APPENDIX 2N

GEOTECHNICAL REPORT TEST FILL STUDY OF QUARTZITE MOLE CUTTINGS

The information contained in this appendix was not revised, but has been extracted from the original FSAR and is provided for historical information.

TEST FILL STUDY

OF

QUARTZITE MOLECUTTINGS

Submitted to

Public Service Company of New Hampshire

Submitted by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Purpose

The intake and discharge tunnels at Seabrook Station are being excavated using a tunnel boring machine, more commonly termed a mole. The excavated material from the mole is a widely-graded crushed stone commonly termed tunnel muck, which, for this report, shall be termed "molecuttings."

The purpose of the test fill study was to determine if the quartzite molecuttings obtained from-the tunnel excavations could be used for Safety and Nonsafety-Related Structural Fill. Construction of the test fills provided the opportunity to observe the behavior of the molecuttings during placement and obtain data necessary to develop procedures to control the compaction of the molecuttings during placement.

1.2 Background

The molecuttings from the quartzite bedrock in the tunnels are widely-graded crushed stone containing up to 13% passing the No. 200 sieve. The grain size curve of the molecuttings plots below the lower limit of the Safety and Nonsafety-Related Structural Backfill specification. The resistivity of the molecuttings is generally below the specified minimum value of 10,000 $ohms\text{-}cm^3$. Thus, although the molecuttings appeared superior to the gravelly sand structural fill as a backfill material, it was rejected because the gradation and resistivity requirements did not comply with the specifications. Use of the molecuttings for Safety and Nonsafety-Related Structural Fill required that selected tests be performed which would demonstrate that the molecuttings were as good or better than the presently used gravelly sand when both materials were placed at the same percent compaction. Investigation of the resistivity problem was addressed by UE&C.

The Safety and Nonsafety-Related Structural Fill is used for backfill around pipes and conduits, under floor slabs, roads, etc. For these applications the deformation characteristics of the backfill will control the soil support of the pipes and settlements of structures. One method of determining the deformation properties of a soil is by determining the soil modulus by the use of a plate load test. Plate load tests were performed on carefully constructed test fills consisting of (a) gravelly sand, (b) molecuttings, and (c) a test fill of essentially alternating layers of gravelly sand and molecuttings which herein will be referred to as the stratified gravelly sand and molecuttings test fill

The modulus from each test fill was used as a means of comparing the desirability of the molecuttings versus the gravelly sand for use as Safety and Nonsafety-Related Backfill.

The molecuttings are widely graded and contain high percentages of stone retained on the 3/4-in. sieve. In many cases the percent retained on the 3/4-in. sieve exceeds the allowable limits for the Modified AASHO compaction test (D1557). Thus, it was necessary to determine by means of field and laboratory tests performed during construction of the test fill how construction control of the placement of the molecuttings should be handled.

1.3 Summary

The results of the plate load tests indicate that the molecuttings will provide superior support for pipes and structures than the gravelly sand currently accepted for Safety and Nonsafety-Related Structural Fill when both materials are placed at the same percent compaction. The molecuttings and gravelly sand will provide about equivalent deformation properties when the percent compaction of the molecuttings is as much as 2 to 3% lower than the gravelly sand. Therefore, the use of molecuttings for Safety and Nonsafety-Related Structural Fill is recommended. Further, it is recommended that the percent compaction of the molecuttings for Safety and Nonsafety-Related Structural Fill be 95% and 93%, respectively.

The molecuttings used in constructing these test fills were widely graded crushed stone with up to 7% passing the No. 200 sieve. The water content of the material varied from 3 to 4% up to 10% during placement. Because of the grain-size distribution compaction of the molecuttings was sensitive to fluctuations in the water content of the material. Based on data obtained from tests performed during construction of the test fills, limitations on the grain-size distribution and water content'of the molecuttings during placement have been recommended in Section 5.

Construction of the test fills indicated that placement of the molecuttings can be controlled by modifying standard testing procedures. The in-place dry density can be measured using the nuclear density meter and the laboratory reference dry density determined by modifying the currently specified compaction tests.

Details of the construction of the test fills, performance and results of the plate load tests, and procedures for control of placement and compaction of molecuttings are presented in the following sections.

2. CONSTRUCTION OF TEST FILLS

Four test fills were constructed for this study. The orientation of the test fills is shown in Fig. 1. The soils and details of placement for each test fill is presented below.

2.1 Gravelly Sand

Gravelly sand satisfying the requirements for Safety and Nonsafety-Related Structural Fill Specifications 9763-8-5 and 9763-8-4 was placed in 8-in. -thick loose lifts and compacted to a minimum of 95% of the maximum dry density as determined by ASTM D1557, Method D. Satisfactory compaction was generally achieved by applying water to the surface of the loose lift and compacting with six coverages with the Mikasa double drum roller. Eight lifts of gravelly sand were placed and compacted, resulting in a total height of about 4 ft.

2.2 Molecuttings (Controlled Placement)

The construction of this test fill was controlled to achieve the compaction requirements of Safety and Nonsafety-Related Structural Fill (i.e., 95% of the maximum dry density as determined by ASTM D1557).

Molecuttings were placed in 8-in. loose lifts and compacted to 95% compaction. To achieve 95% compaction, control of the water content to within a few percent of the optimum water content, and numerous coverages with the Mikasa double drum roller was required. Attempts at controlling the water content included mixing of wet and dry molecuttings and adding water to molecuttings with water contents 2 to 3% below optimum. Molecuttings placed at water contents several percent higher than optimum could not achieve 95% compaction until sufficient drainage had reduced the water content to near the optimum value. Eight lifts of molecuttings were placed and compacted resulting in a total height of about 4 ft.

2.3 Molecuttinqs (No Special Controls)

Construction of this test fill involved the placement of the molecuttings with limited control of water content and a specified compactive effort. The molecuttings were generally placed in G-in. loose lifts and compacted by six coverages with the Mikasa double drum roller. In some instances, water content control was limited to permitting drainage of a compacted layer overnight before placement of the succeeding layer. Eight lifts of molecuttings were placed and compacted.

2.4 Stratified Molecuttings and Gravelly Sand

The first three lifts of this test fill were constructed the same way as the test fill of Molecuttings (No Special Controls). The water content of the molecuttings placed for the third lift was about 3% higher than optimum. The surface of the third lift was saturated and became severely rutted during compaction. Sandwiching layers of gravelly sand between layers of molecuttings was done to determine (1) if the gravelly sand provided drainage of sandwiched layers of molecuttings and (2) the feasibility of constructing a backfill of stratified gravelly sand and molecuttings (which may be required in the zone of frost penetration). Therefore, lifts 4 and 6 were constructed using gravelly sand. Lift 4 was compacted with six coverages of the Mikasa double drum roller and lift 6 was compacted to at least 95% compaction. Molecuttings for lifts 5, 7 and 8 were generally placed in 8-in. loose lifts with limited water content control and compacted with six coverages of the Mikasa double drum roller.

3. PERCENT COMPACTION OF TEST FILLS

3.1 Gravelly Sand

The percent compaction of each lift was determined by performing in-place density tests and laboratory compaction tests. The average percent compaction of the gravelly sand test fill was 97.4%.

The in-place density for each lift, after compaction, was determined by performing two 6-in. -diameter Sand Cone (SC) tests and three Nuclear Density Meter (NDM) tests. The in-place density determined by the NDM was generally performed at probe depths of 4 in. and 8 in. The two SC tests were performed adjacent to two of the NDM tests to provide a comparison of the water content and dry density measured by each 'method. The SC and NDM tests were generally performed within a 5-ft radius of the plate load test location. .

One-point compaction samples were obtained adjacent to the SC and NDM test locations. The one-point samples were compacted in accordance with ASTM D1557, Method D. The maximum dry density for the one-point sample was determined by plotting the one-point dry density on a family of curves for the gravelly sand and interpolating the maximum dry density. The percent compaction was computed by dividing the in-place dry density by the corresponding one-point compaction determined maximum dry density. Table 1 presents the summary of the percent compaction achieved in the test fill. A profile of the test fill and the average percent compaction for each lift is shown on Fig. 2.

Three compaction tests were performed in accordance with ASTM D1557, Method D, on bag samples of gravelly sand obtained from material placed in lifts 2, 4 and 7. The compaction curves and related grain-size curves performed by Pittsburgh Testing Labs are shown on Figs. 4 and 5, respectively.

3.2 Molecuttings (Controlled Placement)

The average percent compaction achieved for this test fill was 96.7%. The in-place density of each lift after compaction was determined by performing several NDM tests and, when the soil conditions were acceptable, one 12-in.-diameter SC test. The SC test was performed adjacent to a NDM test to provide a comparison of the water content and dry density measured by each method. Observations in the field and data from tests indicated that the hole excavated for the SC test tended to squeeze in or reduce in volume when the molecuttings were placed and compacted

at water contents above or near optimum. Results from the SC tests when these conditions existed gave unreasonably high dry densities, and, as a result, SC tests were considered valid only when they were performed in areas where the water content of the molecuttings was less than 5%. A more complete discussion of this problem is presented in Section 5. The SC and NDM tests were generally performed within about a 5-ft radius of the plate load test.

Generally, several NDM tests were required before a lift of the molecuttings was compacted to a dry density that was estimated to provide 95% compaction. One-point compaction samples were obtained adjacent to the series of NDM and SC tests that indicated about 95% compaction had been achieved. The one-point samples were compacted in accordance with ASTM D1557, Method C, except the minus **1½-in.** material was included for compaction. The maximum dry density for the one-point sample was determined by plotting the one-point dry density on a family of compaction curves for molecuttings and interpolating the maximum dry density.

Correction of the in-place dry density to account for the plus **1½-in.** material, which was removed for the laboratory test, was necessary in order to determine the percent compaction. Details of the correction procedure are presented in Appendix A. The percent compaction was computed by dividing the corrected in-place dry density by the corresponding maximum dry density determined by the one-point compaction technique. Table 2 presents the summary of the percent compaction achieved in the test fill. A profile of the test fill and the average percent compaction for each lift is presented in Fig. 2.

Two compaction tests were performed in accordance with ASTM D1557, Method C, except the minus **1½-in.** material was included and there was no limit on the percent retained on 1&-in. sieve on bag samples of molecuttings from lifts 4 and 6. The compaction curves and related grain-size curves are shown on Figs. 6 and 7, respectively.

