UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO LIQUEFACTION POTENTIAL AT THE LA CROSSE SITE

DAIRYLAND POWER COOPERATIVE

DOCKET NO. 50-409

1.0 Introduction

Dairyland Power Cooperative's (the licensee) site for the La Crosse Boiling Water Reactor is located on the east bank of the Mississippi River approximately one mile south of Genoa, Wisconsin.

The major structures at the site include the Reactor, Turbine, Diesel Generator and Waste Disposal Buildings, the stack and the gas vault. All of these structures are supported on pile foundations. The crib house and circulating water system are also important components. Figure 1 shows a plan view of the plant layout.

2.0 Background

The initial soils investigation at the La Crosse site was conducted in 1962. Due to the low densities of the sands encountered at the site and the concern for settlement, piles were required to support structural loads for most of the safety related structures. The Construction Permit was granted in 1963 and the Operating License was issued in 1967.

In 1973, an additional investigation was performed by Dames and Moore, to provide seismic design information in support of an application for full-term operating license. These studies included an evaluation of the geology, seismology and liquefaction potential. Six test borings (DM-1 thru DM-6) were performed to depths ranging from 131 to 148 feet. Soil Samples were obtained with the Osterberg, Dames & Moore and split spoon samplers. A laboratory testing program was conducted to provide data for a liquefaction evaluation.

The La Crosse plant is founded on loose to medium dense sand deposits and hydraulic fill. About 20 feet of hydraulic fill was placed over the site to raise plant grade to elevation 639. The hydraulic fill is a brown medium to coarse sand. Under the hydraulic fill is a nearly continuous layer of dark gray clayey silt and very silty fine sand which is about five feet thick. This dark gray soil is absent near the existing river bank (Boring DM-11) and under the containment and stack foundation. It was removed during construction excavation.

Underlying the silt and fine sand layer is 100 to 130 feet of gray to brown, fine to coarse sand with traces of gravel. These natural granular soils are glacial outwash and fluvial deposits of the Mississippi River Valley. Below the outwash deposits the bedrock consists of nearly flat-lying sandstones and shales. Figure 2 shows an idealized soil profile in the free field. This type of soil may be subject to liquefaction during strong seismic loading. Loose sands tend to compact under cyclic loading which can cause an increase in the pore pressure, if saturated, with a resulting reduction in shear strength. When subjected to strong vibratory motion and high pore pressure development, loose sands can undergo complete loss of strength and liquefaction occurs. Methods to evaluate soil liquefaction potential have been developing over the last 15 years but were not available at the time the plant was originally designed and constructed.

3.0 Evaluation

Evaluation of liquefaction potential involves comparison of induced shear stress (loading) due to vibratory ground motion with the available shear stress (strength) in a soil which will resist liquefaction (e.g., see Figure 3). The induced shear stresses are evaluated based on the peak ground acceleration, earthquake magnitude, epicentral distance, and duration of strong motion, coupled with the site soils ability to transmit the imposed vibratory motion.

Evaluations of cyclic shear strength of the soils consider the soil type, density, confining pressure, degree of saturation and drainage characteristics. Two methods are commonly used to evaluate the cyclic strength of a saturated sand deposit and include a laboratory/analytical approach and an empirical approach. Both approaches are considered important by the staff in determining soil resistance to liquefaction at nuclear power plant sites. The laboratory/analytical approach involves modeling the site soil conditions in the laboratory, correcting for known differences between lab and field conditions, and establishing cyclic shear strengths over a range of vibratory loading cycles. The empirical approach utilizes the results of observations for sites where liquefaction occurred or did not occur in past earthquakes (Ref. 1). Site dependent standard penetration test (SPT) hammer blow* values are used to assess the dynamic performance characteristics of the site soils.

There has been general agreement between the staff and the licensee that the earthquake loading at the La Crosse site can be conservatively characterized as a magnitude 5 to 5-1/2 event at a distance of less than

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* Hammer blows measure soil penetration resistance which is indicative of soil characteristics such as density and shear strength.

25 KM with a peak ground acceleration of 0.12 g* and an equivalent duration of 5 cycles. There have been past discussions about lower peak acceleration values and higher duration periods of strong shaking, but the staff has concluded that the above seismic parameters are adequate and conservative for evaluation of the liquefaction potential at the La Crosse site.

