Good to fair.....	Good to fair.....	Good to fair.....	Fair to poor.....	Very poor.....	Very poor.....	Very poor.....	Do.....
Required total thickness for subbase, base and surfacing, inches.....	0-4.....	0-6.....	2-8.....	0-8.....	0-18.....	0-24.....	12-24.....	12-24.....	

¹ Percentage passing No. 200 sieve, 9 to 10.

² When used as a base course for thin flexible surfaces the plasticity index and liquid limit should not exceed 6 and 25, respectively.

NP—nonplastic.

SUMMARY OF CLASSIFICATION SYSTEM IN USE BY PUBLIC ROADS ADMINISTRATION

(From "Public Roads", Feb. 1942, Vol. 22, No. 12)

FIGURE 2A

No. 1 — Loose Sands

Deep loose, porous, incoherent sand. Particles vary from .25 to 1 millimeter in size, sometimes mixed with a small percentage of coarser material (gravel) or finer material (silt).

Found along lake and ocean beaches, near major stream courses, outwash benches and in areas where sandstone rock has disintegrated. Common to semi-arid and arid climates. Usually covers less than 5 percent of the surface of large land areas.

Topography varies from nearly level and billowy to dune-like. Dunes varying in height from a few to a hundred feet or more.

Single grained structure—particles give way readily when dry—particularly if well-rounded and about the same size. Has more bearing power when partly wet than dry. Usually very low in content of organic matter.

No. 2 — Soils with low tractive efficiency. (Slippery when wet). Fine sandy, silty or loamy granular surface soil with compacted but permeable subsoil.

Found mostly on uplands derived from crystalline and sandy sedimentary rocks and from medium textured glacial and marine deposits.

Topography varies from nearly level to rolling and steep. Covers large areas in the United States and distributed generally over the land surface of the earth.

Variable in content of organic matter depending on climatic conditions. Structure of the surface soil laminated or single grained in humid areas, granular in prairies and subhumid areas.

Characterized by the medium textured types of the following soil series: Ontonagon, Harmon, Chester, Cecil, Orangeburg, Ruston, Clinton, Bates, Grenada, Clarion, Barnes, Colby.

No. 3 — Soils with high adhesive and cohesive properties. (Sticky and gummy when wet).

Clay loams and clays with slowly permeable heavy textured subsoils.

Found on nearly level to gently sloping alluvial and bench lands and in uplands derived from fine textured sedimentaries (limestones and shales), glacial water laid and marine deposits.

Variable in organic matter content depending on climatic environment. Soils from limestone and other calcareous materials usually dark colored. Structure granular in the surface soil to compact and massive in the subsoil.

Characterized by the heavy textured types of the following soils series: Susquehanna, Wabash, Oktibbeha, Houston, Gila, Fargo, Otero, Pierre.

No. 4 — Soils with little bearing power when saturated (including soils of uniform texture, single grained structure and deflocculated). (Primarily silts and fine sands).

Silts and fine sands 2-1/2 or more feet in thickness overlying a slowly permeable strata. Nearly uniform in texture and of single grained structure or clays deflocculated by salts.

Occur in relatively small areas as colluvial or alluvial deposits, also in semi-arid or arid climates or as windblown accumulations. Topography nearly level to only slightly sloping.

Characterized by silty, fine sandy or clayey types of the following soil series: Waverly, Cory, Amity, Gila, Yolo.

No. 5 — Soils with high tractive efficiency and bearing power. (only slightly plastic when wet).

Loamy sands and sandy loams with freely permeable subsoils.

Occur in outwash and major stream valleys, marine deposits, sandy sedimentary and crystalline rock areas and in semi-arid and arid climates.

Topography variable from nearly level to steep. Usually low in organic matter and somewhat droughty — absorbs water readily and occupies positions where drainage is rapid.

Occurs widespread over the land surface.

Characterized by the loamy and sandy members of the following soil series: Norfolk, Plainfield, Sasfras, Vallri, Rewes, Springer.