3.3 Molecuttings (No Special Controls)

The average percent compaction of this test fill was 93.0%. The water content of the molecuttings during placement was generally above optimum and was not controlled during compaction. Sand Cone tests to determine the in-place dry density were not performed because of the inaccuracy in performing the test in molecuttings compacted at water contents near or above optimum. The in-place dry density was determined by performing at least

two and most usually three to five NDM tests at probe depths of 4 and 8 in. The NDM tests were generally performed within a 5-ft radius of the plate load test location.

One-point compaction samples were obtained adjacent'to the series of NDM tests that indicated the next lift of molecuttings could be placed. In some cases after a lift had been compacted, NDM tests performed, and one-point samples obtained, the lift was permitted to drain overnight and additional NDM tests taken in the morning. One-point compaction samples generally were not obtained for the NDM tests performed after drainage. The procedure to compute the percent compaction for each in-place density test was the same as described in the previous section.

Table 3 presents the summary of the percent compaction achieved in the test fill. A profile of the test fill and the average percent compaction for each lift is presented in Fig. 3.

Two compaction tests were performed in accordance with ASTM D1557, Method C, except the minus 1½-in. material was included and there was no limit on the percent retained on the 1½-in. sieve on bag samples obtained from lifts 2A and 7A. The compaction curves and the grain-size curve for lift 2A are shown on Figs. 6 and 7, respectively.

3.4 Stratified Molecuttings and Gravelly Sand

The average percent compaction of the gravelly sand and molecuttings test fill was 92.8%. Molecuttings were used **for** lifts 1, 2, 3, 5, 7, and 8 for this test fill. The in-place dry density and percent compaction of the molecuttings was determined in accordance with the procedure described in the previous section. Lifts 4 and 6 of the test fill were constructed using gravelly sand. The in-place density for lift 4 was determined by four NDM tests. One SC test and 3 NDM tests were performed in lift 6. The maximum dry density and computation of the percent compaction at each in-place density test location was as described in the section for gravelly sand. Table 4 presents the summary of the percent compaction in the test fill. A profile of the test fill and the average percent compaction of each lift is presented in Fig. 3.

4. PLATE LOAD TESTS

Five plate load tests were performed on the four test fills. The plate load test number, test fill and date of the test is presented below.

Plate Load Test No.	Test Fill	Date of Test
1	Gravelly Sand	June 7, 1979
2	Molecuttings (No Special Control) .	June 14, 1979
3	Stratified Mole-cuttings and Gravelly Sand	June 15, 1979
4	Molecuttings (Controlled Placement)	June 18, 1979
5	Molecuttings (No Special Control)	June 27, 1979

The locations of the tests are indicated on Fig. 1 and details of the procedure are presented in Appendix B. In brief the procedure was as follows: an 18-in.-diameter steel plate was generally placed 12 in. below the surface of the test fill and loaded to produce contact stresses to 4 tsf and then to 12 tsf. Deflections of the plate were measured and recorded.

The results of the plate load tests are presented in Figs. B2 through B6. Values of Young's Modulus, E, were calculated from the results of the plate load tests using elastic theory. A description of the analysis is presented in Appendix B. A summary of the modulus calculated for each test is presented in Table 5. The percent compaction indicated in Table 5 represents the average percent compaction of lifts within the zone of significant stress increase due to the load on the plate. For an 18-in. -diameter plate this zone is about 18- to 36-in.-thick.

The soil modulus determined by the plate load test vs percent compaction is plotted on Fig. 8. The results indicate that the molecuttingshave a much higher modulus than the gravelly sand when both materials are compacted to the same percent compaction. In fact, the modulus of the molecuttings compacted to 93% compaction is approximately equivalent to the modulus of the gravelly sand placed at 97% compaction. Plate Load Test No. 5 (PLT-5) was performed 13 days after and about 4 ft away from Plate Load Test No. 2 (PLT-2). The soil modulus for PLT-5 was about two times

the modulus for PLT-2. The increase in modulus may have been caused by densification of the molecuttings as a result of drainage over the 13 day period between the performance of the two tests. Assuming that the molecuttings were saturated after PLT-2 and the water content reduced by 1% during a period of 13 days, the in-place dry density would have increased by 2 to 3 pcf or about a 1 to 2% increase in the percent compaction. The modulus for PLT-5, as a result of the densification, nearly plots on the line from PLT-2 to PLT-4.

Test PLT-3 was performed on the stratified molecuttings and gravelly sand test fill. The average percent compaction of the molecuttings and gravelly sand was 92.5 and 96.1%, respectively. , Plate load tests, PLT-2 and PLT-1, were performed on separate test fills of molecuttings and gravelly sands compacted to about the same percent compaction and the moduli were 7,300 psi and 10,100 psi, respectively. The moduli determined for the stratified test fill, however, was 17,000 psi. Based on the results of PLT-1 and PLT-2 the anticipated modulus determined by FLT-3 was between 8 and 10,000 psi. The high modulus measured by PLT-3 may have been caused by one or more of the following factors:

1. Distribution of the load may have been more rapid for the layered fill than in a homogeneous fill, and

2. Drainage of the molecuttings and related increases in dry density and modulus may have accelerated faster in the stratified test fill than in the homogeneous molecuttings (No Special Controls) test fill due to drainage through the gravelly sand layers.

5. PLACEMENT AND FIELD CONTROL OF MOLECUTTINGS

The purpose of this section is to present recommendations for the placement and field control of molecuttings based on field and laboratory data obtained during construction of the test fills.

Review of the data obtained provided the information necessary to make recommendations on the limits for grain size, lift thickness, determination of in-place density and percent compaction, and control of water contents of the molecuttings. A discussion of each of the items is presented below.

5.1 Grain-Size Limits

Grain-size analyses were performed on thre'e samples of the molecuttings used for the test fills. The grain-size curves are presented on Fig. 7. The molecuttings were generally widely graded with uniformity coefficients of 45 to 100. The maximum particle size was generally less than 3-in.-diameter and the percent by weight passing the No. 200 sieve was from 5 to 7%. Based on these and other grain-size analyses recommendations for gradation requirements were developed and are presented in Appendix A.

5.2 Lift Thickness

The molecuttings were placed in 8-in.-thick loose lifts during construction of the test fills. Observations made during placement of the molecuttings indicated that the ability to achieve a specific percent compaction was mostly affected by the water content of the material rather than the thickness of the lift. When the molecuttings were placed at water contents above optimum, a specific degree of compaction generally **was** not achieved until the water content was reduced to'or below the optimum water content as a result of drainage. The time required for drainage is a function of the lift thickness and, therefore, where 95% and 93% compaction is required, lift thicknesses of 8-in. and 12-in. are recommended. The 12-in.-thick loose lift in areas where 93% compaction is required was recommended based on the fact that the average percent compaction of 93.0% was achieved for the molecuttings (No Special Controls) test fill without the benefit of extensive compactive efforts.

5.3 Determination of In-Place Dry Density

The nuclear density meter (NDM) provides a much faster determination of the field in-place dry density and water content than the sand cone (SC). The accuracy of the NDM tests performed in the gravelly sand and molecuttings was verified by comparing the results of adjacent NDM and SC tests.

5.3.1 Gravelly Sand

Generally, two SC tests were performed adjacent to two NDM tests on each lift of the test fill to compare the in-place dry density and water content measured by each method.. The in-place water content determined by the sand cone versus nuclear density meter is plotted on Fig. 9. The data indicate that both methods measure essentially the same water content at values less than 8% and, as the water content increases, the NDM measures a lower value than the SC. As a result, a correction was applied to the water content measured by the NDM to compute the in-place dry density... A plot of sand cone versus nuclear density meter determined in-place dry density is shown on Fig. 10. The correlation of the densities determined by each method was considered to be poor. The correlation may have been improved if more frequent moisture checks had been performed during construction of the test fill.

5.3.2 Molecuttings

Twelve-inch-diameter sand cone tests were performed in the molecuttings to reduce the effects that the maximum particle size and percentage of material larger than the 1½-in. sieve would have on in-place dry density determination. The in-place dry density and water content determined by the SC test was compared to the results from adjacent 8-in.-deep NDM tests. Comparison of the results indicated the water content determined by the NDM averaged 1.7% higher than that determined by the sand cone. The 1.7% difference in water contents was confirmed by performing water content checks at random NDM test locations. A 1.7% bias correction was applied to the water contents determined by the NDM. A plot of sand cone determined water content versus nuclear density meter water content (with a 1.7% bias correction) is presented on Fig. 11.

The plot shows there is a good correlation between the sand cone and nuclear density meter (after bias correction) water content determinations. A second water content check was made on molecuttings.after the test fill was completed which indicated that the bias had increased to 2.5%. Because the water content bias changed significantly within a period of two weeks periodic checks of the bias are recommended.

The in-place dry density determined by the sand cone test and the 8-in. NDM test after correction for the water content bias is plotted on Fig. 12. The solid dots and dashed circles represent in-place dry density measurements at water contents less than 5% and greater than 5%, respectively. The data indicate that there is good correlation of dry densities determined by both methods at water contents less than 5% and that the SC measured higher dry densities than the NDM at water contents above 5%. For this test fill the SC tests performed in molecuttings compacted at water contents above 5% are not considered valid for the reasons presented in the following discussion.

When the molecuttings were placed at water contents above about 5%, the compacted surface would exhibit a spongy behavior when one walked across the surface. The degree of sponginess increased as the moisture increased above the optimum water content. The sponginess is believed to be caused by water and air pore pressures. The net effect was that as the sand cone hole was excavated the pore pressures at the walls of the hole were relieved by the walls moving laterally into the hole until an equilibrium of the pore pressure at the walls of the hole was reached. Thus, by the time the volume of the hole was measured a significant decrease in the volume of the hole had occurred but the quantity of soil excavated was from the original volume. The result was that the dry soil excavated was divided by a reduced.volume which resulted in an inaccurately high computed dry density.

The SC and NDM test results indicate that the NDM can be used to determine the in-place dry density and water content of molecuttings. The water content bias should be checked periodically to account for changes that occur in the molecuttings. Details of a recommended placement procedure arepresented in Appendix A.

5.4 Determination of Percent Compaction

The field and laboratory data indicated the nuclear density meter could be used to determine the in-place dry density after the appropriate water content bias had been determined for the molecuttings being tested.

The preferred field procedure for determing the percent compaction of compacted soil is as follows:

1. Gbtain a one-point sample of the soil before compaction.

2. Perform the' one-point compaction test in the lab and determine the maximum dry density from a family of curves.

3. Perform the in-place dry density of the compacted lift using the nuclear density meter at or near the location of where the one-point sample was taken.

This procedure can be used for the molecuttings if at least three nuclear density meter determinations of the in-place dry density are made. The average of the three tests should be used to represent the in-place density for computation of the percent compaction. The above procedure will reduce the effect that minor variations in the character of the molecuttings will have on the in-place dry density determination.