Following the 1973 subsurface investigation, Dames and Moore evaluated the cyclic strength of the saturated sand deposits based on the laboratory/analytical approach alone. Laboratory test results from reconstituted samples were utilized in the evaluation with a duration of 10 cycles. The Dames & Moore results of this evaluation indicated a factor of safety in excess of 1.47 as shown in Table 1.

In June of 1978 (Ref. 2), the Corps of Engineers was requested, as a Consultant to the NRC, to evaluate the liquefaction potential for the La Crosse site as part of the Systematic Evaluation Program (SEP). On December 6, 1978 the Corps of Engineers submitted the results of their review. In the Summary and Conclusions of this Report (Ref. 3), the Corps of Engineers reached a conclusion different from Dames and Moore. Because of a lower estimate of the laboratory cyclic shear strength, soil liquefaction was indicated between a depth of 32 and 48 feet below plant grade. This conclusion on the liquefaction problem at the La Crosse site was also reached using the empirical approach for a depth between 24 and 35 feet (See Figure 4). The Corps' evaluations were based on necessarily conservative assumptions because of very limited data available on actual foundation conditions and soil properties. The staff and Corps of Engineers agreed that additional drilling and testing would be needed to refine the evaluation of soil liquefaction potential at the La Crosse site.

In May of 1979, five additional borings (DM-7 thru DM-11) were drilled in the yard area at the La Crosse site to obtain undisturbed samples and additional in-situ testing. The undisturbed samples were tested in the laboratory and the results were used by Dames and Moore for a revised laboratory/analytical evaluation. The standard penetration test results were also used in the empirical approach. The Dames & Moore report (Ref. 4) concluded that for the postulated earthquake with a 0.12 g peak ground acceleration the laboratory/analytical approach yielded a minimum safety factor of 1.5 and for the empirical approach a minimum value of 1.0 was determined.

* g is acceleration of gravity i. e. 32.2 ft/sec/sec

The staff and Corps of Engineers reviewed the Dames and Moore report (Ref. 4) and concluded that the laboratory shear strength curves used in this analysis were unconservative. No correction was made due to sample disturbance of the recovered loose foundation soils. This unavoidable disturbance was estimated by the Corps of Engineers to result in an increase in measured dry density up to 3 to 4 lb/cu. ft. In addition, using the empirical approach, factors of safety less than 1.0 were obtained for foundation soils below the water table down to the depth of about 35 feet. Based on these findings, the staff concluded that the foundation soils down to a depth of approximately 40 ft. were not safe against liquefaction, if these soils were subjected to an earthquake with a peak ground acceleration of 0.12 g.

Because of this staff conclusion, Dairyland Power Co. was requested to provide a plan to mitigate the consequences of liquefaction at the La Crosse site. In a letter to D. Ziemann dated November 29, 1979, Dairyland provided a proposed measure to mitigate liquefaction. This involved a dewatering plan to lower the groundwater level. Subsequently this proposal was withdrawn by the licensee and a Show Cause Order was issued by NRC on February 25, 1980. This Order required the licensee to show cause why it should not submit a detailed design proposal for a dewatering system and make the system operational no later than February 25, 1981.

In response to the Show Cause Order, Dairyland cited the improved density, which could be expected, due to driving displacement piles under pile supported structures as a reason why a dewatering system was not required. In an attempt to document this condition, a research survey of pertinent case histories was performed combined with a drilling program under pile support structures to provide site specific data. Two reports were provided, one dated July 11 and one dated July 25, 1980. These reports were prepared by Dames & Moore, a consultant for the licensee. The Corps of Engineers, reviewed these reports and provided comments in a letter dated July 25, 1980 (Ref. 5). Based on the evaluation of the applicable new information, we have revised our position, as explained in the following paragraphs.

The documentation and quantification required to assess the increase in density in the soils under the pile supported turbine, containment and stack foundations has been provided in the recent Dames & Moore reports. The July 25, 1980 Dames & Moore report includes four recent test borings beneath plant structures which clearly indicate an increased density below these pile supported structures. Specifically borings DM-12 and DM-13 taken in the northwest corner of the turbine building show a range in Standard Penetration Tests (SPT) hammer blow values taken in clean sands below the water table from 12 to 34 per foot of depth. This is a significant improvement over the SPT results from the free field boring (DM-7, 8, 10 and 11) which ranged from 2 to 17 blows per foot over the same depth. Test borings (DM-14 and DM-15) drilled under the stack foundation indicate an even larger increase in soil density. The SPT values under the stack, which has a much closer pile spacing, range from 23 to more than 50. Based on our review of the site foundation conditions, the borings under the turbine and stack foundations are considered representative for other adjacent structures that are pile supported, including for example the reactor containment building.