No. 6 — Peats and Mucks (Marshes and bogs)

No. 7 — Soils shallow to rock including exposed rock surfaces.

Thin (6 inches or less) covering of soil over rock to exposed rock surfaces. Usually very rolling to steep rough and mountainous topography.

Characterized by rough, stony and rocky land.

ORDNANCE DEPARTMENT SOIL CLASSIFICATIONS

(Furnished by Ordnance Department)

FIGURE 3A

APPENDIX B

PROCEDURES FOR PREDICTING TRAFFICABILITY OF SOILS

1. This appendix presents procedures for making field reconnaissance, laboratory tests, and analysis for use in predicting the trafficability of soils.

2. Equipment

a. Field Equipment. The survey party must be equipped with one or more cone penetrometers, one Fort Peck Sampler with a supply of sampling tubes (estimated five), and a large supply of 8-ounce cans (estimated two gross).

b. Laboratory Equipment. A liquid limit device, oven, and balances for moisture content determinations are required.

3. Test Procedure.

a. Cone Penetrometer. Insert the cone into the ground until the top of the cone is flush with the surface, slowly apply a steady pressure until the instant that movement of the cone is observed. Release the pressure and read the maximum load required to produce movement (a ring on the plunger rod is provided for this purpose). Bearing values for depths below the surface are obtained in the same manner by first pushing the cone to the required depth. Circular marks on the device, spaced at 3-inch intervals from the top of the cone, are provided to measure the depth at which the tests are performed. It is recommended that several check tests be made in a given location to obtain representative values.

b. Fort Peck Sampler. The sampler is provided with two handles, the upper one of which is attached to a suction valve in the sampling tube. The lower handle is used to force the sampler into the soil. Holding the top handle steady or raising it slightly, force the sampler into the soil. If the soil is stiff (cone bearing 50 to 80), some difficulty may be experienced; however, by slowly twisting the sampler while pressure is applied, it will be possible to push the sampler to its full depth. Twist the sampler several times to break the soil bond at the bottom. Increase the vacuum in the sampling tube by raising the upper handle, at the same time withdrawing the sampler. If moisture samples only are desired, the sample may be expelled on the site by pushing on the upper handle. If undisturbed (relatively) samples are required, the tube is removed from the sampling head and capped at both ends.

4. Data Required for Soil Analysis. A certain amount of basic information must be obtained by the field reconnaissance if the trafficability of soils is to be estimated with reasonable accuracy. This

information is listed below. It is recognized that the list presented here is incomplete as far as the over-all problem is concerned; also, certain factors overlap into other phases of the general problem. In these cases they are listed only as they affect the trafficability of the soils.

a. Representative cone bearing values to a depth of at least 3 feet. The values should be obtained for the undisturbed material and, if possible, for remolded material. Remolding can be accomplished by tamping with bars or poles or by men tramping over a small area.

b. Representative moisture samples at the same locations and depths at which the cone bearing values were determined.

c. Representative samples of sufficient size for laboratory tests.

d. Estimate in the field the limiting area to which a group of representative cone bearing values, moisture contents, and samples should apply.

e. If areas are encountered where the bearing values are considerably below the general average, the extent of the area should be outlined and alternate routes selected and explored.

f. Depth to ground-water table.

g. Information on terrain that will determine whether vehicles can be deployed over a wide area or if they must be concentrated in a few sets of ruts.

h. If area is covered with water, determine if drainage is desirable (for limited operation) and practicable (for unlimited operation).

i. Determine if area is subject to flooding from natural causes and if area can be flooded by enemy or by friendly forces.

j. Rough estimates of the maximum and average slopes.

k. Determine entrance and exit conditions for muddy areas.

l. Note and sample sand areas and investigate possibility of keeping such areas wetted.

m. Vegetation along route, particularly grass or other vegetation that will form a mat.

5. Laboratory Tests. It is necessary to determine the liquid limit, plastic limit for representative soil types encountered, and the moisture content on all samples taken at the locations of cone

penetrometer readings.