The use of a standard laboratory compaction test or one which was slightly modified was considered the best method of determining the maximum dry density of the molecuttings. The Modified AASHG Compaction Test, ASTM D1557, permits the use of minus 3/4-in. material to be compacted in 6-in. molds. Grain-size analyses performed on molecuttings indicate that nearly 50% of the sample is retained on the 3/4-in. sieve, and, as a result, the material passing the 3/4-in. sieve would behave much differently than the total sample during compaction. A sample of the molecuttings that would represent the compaction behavior of the material was considered possible if the amount of coarse material removed was limited to about 20% by weight of the total sample. This could generally be achieved by removing material retained on the 1½-in. sieve. For the test fill the laboratory compaction used was ASTM D1557, Method C, except the plus 1½-in. material was removed. Because this compaction test, as modified above, was used for the test fill and gave reasonable results its use is recommended for performing laboratory compaction tests on the molecuttings.

5.5 Water Content Control

The laboratory compaction curves for compaction tests performed on samples of molecuttings show a sharp peak in dry density at the optimum water content, Fig. 6. The dry density drops as the water increases or decreases from the optimum value. The laboratory data show that small variations in water content significantly affect the degree of compaction that can be achieved in the molecuttings. This behavior was also observed during placement and compaction of the molecuttings in the test fills. In the test fill where placement of the molecuttings was controlled, the required percent compaction generally could only be achieved by controlling the water content, by either wetting or drying, of the molecuttings. The most efficient compaction of the molecuttings was when the water content was from about 4 to 6%. Therefore, the water content of the molecuttings should not differ from optimum by more than ± 1%, for most efficient compaction.

TABLES

TABLE 1 - SUMMARY OF FIELD DENSITY TESTS
GRAVELLY SAND TEST FILL
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Point Compaction: Percent +3/4-in. Material %	One-Point Compaction: Water Content %	One-Point Compaction: Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: Total Sample	In-Place Dry Density, pcf: Corrected For +3/4-in. Material	Percent Compaction %
1	ND-1	One-point samples not obtained			122.1 (1)	120.9	This column does not apply for compaction test performed using ASTM D1557, Method D	99.0 (3)
	ND-2					123.7		101.3 (3)
	ND-3					121.1		99.2 (3)
	SC-1					118.1		96.7 (3)
2	SC-1	11.1	9.7	120.9	123.0	115.0		93.5
	ND-2	4.8	10.0	116.8	120.5	117.1		97.2
	SC-3	9.4	9.0	120.1	123.0	120.3		97.8
	ND-4 (1)	8.1	9.2	117.9	122.0	119.5		97.2 (3)
	ND-5 (1)	N.A.	13.0	122.3	122.3	119.2		97.4 (3)
3	ND-1	One-point samples not obtained				123.0		100.6 (3)
	SC-2					126.0		103.2 (3)
	ND-3					121.4		99.4 (3)
	SC-4 (1)					122.5		100.3 (3)
	ND-5 (1)	N.A.	5.2	115.5	122.1	121.5		99.4 (3)
4	ND-1 (2)	8.5	4.9	117.8	125.5	119.1		94.9
	SC-2 (2)	8.5	4.9	117.8	125.5	120.5		96.0
	ND-3 (2)	5.0	7.4	119.1	124.0	124.1		100.0
	SC-4 (2)	5.0.	7.4	119.1	124.0	118.8		95.8
	ND-5	5.8	7.0	121.5	126.0	119.0		94.4

NOTES: (1) One-point compaction sample performed by Pittsburgh Testing Labs.
(2) One one-point compaction sample obtained for sand cone and nuclear density test performed adjacent to each other.
(3) Percent compaction computed using maximum dry density determined by Pittsburgh Testing Lab.

TABLE 1 - SUMMARY OF FIELD DENSITY TESTS
GRAVELLY SAND TEST FILL
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Point Compaction: Percent +3/4-in. Material %	One-Point Compaction: Water Content %	One-Point Compaction: Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: Total Sample	In-Place Dry Density, pcf: Corrected For +3/4-in. Material	Percent Compaction %
5	ND-1 (2)	4.8	9.7	124.5	125.0	125.5		100.4
	SC-2 (2)	4.8	9.7	124.5	125.0	123.8		99.0
	ND-3	5.8	10.3	123.1	124.0	120.9		97.5
	SC-4 (2)	13.0	9.3	126.4	127.0	124.9		98.0
	ND-5 (2)	13.0	9.3	126.4	127.0	121.3		95.5
6	ND-1	3.9	10.0	122.3	123.2	117.8		95.6
	ND-2 (2)	13.2	8.4	126.0	127.0	118.7		93.5
	SC-3 (2)	13.2	8.4	126.0	127.0	125.7		99.0
	SC-4 (2)	9.1	7.6	123.3	126.5	123.0		97.2
	ND-5 (2)	9.1	7.6	123.3	126.5	126.6		99.7
7	ND-1 (2)	5.9	6.8	120.5	126.5	122.5		96.8
	SC-2 (2)	5.9	6.8	120.5	126.5	123.8		97.9
	ND-3 (2)	10.7	7.8	121.0	124.8	121.6		97.4
	SC-4 (2)	10.7	7.8	121.0	124.8	123.2		98.7
	ND-5	11.3	7.6	121.5	125.8	121.9		96.9
8	ND-1	One-point samples not obtained				119.6		98.9 (3)
	SC-2					118.9		98.3 (3)
	ND-3					120.2		99.4 (3)
	SC-4					118.8		98.3 (3)
	ND-5 (1)	N.A.	13.8	117.9	120.9	116.2		96.1 (3)

NOTES: (1) One-point compaction sample performed by Fittsburgh Testing Lab.
(2) One one-point compaction sample obtained for sand cone and nuclear density test performed adjacent to each other.
(3) Percent compaction computed using maximum dry density determined by Pittsburgh Testing Lab.

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July 12, 1979

TABLE 2 - SUMMARY OF FIELD DENSITY TESTS
MOLECUTTINGS (CONTROLLED PLACEMENT) TEST FILL
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Point Compaction: Percent +1½-in. Material %	One-Point Compaction: Water Content %	One-Point Compaction: Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: Total Sample	In-Place Dry Density, pcf: Corrected For +1½-in. Material	Percent Compaction %
1	ND-12	One-point samples not obtained			N.A.	145.5	N.A.	N.A.
	ND-13				N.A.	144.0	N.A.	N.A.
	ND-14				N.A.	142.6	N.A.	N.A.
	ND-15				N.A.	146.9	144.5	N.A.
2	ND-8	10.8	5.1	145.4	151.0	150.0	146.9	97.3
	ND-9	24.9	5.1	146.0	151.5	149.5	140.9	93.0
	ND-10 (1) SC-11 (1)	(1) 7.(2)	3.7	143.3 143.3 (2)	----- (2) 153.0 (2) 153.0	161.5 152.4	150.5 158.4	98.(3)
3	ND-10	11.4	4.6	145.9	152.0	143.1	139.0	91.4
	ND-12 (1) SC-12 (1)	10. 4.4 (2)	4.1 4.4	144 144.9 144.9 (2)	----- (2) 152.0 (2) 152.5	151.8 145.5 152.4	150.[illegible] 142.8 145.8	98.2 93.5 95.2
4	ND-1	7.3	5.0	151.2	154.0	149.4	147.4	95.7
	ND-2 (1)	8.2	4.6	148.3	154.0	148.3	145.9	94.7
	ND-3 (1)	6.8	4.3	147.5	154.0	144.9	142.7	92.6
	SC-4 (1)	(2)		147.5 (2)	154.0 (2)	149.7	149.7	97.2

NOTES: (1) One one-point compaction sample obtained for sand cone and nuclear density test performed adjacent to each other.
(2) Laboratory one-point compaction test results and interpolated maximum dry density are from adjacent nuclear density meter one-point compaction samples and test results.
(3) In-place dry density measured is in error for reasons discussed in the text.

Geotechnical Engineers Inc.

Project 76301
July 12, 1979

TABLE 2 - SUMMARY OF FIELD DENSITY TESTS
MOLECUTTINGS (CONTROLLED PLACEMENT) TEST FILL
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Point Compaction: Percent +1½-in. Material %	One-Point Compaction: Water Content %	One-Point Compaction: Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: Total Sample	In-Place Dry Density, pcf: Corrected For +1½-in. Material	Percent Compaction %
5	ND-8	5.6	4.9	148.7	155.0	150.6	149.1	96.2
	ND-9 (1)	7.7	4.1	146.5	155.0	148.0	145.7	94.0
	ND-10 (1)	14.5	4.7	146.0 (2)	153.0 (2)	149.4	145.0	94.8
	SC-11	(2)		146.0	153.0	162.3	160.6	(3)
6	ND-4	16.9	4.0	146.0	155.0	152.6	146.0	95.5
	ND-5 (1)	7.8	4.5	147.9	153.0	150.2	148.1	96.8
	ND-6 (1)	7.5	4.2	148.3	154.0	152.3	150.4	97.7
	SC-7	(2)		148.3	154.0			
7	ND-4	12.5	4.9	145.2	151.0	147.1	143.1	94.8
	ND-5	12.2	5.0	147.5	152.0	149.5	145.9	96.0
	ND-6	10.4	4.6	146.3	152.0	147.6	144.4	95.0
8	ND-1	One-point samples not obtained				146.0	N.A.	N.A.
	ND-2					146.5	N.A.	N.A.
	ND-3					146.1	N.A.	N.A.

NOTES: (1) One one-point compaction sample obtained for sand cone and nuclear density test performed adjacent to each other.

(2) Laboratory one-point compaction test results and interpolated maximum dry density are from adjacent nuclear density meter one-point compaction samples and test results.

(3) In-place dry density measured is in error for reasons discussed in the text.