The degree of improvement in foundation support under pile supported structures can be seen in a plot of the variation of penetration resistance with depth (see Figure 5 thru 8). Figure 5 shows the results of borings DM-7, 8, 10 and 11. These borings are located in the free field in areas not influenced by past pile driving operations. Penetration resistance has been corrected for overburden pressure and Figure 5 data shows that liquefaction potential does exist to a depth of 35 feed in the free field when compared with the empirical approach for the lower bound at sites where liquefaction has occurred. This data obtained in the free field is considered applicable to the service water line which is buried in the hydraulic fill and the crib house which is located on the river bank. The results for the Turbine Building and stack are shown on Figures 6 and 7, respectively. These results clearly show that the piles produced an improved condition over earlier free-field subsurface conditions and indicate a low liquefaction potential for the turbine and reactor buildings. The improvement from free field conditions to conditions for widely spaced piles under the turbine building and densely spaced piles under the stack foundation is summarized on Figure 8.

Upon reviewing the recent boring logs and data presented by Dairyland, we and our consultant, the Corps of Engineers, now conclude that the material under the existing turbine building and the reactor containment is adequately safe against liquefaction effects for an earthquake up to a Magnitude 5.5 with a peak ground acceleration of 0.12g. We now conclude that mitigative measures to increase the margin of safety against liquefaction for these structures are not needed. Although liquefaction is of concern for the crib house and underground piping, a site dewatering system is unnecessary to resolve this concern.

By a letter dated August 25, 1980 the licensee proposed to install a dedicated safe shutdown system to "preclude reliance on the Crib House and buried piping" and "to inject grouting in the areas of concern to alleviate any potential for reduction of building integrity". Grouting was proposed to alleviate the concern raised by Corps of Engineers (Ref. 5) regarding voids beneath the concrete slab of the turbine building. A detailed engineering analysis and proposed technical specification changes for the proposed dedicated safe shutdown system will be submitted to NRC within 60 days and the system will be required to be operable by the end of February 1981. A report on the grouting program will also be submitted within 60 days for staff review. We will require completion of an acceptable grouting program by February 1981.

4.0 Summary

We have concluded that the soils under the existing turbine and the reactor containment are adequately safe against liquefaction effects for an earthquake up to a Magnitude 5.5 with a peak ground acceleration of 0.12 g. We have also concluded that the concept for the dedicated safe shutdown system is feasible and that the engineering details and installation can be completed by February 1981. In the unlikely event of an earthquake great enough to damage the crib house and underground piping, emergency cooling water could be provided for safe reactor shutdown using the proposed dedicated safe shutdown system. With the proposed remedial action of grouting the voids and installing the dedicated safe shutdown system, we have concluded that loss of the crib house and underground piping would not endanger the health and safety of the public. Therefore, the liquefaction concern will be resolved for the LaCrosse site. In all events, the staff does not believe a dewatering system for the site is necessary.