6. Interpretation of Test Data. By inspection of the test data or by making plots showing the variation of bearing with depth, establish the limiting bearing value, moisture content, and soil type encountered at a depth of 10 inches or at greater depths if overlying material has cone bearing less than 15. By referring to figure 18 (in main report), it is possible to establish the approximate position of the bearing value in relation to the plastic range of the soil type being studied. An estimate of sticky and/or slippery values can be determined, as well as the possible effects of moisture variations at some future date. If the general soil type, plastic range, and cone bearing value are known for the limiting cases, the type of equipment that can operate, the draw-bar pull, and the maximum traversable gradient can be estimated from the table on figure 19 (in the main report).

APPENDIX C

MATHEMATICAL ANALYSIS OF EFFECT OF GRADIENT

1. This appendix presents a mathematical analysis whereby the draw-bar pull that a vehicle develops on level ground can be used to estimate for similar soil conditions (1) the maximum grade on which the vehicle can operate, and (2) the maximum gross load the vehicle can pull in train on a given slope.

2. Figure A represents a tire loaded with a weight W resting on level ground. For hard, dry ground the frictional relations are given by the formula

$$f = \frac{F}{N}$$

in which f = coefficient of friction

F = total frictional force

$N = W$ = force normal to ground.

While it is true that for soft, muddy soils the forces are not purely frictional, it is assumed that they are proportional to the weight and that the ratio $\frac{F}{W}$ will be a constant for a particular tire and soil.

With the drawbar pull and the gross weight of the vehicle, it is possible to determine the value of this ratio

$$f = \frac{P}{W}$$

in which P = pull necessary to cause slippage

W = weight on tractive wheels

3. It is important to point out that for muddy surfaces the draw-bar pull is not dependent directly on the horsepower of the vehicle as long as the vehicle has sufficient power to cause slippage, since the only force effective in moving forward is the traction between tire and ground.

4. If the vehicle is ascending a hill with slope ϕ (see figure B), it can be seen from the force diagram that the force normal to the ground is now $W \cos \phi$. The value of the ratio f is then

$$f = \frac{F}{W \cos \phi}$$

If the value of f has been determined by tests on level ground, the total uphill force can be computed for the various slopes from

$$F = f W \cos \phi$$

However, there is now a downhill force also, that is, the downhill component of the weight which equals $W \sin \phi$. For any slope, therefore, the net draw-bar pull is the difference between these two forces

$$\text{Net draw-bar pull} = f W \cos \phi - W \sin \phi$$

The maximum slope which can be negotiated is one in which the uphill force just balances the downhill force and the net draw-bar pull is equal to 0.

$$0 = f W \cos \phi - W \sin \phi$$

Thus it can be seen that the ratio $\frac{F}{W}$, determined for level ground, is equal to the tangent of the angle of maximum slope. Since the tangent is the ratio of the vertical rise to the horizontal distance, the per cent of slope is 100 times the tangent.

5. Computations have been made of the effect of the change in load on the axles caused by the shift in center of gravity when the truck is on a slope. For trucks with all-wheel drive, there is no difference. For trucks with drive on rear axle only, the effect is not appreciable where the height to the center of gravity of the load is less than 1/5 of the wheel base. For the ~~extreme~~ case of a 100 per cent slope, the increase in load on the rear axle was only 5 per cent.

6. The method can also be used to compute the draw-bar requirements of vehicles in trains as shown in the examples below:

a. Level Ground

Let F_1 = Draw-bar resistance of towed vehicle

Let F_2 = Draw-bar pull of towing vehicle

Let W_1 = Gross weight of towed vehicle

Let W_2 = Gross weight of towing vehicle

Let f_1 = Ratio $\frac{F_1}{W_1}$

Let f_2 = Ratio $\frac{F_2}{W_2}$

The maximum gross load W_1 which can be towed on level ground is

$$F_1 = F_2$$

$$f_1 W_1 = f_2 W_2$$

$$W_1 = \frac{f_2 W_2}{f_1}$$

b. On Slope of Angle ϕ (see figure B). Assuming that the values of f_1 and f_2 are known from tests on level ground, the net

draw-bar pull of the towing vehicle up the slope is

$$f_2 W_2 \cos \phi - W_2 \sin \phi$$

in which the terms $W_2 \cos \phi$ and $W_2 \sin \phi$ are, respectively, the normal and downhill components of the tractor's weight. The maximum gross load W_1 which can be towed is found by setting the