TABLE 3 - SUMMARY OF FIELD DENSITY TESTS
MOLECUTTINGS (NO SPECIAL CONTROLS) TEST FILL
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Point Compaction: Percent +1½-in. Material %	One-Point Compaction: Water Content %	One-Point Compaction: Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: Total Sample	In-Place Dry Density, pcf: Corrected For + 1½-in. Material	Percent Compaction %
1	ND-4	One-point samples not obtained				146.3		N.A.
	ND-5					142.4		N.A.
	ND-6					145.5		N.A.
	ND-7					149.1	149.1	N.A.
2	ND-4	12.3	4.6	147.7	155.0	149.4	145.7	94.0
	ND-5	10.6	5.8	149.0	152.0	145.8	144.5	95.1
	ND-6	14.5	5.5	149.6	152.0	145.8	142.3	93.6
	SC-7	12.3	4.6	147.7	155.0	157.8	154.5	91.0
3	ND-5	6.0	6.7	147.0	151.0	143.7	141.7	93.8
	ND-6	9.2	6.2	147.8	151.0	141.9	138.5	91.7
4	ND-1	10.6	6.5	148.8	151.1	144.7	141.1	93.3
	ND-2	15.5	6.6	146.0	151.0	143.0	137.1	90.8
5	ND-1	12.3	4.9	148.9	153.0	150.9	147.5	96.4
	ND-2	12.3	5.0	148.1	152.0	152.2	149.0	98.0
	ND-3	24.8	4.7	147.7	153.0	140.5	129.0	84.3
6	ND-5	23.5	4.3	153.3	156.0	154.2	147.7	94.7
	ND-6	8.5	3.6	145.1	153.0	145.1	142.3	93.0
	ND-7	9.4	5.6	153.6	155.0	143.3	140.0	90.3

TABLE 3 - SUMMARY OF FIELD DENSITY TESTS
MOLECUTTINGS (NO SPECIAL CONTROLS) TEST FILL
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Point Compaction: Percent +1½-in. Material	One-Point Compaction: Water Content %	One-Point Compaction: Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: Total Sample	In-Place Dry Density, pcf: Corrected For +1½-in. Material	Percent Compaction %
7	ND-7	5.1	3.1	141.2	149.0	140.0	138.1	92.7
	ND-8	4.0	3.4	140.1	148.0	139.2	137.7	93.0
	ND-9	7.5	3.9	143.6	151.0	148.8	146.6	97.1
8	ND-1	One-point samples not obtained				144.4	N.A.	N.A.
	ND-2					125.0	N.A.	N.A.
	ND-3					144.3	N.A.	N.A.

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Project 76301
July 12, 1979

TABLE 4 - SUMMARY OF FIELD DENSITY TESTS
STRATIFIED MOLECUTTINGS AND GRAVELLY SAND TEST FILL
QLJARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Lift No.	Sample No.	One-Pair Compaction: Percent + 1½-in. Material %	Water Content %	Dry Density γ_d, pcf	Laboratory Maximum Dry Density γ_d, pcf	In-Place Dry Density, pcf: TOY-11 Sample	In-Place Dry Density, pcf: Corrected For +1½-in. Material	Percent Compaction %
3	ND-7	15.0	5.7	149.3	153.0	148.8	144.1	94.2
	ND-8	12.2	6.0	148.8	152.0	145.9	141.8	93.3
4[1]	ND-3	11.3[2]	5.6	118.3	125.0	114.3	N.A.	91.4
	ND-4	11.5[2]	2.7	122.2	124.0	108.1	N.A.	87.2
	ND-5	3.3[2]	3.0	115.1	123.0	108.2	N.A.	88.0
	ND-6	7.4[2]	4.9	116.9	124.5	110.6	N.A.	88.8
5	ND-4	10.4	4.3	145.7	151.0	151.3	148.5	98.4[3]
	ND-5	16.3	3.8	144.8	153.0	138.1	130.8	85.5
6[1]	SC-1[4]	N.A.	N.A.	123.3	1.27.5	123.8	N.A.	97.1
	ND-2[4]	14.1[2]	7.2	123.3	127.5	121.1	N.A.	95.0
	ND-3	2.7[2]	6.8	118.8	124.5	119.3	N.A.	95.8
	ND-4	12.4[2]	8.3	120.3	124.0	119.6	N.A.	96.5
7	ND-10	4.8	2.7	137.5	148.0	140.2	138.4	93.5
8	ND-4	One point samples not obtained				147.3	N.A.	N.A.
	ND-5					140.8	N.A.	N.A.

NOTES :
(1) Gravelly sand used for the construction or Lift.
(2) Values represent percent +3/4-in. material.
(3) Nuclear density probe may have penetrated gravelly sand layer below.
(4) One one-point compaction sample obtained for SC-1 and ND-2.

Geotechnical Engineers Inc.

Project 76301
July 12, 1979

TABLE 5 - SUMMARY OF PLATE LOAD TESTS RESULTS
QUARTZITE MOLECUTTINGS STUDY
SEABROOK STATION

Plate Load Test No.	Soil At Test Location	Soil Modulus, psi		Average Percent Compaction	Remarks
		Virgin	Reload		
1	Gravelly Sand	10,100-10,500	20,000-29,700	97.1	
2	Mole Cuttings (No Special Control)	7,300-7,700	25,200-40,300	92.6	
3	Stratified Mole Cuttings and Gravelly Sand	17,000-26,100	41,200-45,300	M.C.=92.5 G.S.=96.1	Ave. Percent Compaction 93.7
4	Mole Cuttings (Controlled Placement)	28,300-35,900	54,300-66,600	95.3	
5	Mole Cuttings (No Special Control)	13,200-21,200	43,100-49,200		Performed 13 days after PLT-2

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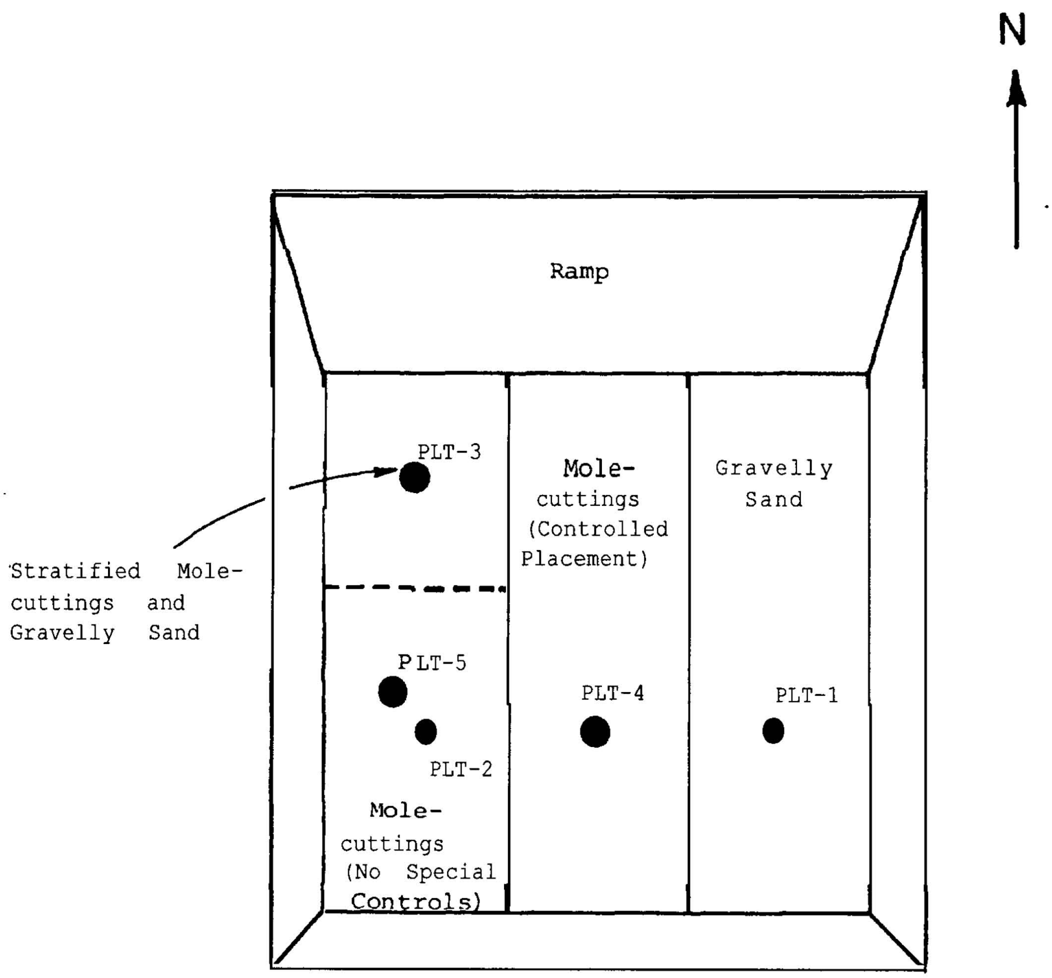
Project 76301
July 11, 1979

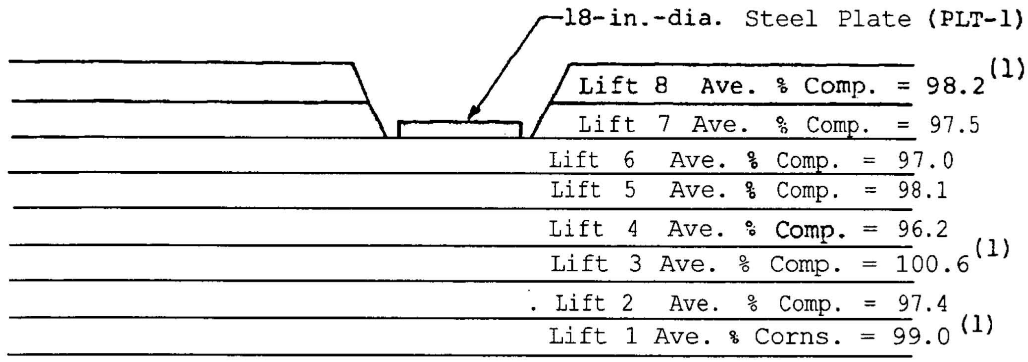
FIGURES



Not To Scale

Public Service Company of New Hampshire	Quartzite Molecuttings Study	PLAN VIEW OF TEST FILLS
GEOTECHNICAL ENGINEERS INC. WINCHESTER, MASSACHUSETTS	Project 76301	July 11, 197[illegible] Fig. 1

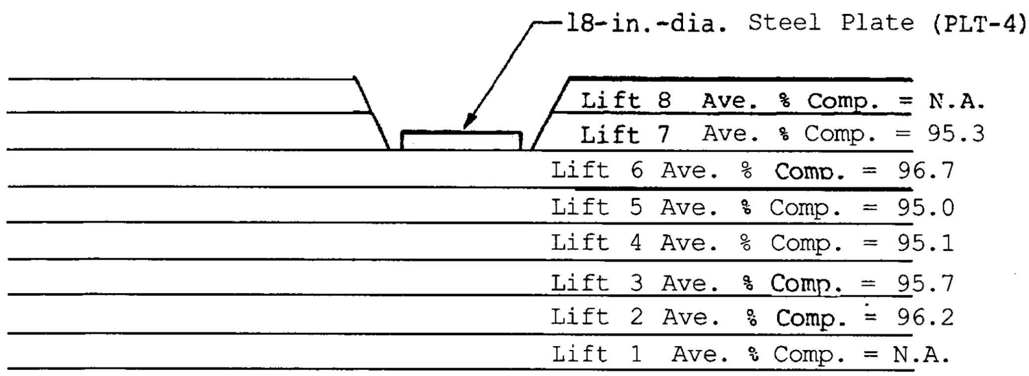
PROFILE OF GRAVELLY SAND
TEST FILL



Scale: 1" = 2.5'

1. One-point compaction samples not obtained. Average percent compaction is based on maximum dry density provided by PTL.