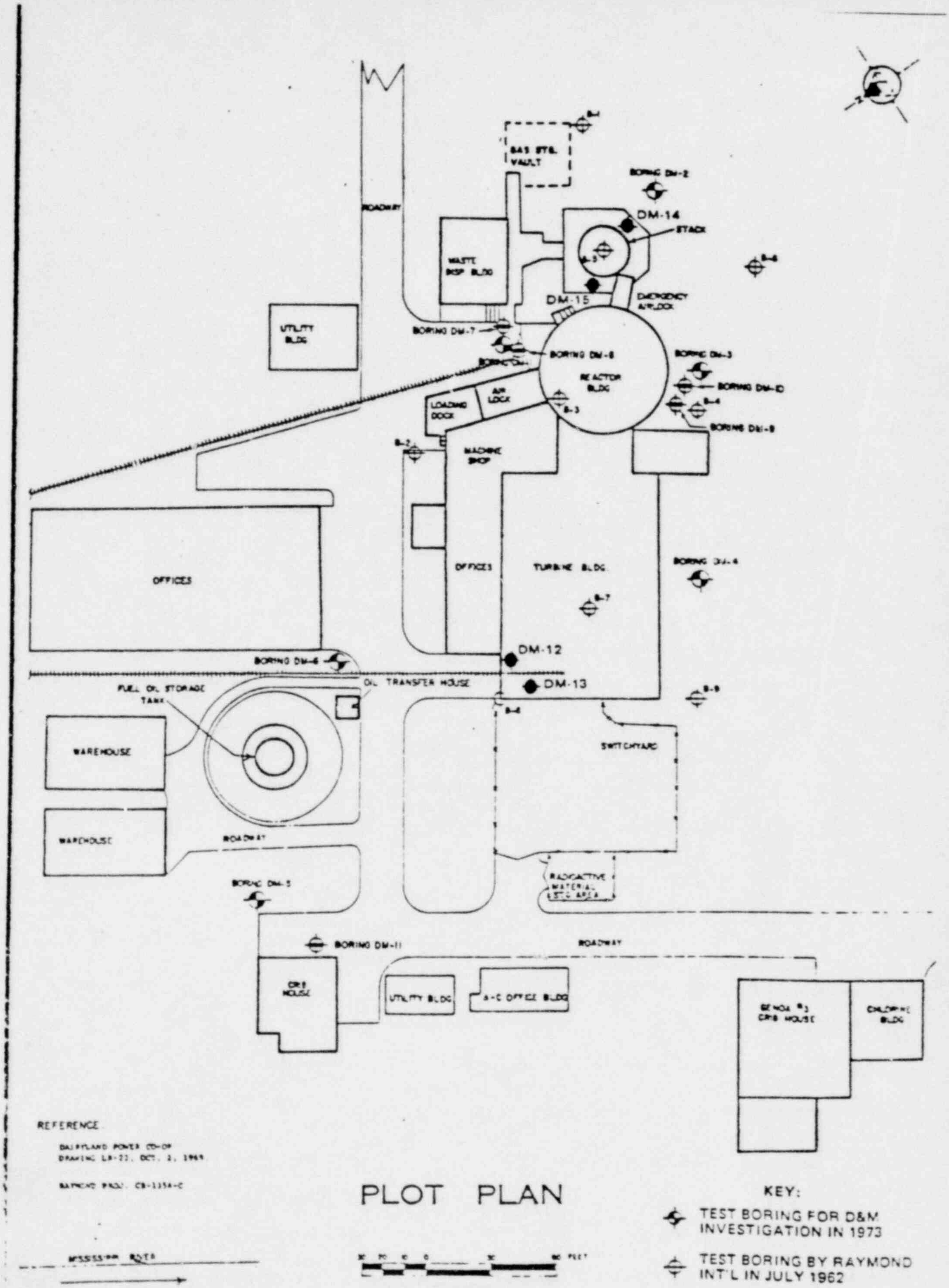
We have also concluded that grouting the voids is feasible. An acceptable program will resolve our concerns related to the Turbine Building and emergency diesel generator structural integrity during earthquakes.

5.0 Conclusion

Based on the above discussion, we have concluded that it is not necessary for the licensee to install a dewatering system at the La Crosse site. The licensee has shown adequate cause under the Order to Show Cause of February 25, 1980, why it should not be required to design and install such a system.