Net draw-bar pull of towing vehicle = Resistance of towed vehicle

$$f_2 W_2 \cos \phi - W_2 \sin \phi = f_1 W_1 \cos \phi + W_1 \sin \phi$$

$$\frac{W_2 (f_2 - \tan \phi)}{(f_1 + \tan \phi)}$$

Since the term $(f_2 - \tan \phi)$ becomes equal to 0 when f_2 equals $\tan \phi$, the steepest slope which can be negotiated is one with $\tan \phi = f_2$.

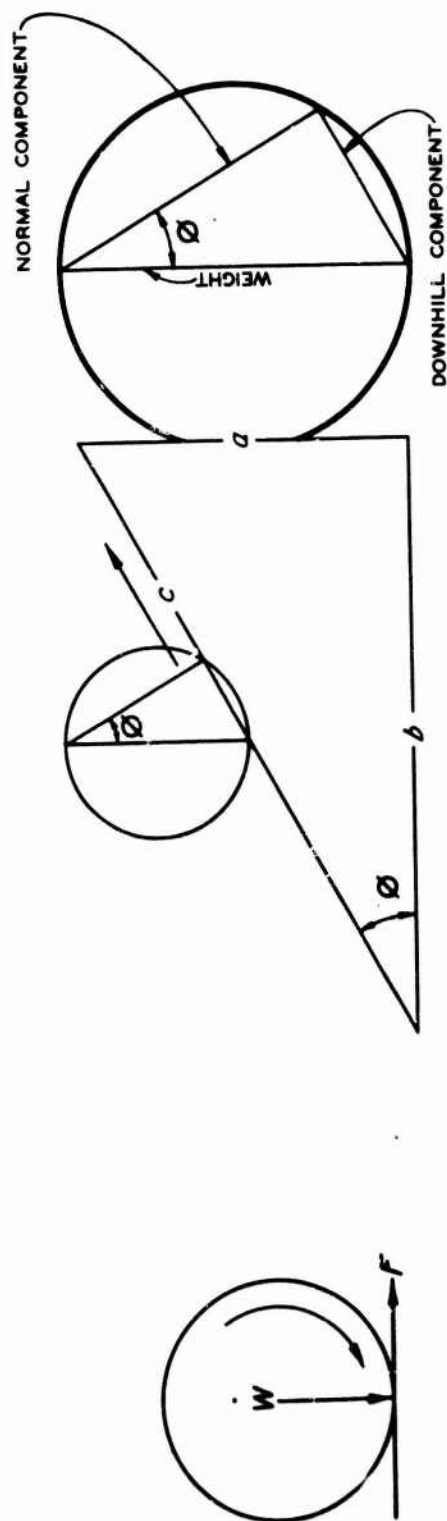


FIGURE A

FIGURE B

MISSISSIPPI RIVER COMMISSION
U. S. WATERWAYS EXPERIMENT STATION
TRAFFICABILITY OF SOILS
MATHEMATICAL ANALYSIS
OF EFFECT OF GRADIENT

APPENDIX D *

MOBILITY OF STANDARD MILITARY VEHICLES

1. General. The trafficability of military vehicles is dependent upon the physical characteristics of the vehicle. In the case of self-propelled vehicles, the basic factors that must be considered are unit ground pressure, ground clearance, traction and power for propelling the vehicle. Basic factors to be considered for towed vehicles are rolling resistance, axle loadings, ground clearance, gross weight with load, and unit ground pressure.