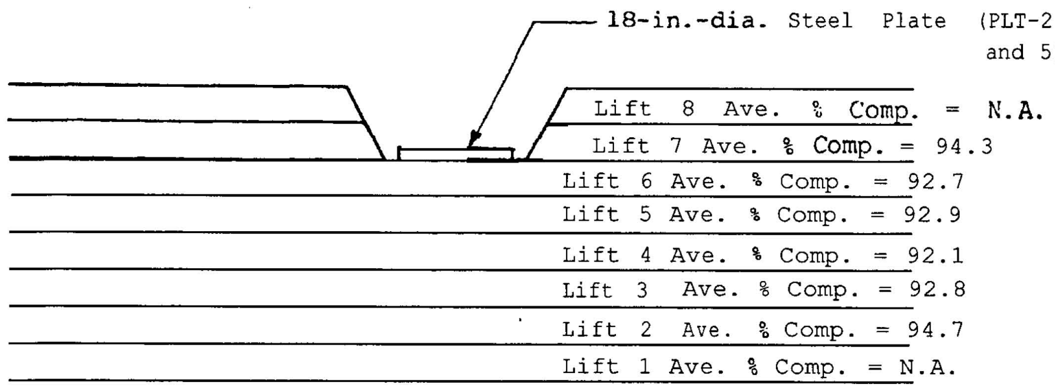
PROFILE OF MOLECUTTINGS
(CONTROLLED PLACEMENT) TEST FILL



Scale: 1" = 2.5'

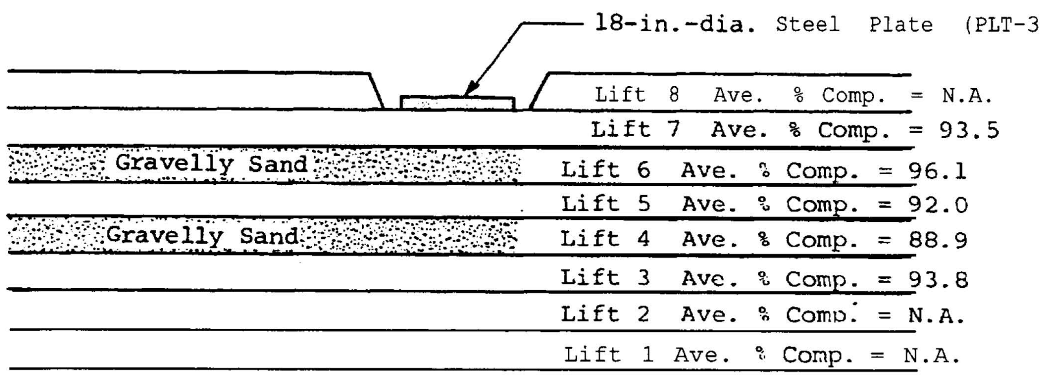
Public Service Company of New Hampshire	Quartzite Molecuttings Study	PROFILE OF TEST FILLS
GEOTECHNICAL ENGINEERS INC WINCHESTER, MASSACHUSETTS	Project 76301	July 11, 19[illegible] Fig. 2

PROFILE OF MOLECUTTINGS
(NO SPECIAL CONTROLS) TEST FILL



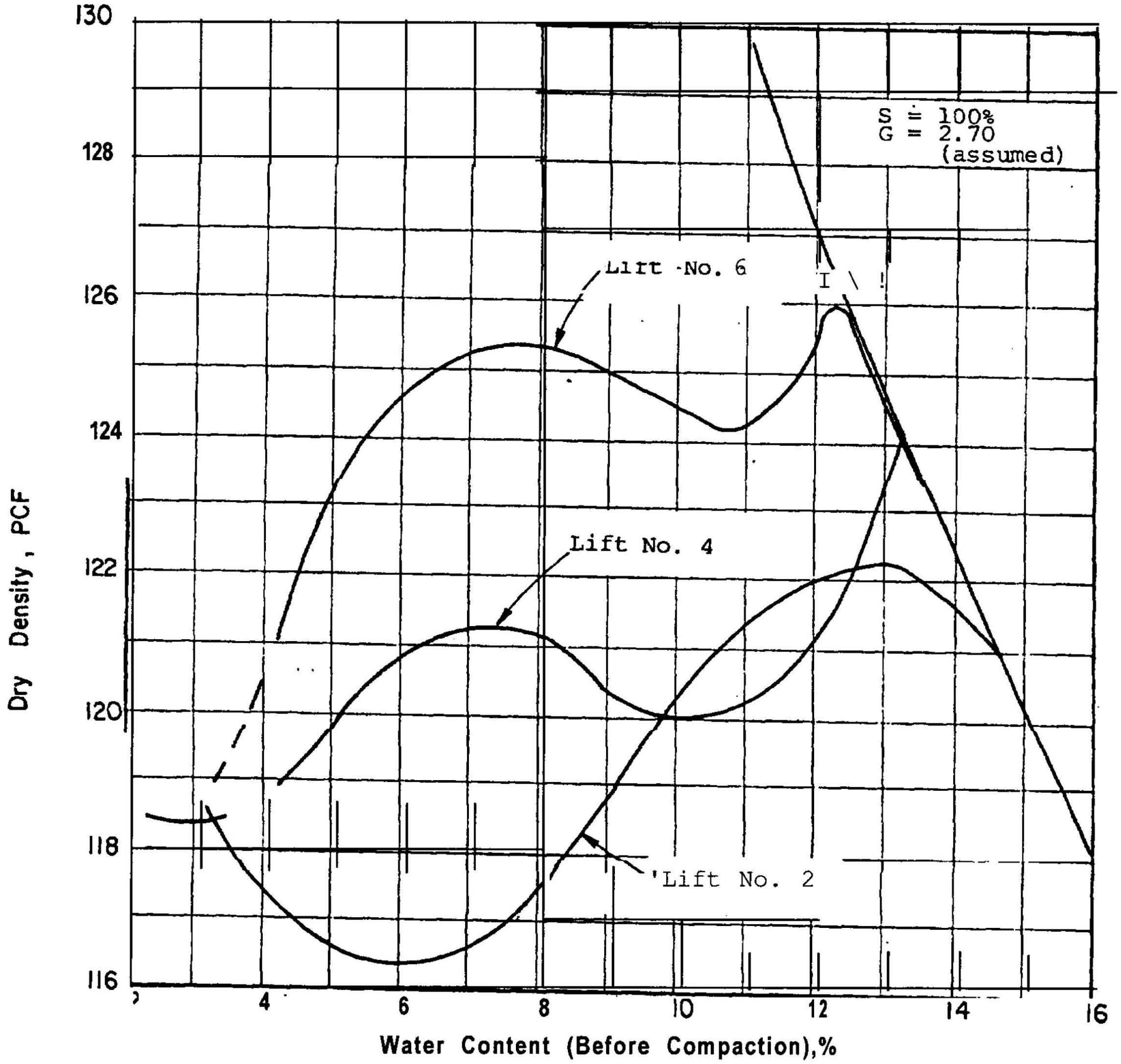
Scale: 1" = 2.5'

PROFILE OF STRATIFIED MOLECUTTINGS
AND GRAVELLY SAND TEST FILL



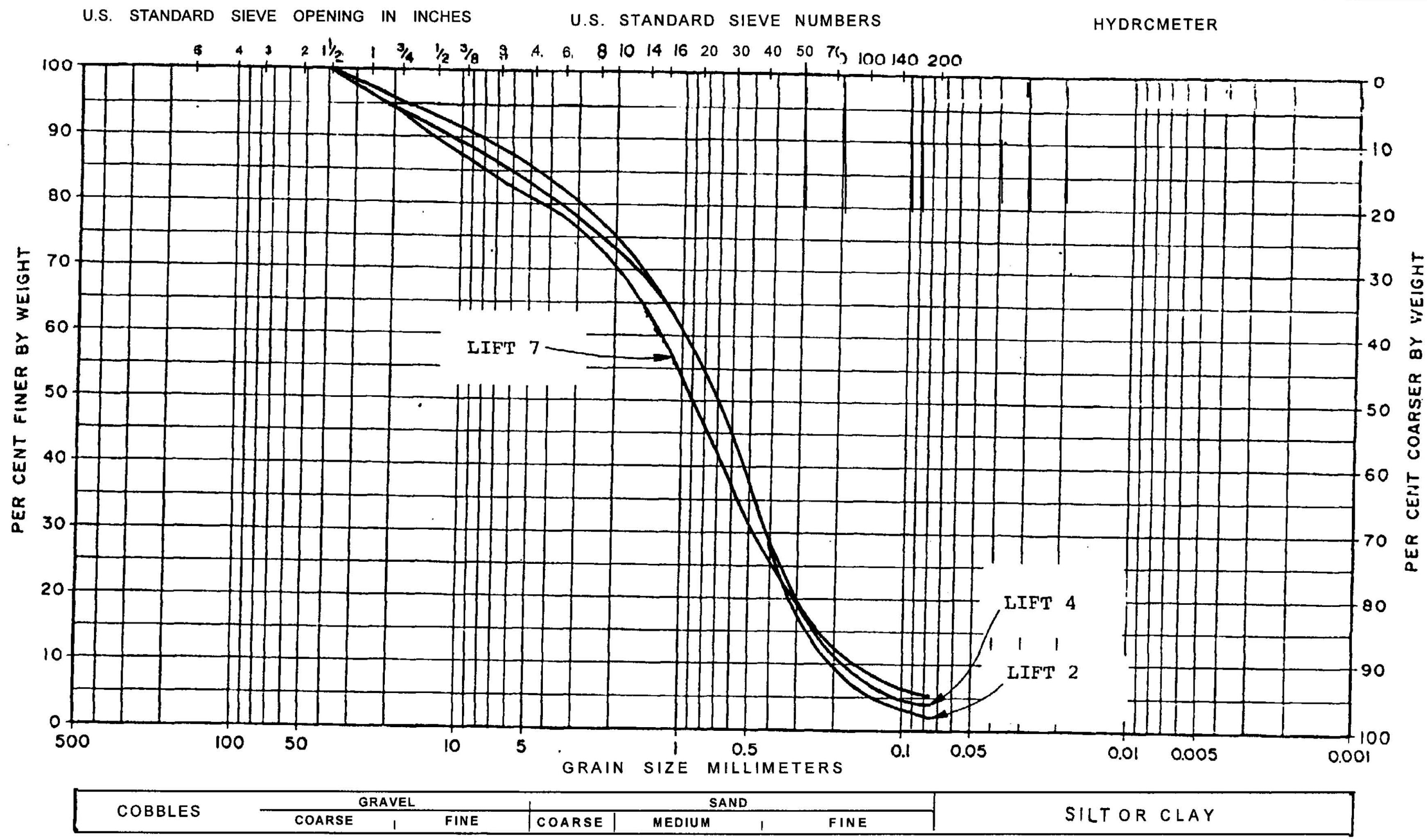
Scale: 1" = 2.5'