Date: August 29, 1980

Attachments:
1. Figures 1 thru 8
2. Table 1



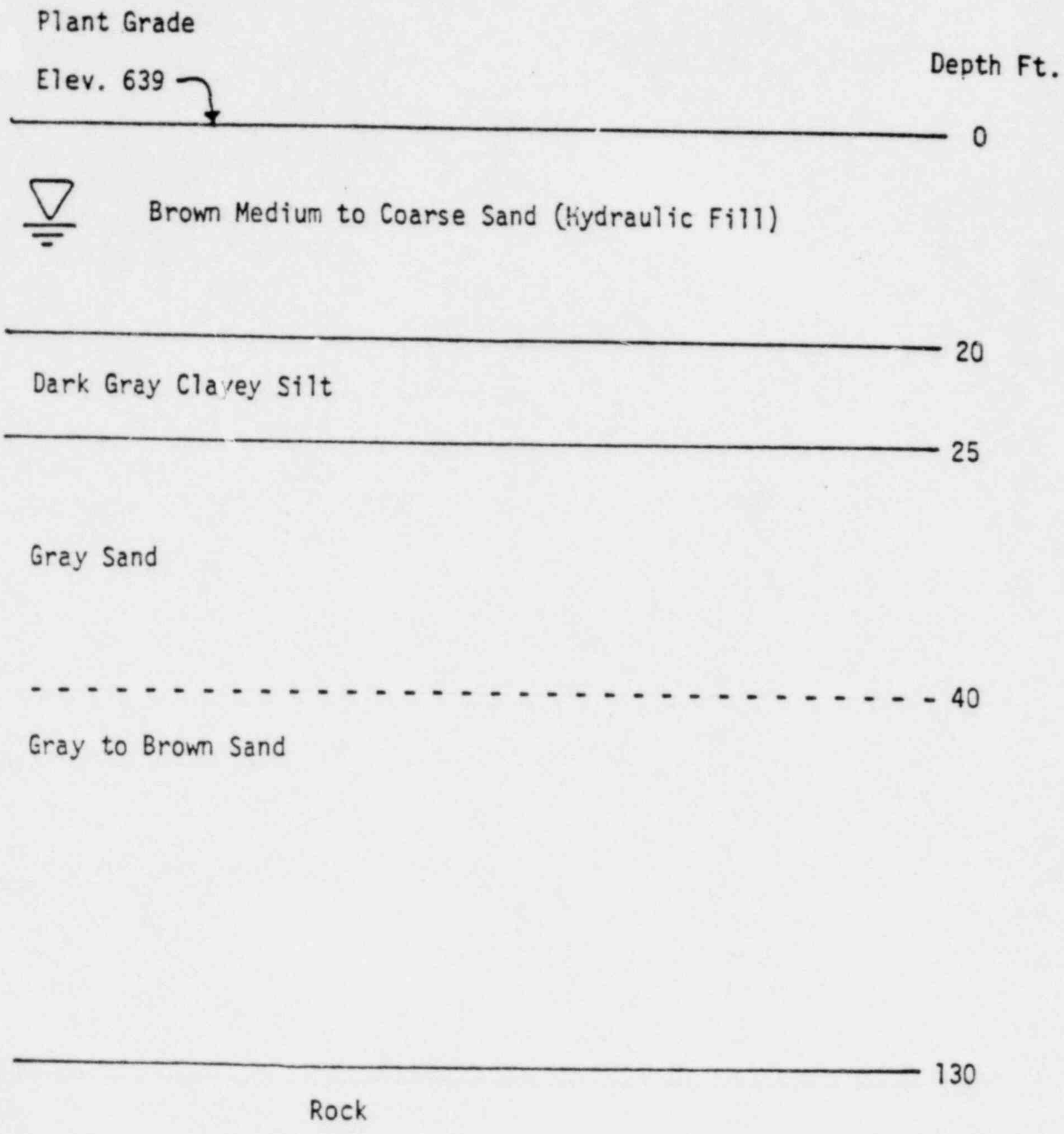
PLOT PLAN

KEY:

- TEST BORING FOR D&M INVESTIGATION IN 1973
- TEST BORING BY RAYMOND INT'L IN JULY 1962
- TEST BORING FOR D&M INVESTIGATION IN 1979
- TEST BORING FOR D&M INVESTIGATION IN 1980