2. Mud Class. Mud class is that group of vehicles and vehicle types that have basic characteristics that give them approximately the same mobility in mud terrain. Only limited test data on a few specific items have been available for determining mud mobility of vehicles. However, in order to make a classification that incorporates all representative military vehicles, a paper study has been made of information contained in TM-9-2800, "Standard Military Motor Vehicles," TB 5-9720-1, "Technical Data for Grading, Excavating and Earth Moving Equipment," and other available literature on military vehicles and equipment. Since specifications alone do not reveal the true performance characteristics of vehicles, the classification listed below can not be considered conclusive but rather as a guide until such time as detailed investigations and tests can be conducted to obtain actual performance data on all vehicles when operating in mud terrain.

a. Class A. Negotiate a limited number of trips (not more than 25) over mud terrain having a minimum cone bearing value of 15 within a depth not to exceed 10 inches.

(1) Self-propelled vehicles

Carrier, light cargo, T-15
 Carrier, personnel, 1/4-ton, M29C
 Tractor, Crawler, Diesel, all types when equipped with 60-inch track extensions.
 Special low ground pressure D-7 tractor
 Tractor, Crane, all types when equipped with 60-inch track extensions.

(2) Towed vehicles

Sled, cargo, 1-ton, M-1
 Sled, cargo, 4-ton, Engineer Board Spec.

*NOTE: This appendix was prepared by Captain W. R. Wallace of The Engineer Board.

b. Class B. Negotiate a limited number of trips (not more than 25) over mud terrain having a minimum cone bearing value of 35 within a depth not to exceed 10 inches.

(1) Self-propelled vehicles

Landing vehicles, tracked, all types
 Tank, light, T9E1
 Tractor, Crane, all types, without track extensions
 Tractor, Crawler, Diesel, all types, without track extensions

(2) Towed vehicles

No towed vehicles in this class

c. Class C. Negotiate a limited number of trips (not more than 25) over mud terrain having a minimum cone bearing value of 50 within a depth not to exceed 10 inches.

(1) Self-propelled vehicles

Carrier, cargo, T-14, with grousers
 Carriage, motor, full-track, all types, with grousers
 Car, armored, 6 x 6, all types, with traction devices
 Tanks, all types, equipped with grousers
 Tractors, high speed, all types
 Trucks, 6 x 6, all types, with traction devices
 Trucks, 4 x 4, all types, with traction devices
 Vehicle, tank recovery, all types, with grousers

(2) Towed vehicles

Crane, tractor operated, all types
 Trailer, track laying, all types, with 60-inch track extensions
 Trailer, wheeled, 1/4- to 1-ton capacity, all types
 All trailer mounted equipment with gross weight of 2-1/2 tons and less

d. Class D. Capable of off-road travel over terrain having a cone bearing value in excess of 80 within a few inches of the ground surface. This type of terrain is not considered a mud condition.

(1) Self-propelled vehicles

Carrier, cargo, T-14, without grousers
 Carriage, motor, full-track, all types, without grousers
 Car, armored, all types, without chains
 Graders, road, motorized, all types

Shovels, crawler mounted, all types
Tanks, all types, without grousers
Tractors, wheeled, all types
Trucks, 4 x 4 and 6 x 6, all types, without traction devices
Vehicles, half-track, all types

(2) Towed vehicles

All trailer mounted equipment with gross weight less than 2 tons
Trailer, track laying, all types, without track extensions
Trailer, wheeled, all types, less than 8-ton capacity
Semi-trailers, all types, less than 8-ton capacity
Wagons, crawler, rock or dirt, all types

c. Class E. Vehicles and other equipment which due to excessive weight, high unit ground pressure, lack of practice, lack of power, and other peculiarities of design, are not suitable for off-road use.

(1) Self-propelled vehicles

Bus, commercial type, all sizes
Cars, passenger, all types
Motorcycles, all types

(2) Towed vehicles

All trailer mounted equipment with gross weight of 8 tons and over
Trailers, wheeled, all types, with capacity of 8 tons and over
Semi-trailers, all types with capacity of 8 tons and over