Public Service Company of New Hampshire	Quartzite Molecuttings Study	PROFILE OF TEST FILLS
GEOTECHNICAL ENGINEERS INC WINCHESTER • MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 3



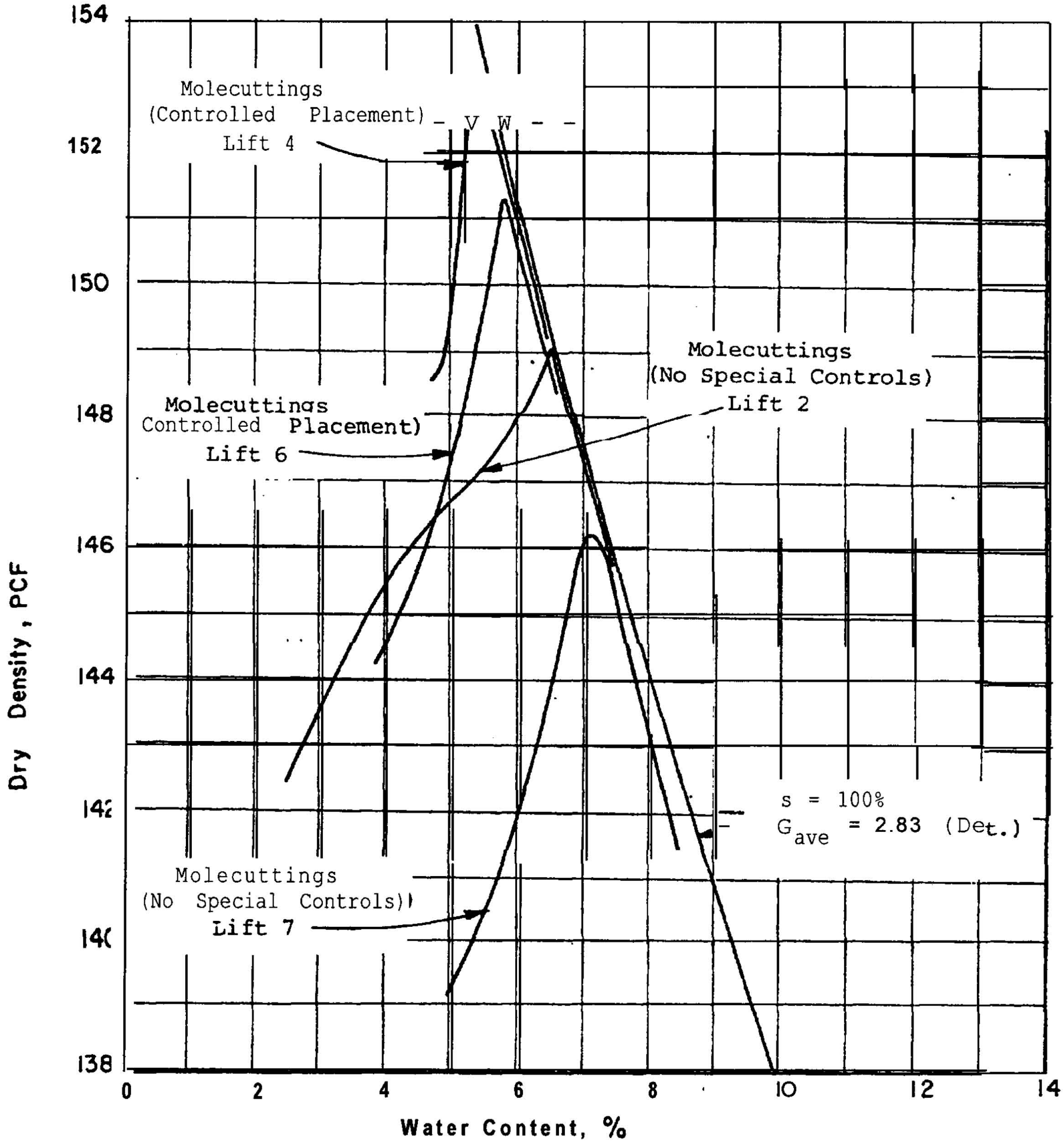
NOTE: Compaction test performed in accordance with ASTM D1557, Method D, by Pittsburgh Testing Labs.

Public Service Company of New Hampshire	Quartzite Molecuttings Study	COMPACTION CURVES GRAVELLY SAND TEST FILL
GEOTECHNICAL ENGINEERS INC. WINCHESTER, MASSACHUSETTS	Project 76301	July 12, 1979 Fig. 4



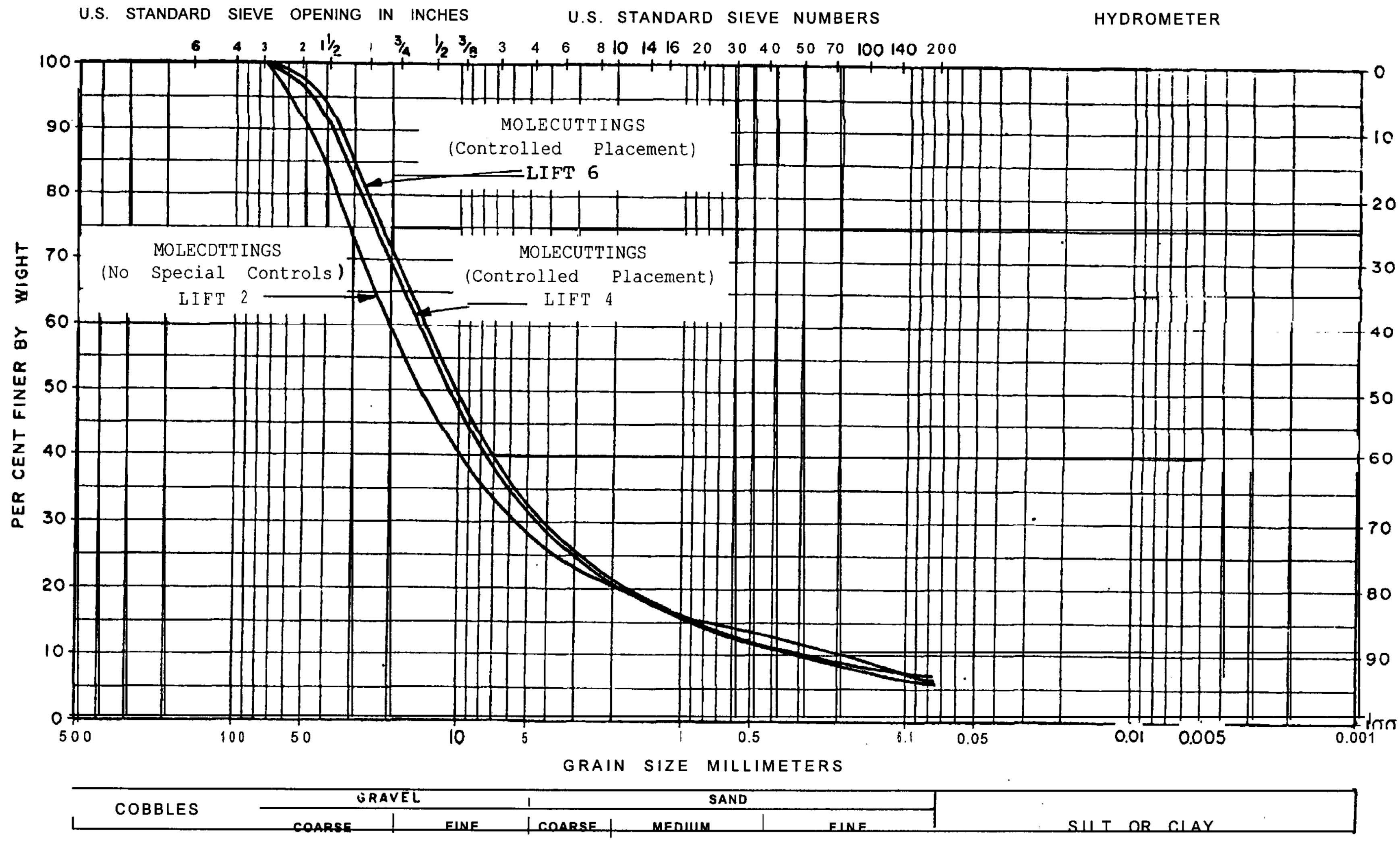
Grain-size analyses per'formed by Pittsburgh Testing Labs.