Figure 1

DAMES & MOORE



Typical Soil Profile
Figure 2

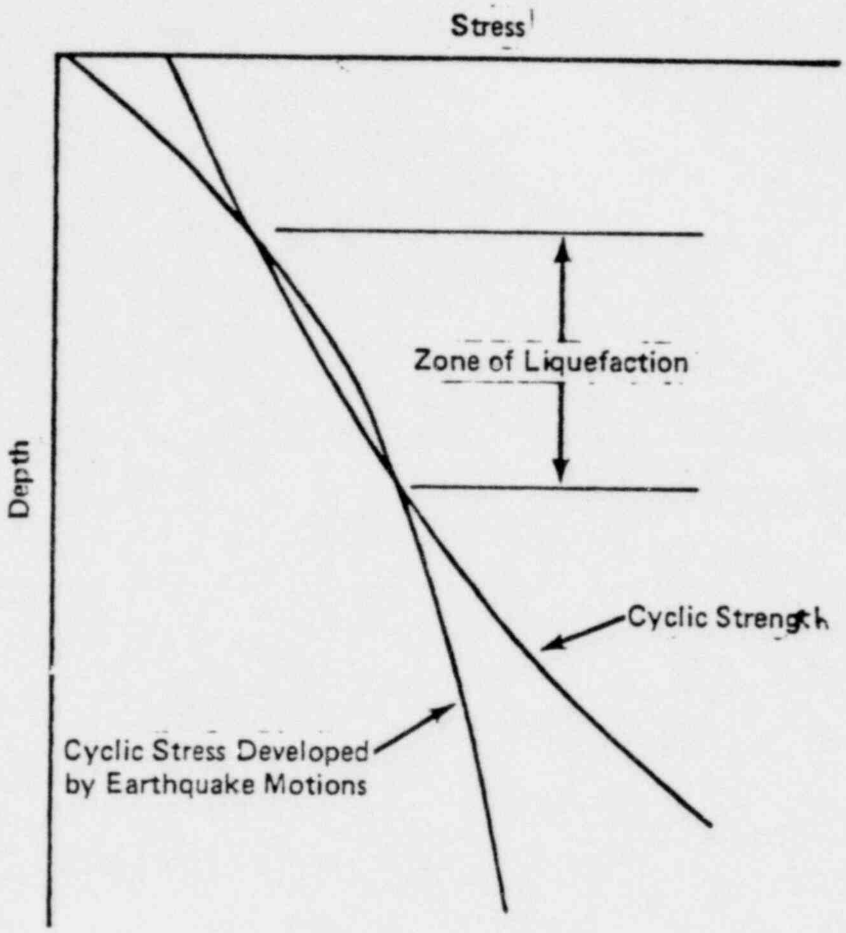


Figure 3. Method of Evaluating Liquefaction Potential

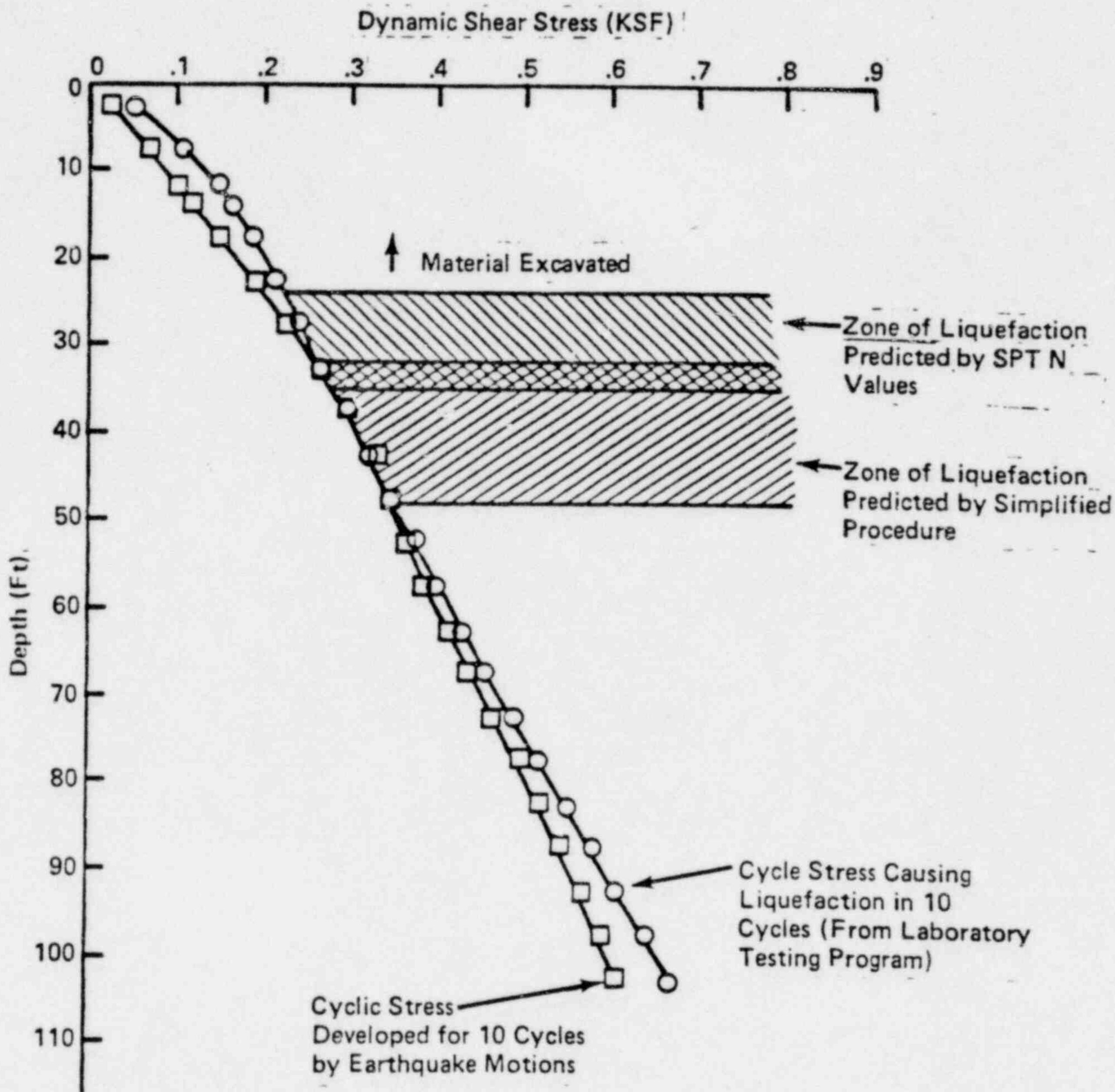


Figure 4. Results of SPT Empirical Study for SSE = 0.12 G