Public Service Company of New Hampshire	Quartzite Molecuttings Study	GRAIN SIZE CURVES GRAVELLY SAND TEST FILL
GEOTECHNICAL ENGINEERS INC WINCHESTER • MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 5



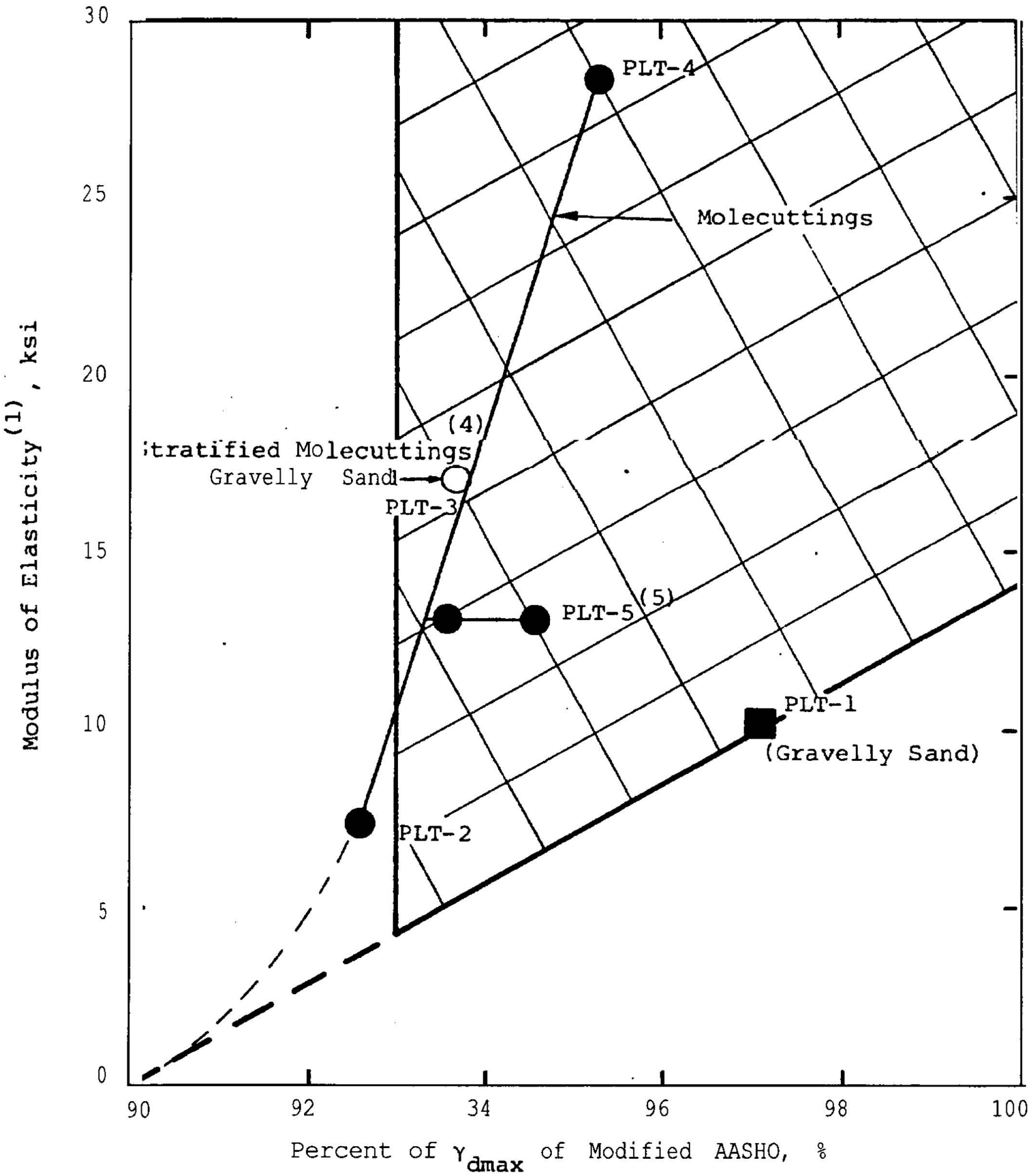
NOTE: 1. Compaction test performed in accordance with ASTM D1557, Method C, except the plus 1½-in. material was discarded and no limitation placed on the percent retained on the 1½-in. sieve.

Public Service Company of New Hampshire	Quartzite Molecuttings Study	. COMPACTION CURVES Molcuttings
GEOTECHNICAL ENGINEERS INC WINCHESTER · MASSACHUSETTS	Project 76301	July 12, 1979 Fig. 6



Grain-size analyses performed using successive elutriation.

Public Service Company of New Hampshire	Quartzite Molecuttings study	GRAIN SIZE CURVES SAMPLES OF MOLECUTTINGS
GEOTECHNICAL ENGINEERS INC. WINCHESTER . MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 7



NOTES: 1. Modulus of elasticity computed using theory of elasticity for semi-infinite, isotropic soil.

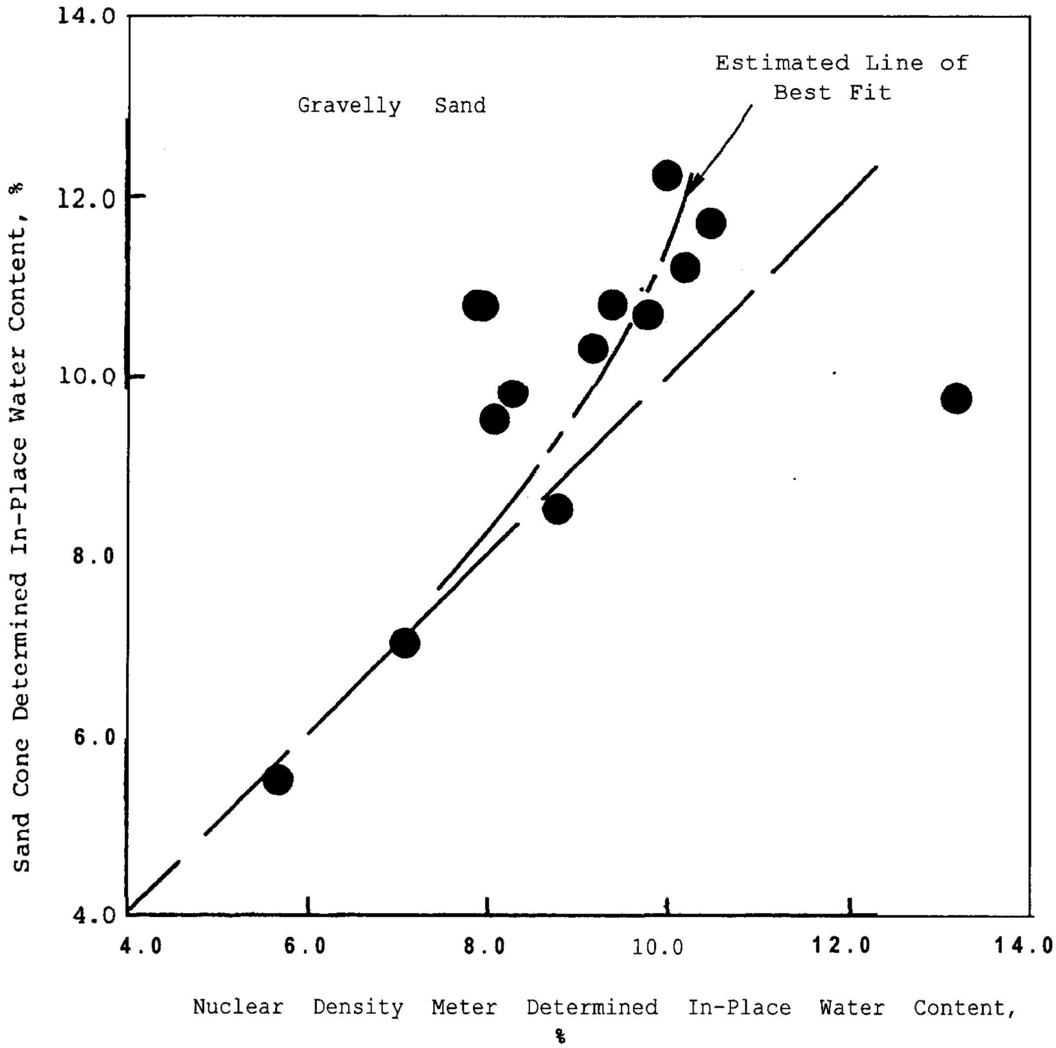
2. Modulus of elasticity value plotted is minimum value from virgin loading curve.

3. Percent compaction is the average percent compaction of the first three layers of soil under the plate.

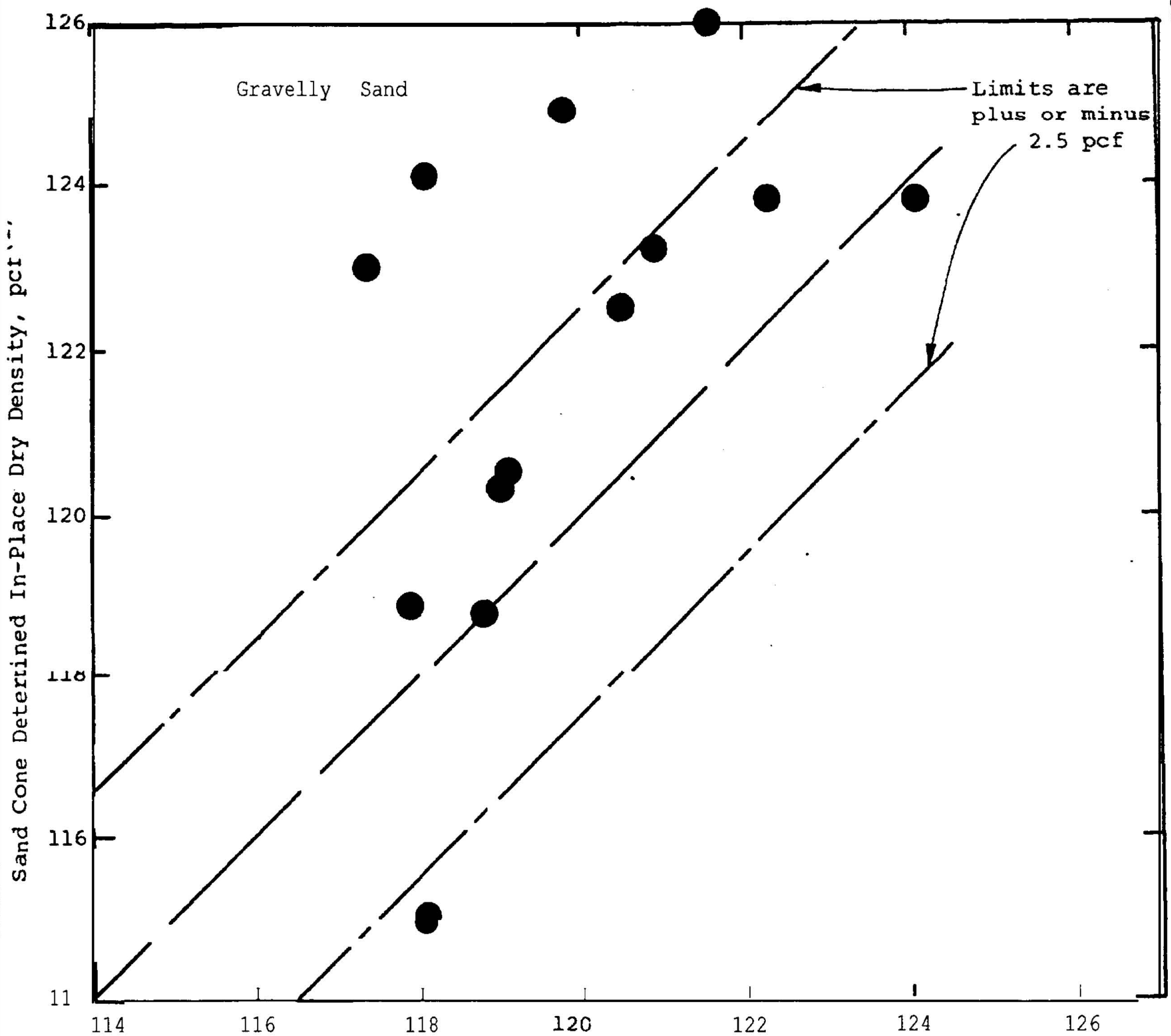
4. Percent compaction the average percent compaction of two layers of molecuttings and one layer of gravelly sand.

5. Range in percent compaction is estimated. See discussion in text.

Public Service Company of New Hampshire	Quartzite Molecuttings Study	MODULUS OF ELASTICITY VERSUS PERCENT COMPACTION MOLECUTTINGS-GRAVELLY SAN
GEOTECHNICAL ENGINEERS INC WINCHESTER • MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 8



Public Service Company of New Hampshire	Quartzite Molecuttings Study	WATER CONTENT SAND CONE VS NUCLEAR DENSITY METER GRAVELLY SAND
GEOTECHNICAL ENGINEERS INC WINCHESTER • MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 9



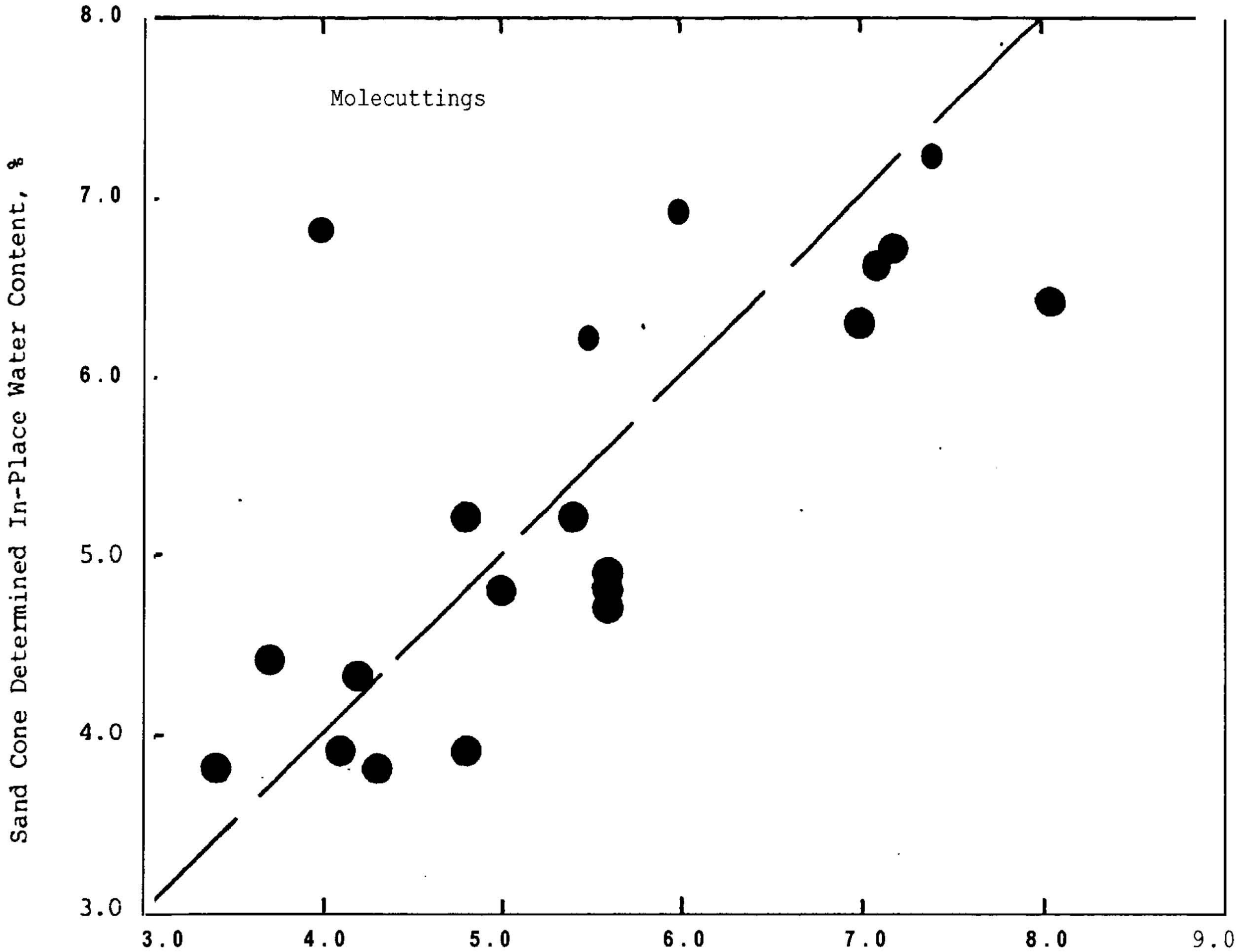
Nuclear Density Meter Determined In-Place Dry Density, pcf (2)

NOTES: 1. In-place dry density includes plus 3/4-in. material.

2. In-place dry density based on 8-in. deep nuclear test. Densities have been corrected for water content bias according to plot of "W" sand cone versus "W" nuclear device for gravelly sand:

3. Sand Cone and Nuclear Density Meter determinations were performed adjacent to each other (about 6-12 in. apart).

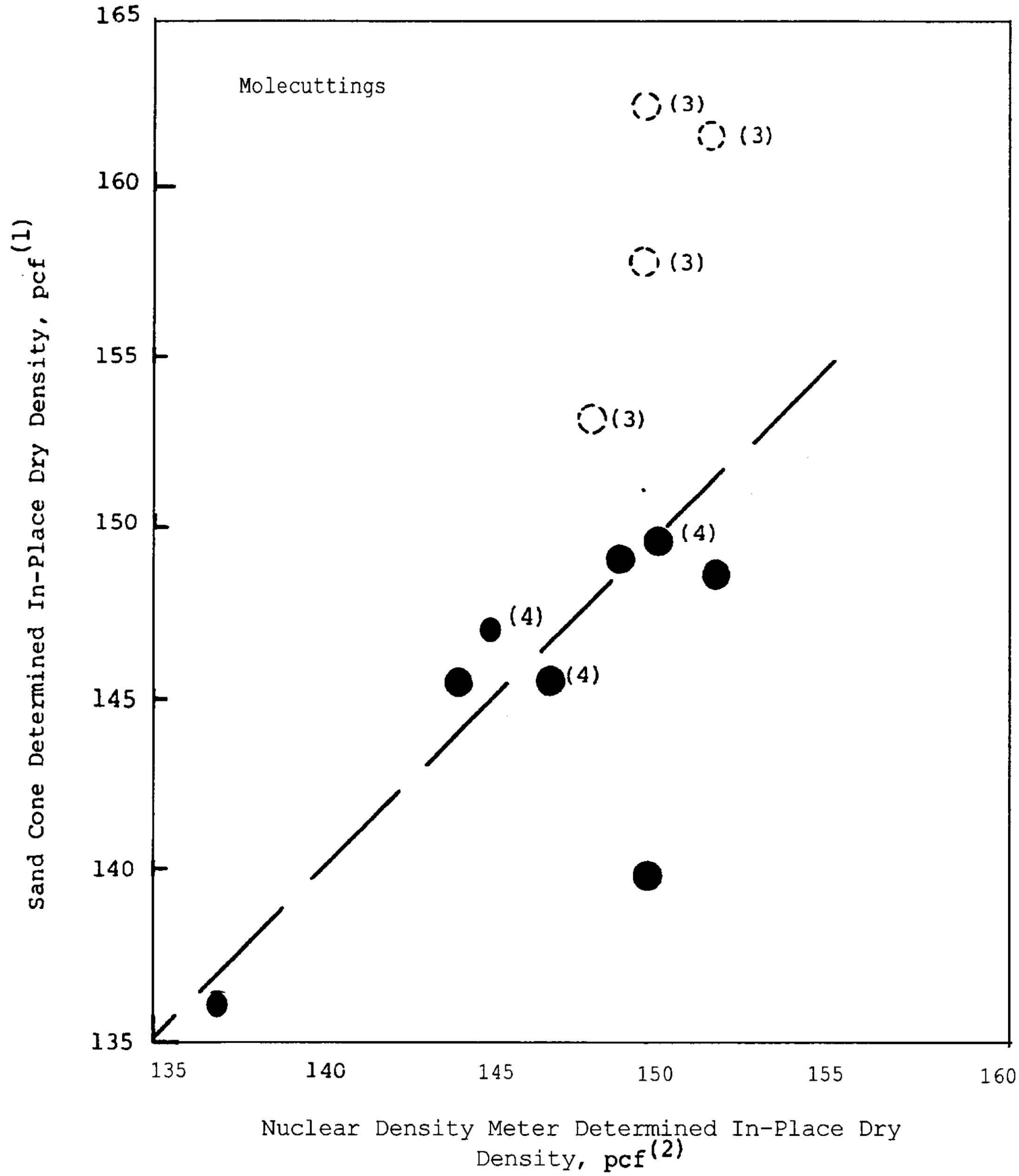
Public Service Company of New Hampshire	Quartzite Molecuttings study	SAND CONE VS NUCLEAR DENSITY METER DET. IN-PLACE DRY DENSITY — GRAVELLY SAND
GEOTECHNICAL ENGINEERS INC WINCHESTER, MASSACHUSETTS	Project 76301	July 11, 1973 Fig. 10



Nuclear Density Meter Determined In-Place Water Content, %
(after bias was corrected)

NOTES: 1. In-place water content is based on 8-in. deep nuclear test.

Public Service Company of New Hampshire	Quartzite Molecuttings Study	WATER CONTENT SAND CONE VS NUCLEAR DENSITY METER MOLECUTTINGS
GEOTECHNICAL ENGINEERS INC WINCHESTER • MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 11



NOTES:
1. In-place dry density is uncorrected for the plus 1½-in. material.
2. In-place dry density is based on the 8-in. deep nuclear test, except where noted.
3. Water content of Sand Cone was greater than 5.0%.
4. In-place density is based on 4-in. deep nuclear test.

Public Service Company of New Hampshire	Quartzite Molecuttings Study	SAND CONE VS NUCLEAR DENSITY METER DET. IN-PLACE DRY DENSITY MOLECUTTINGS
GEOTECHNICAL ENGINEERS INC WINCHESTER, MASSACHUSETTS	Project 76301	July 11, 1979 Fig. 12

APPENDIX A