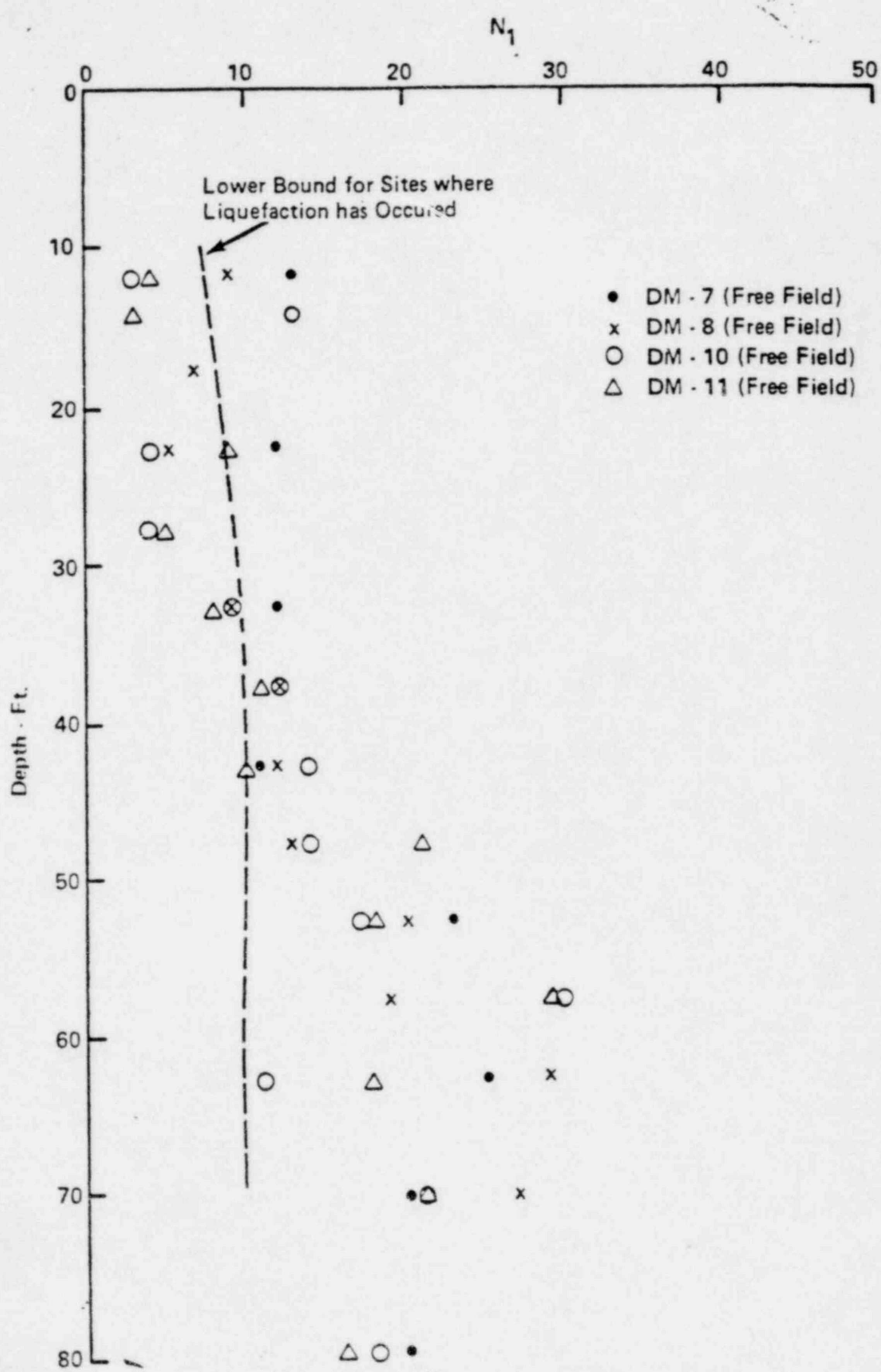


Figure 5. Free Field

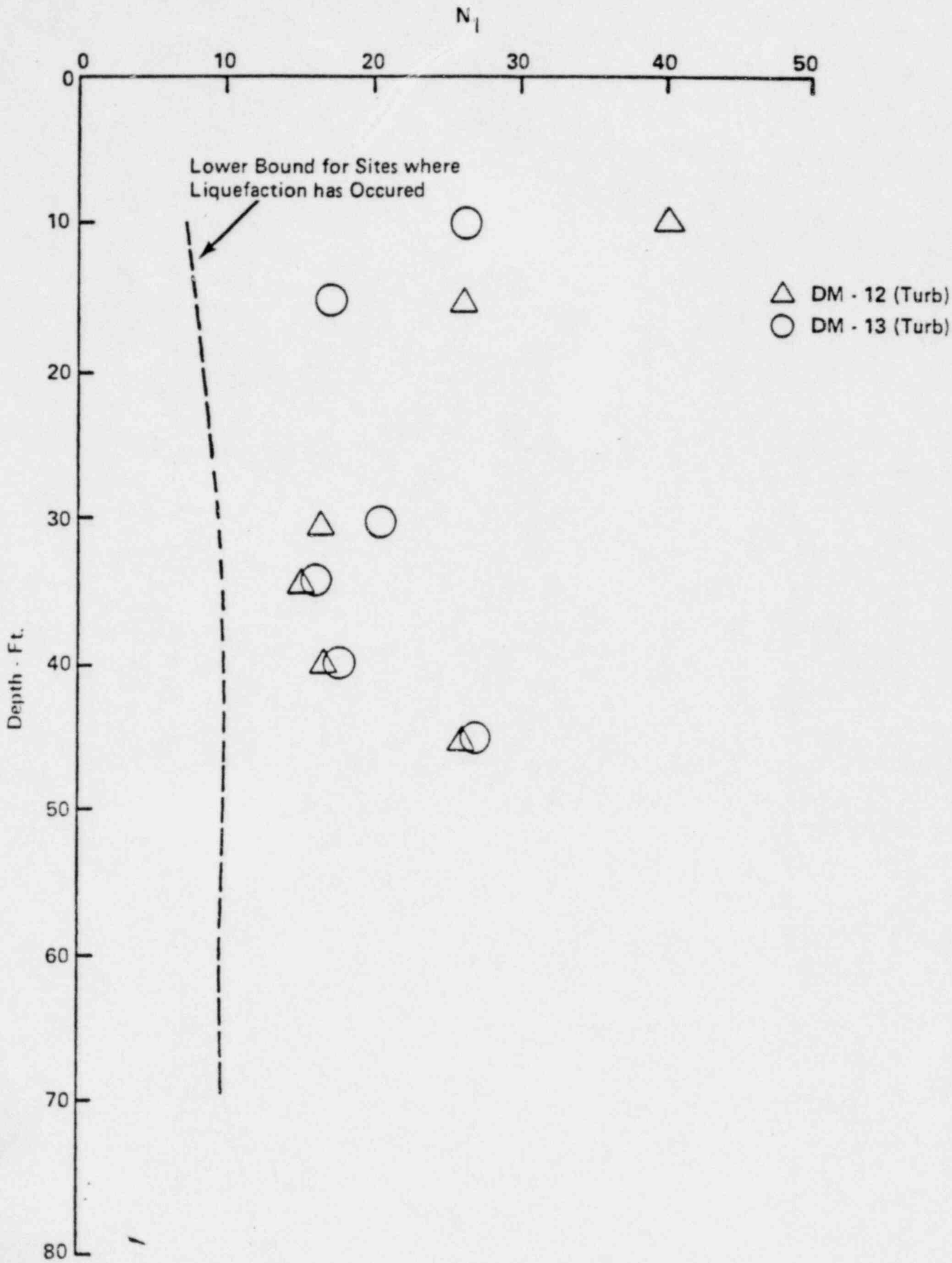


Figure 6 Turbine Building

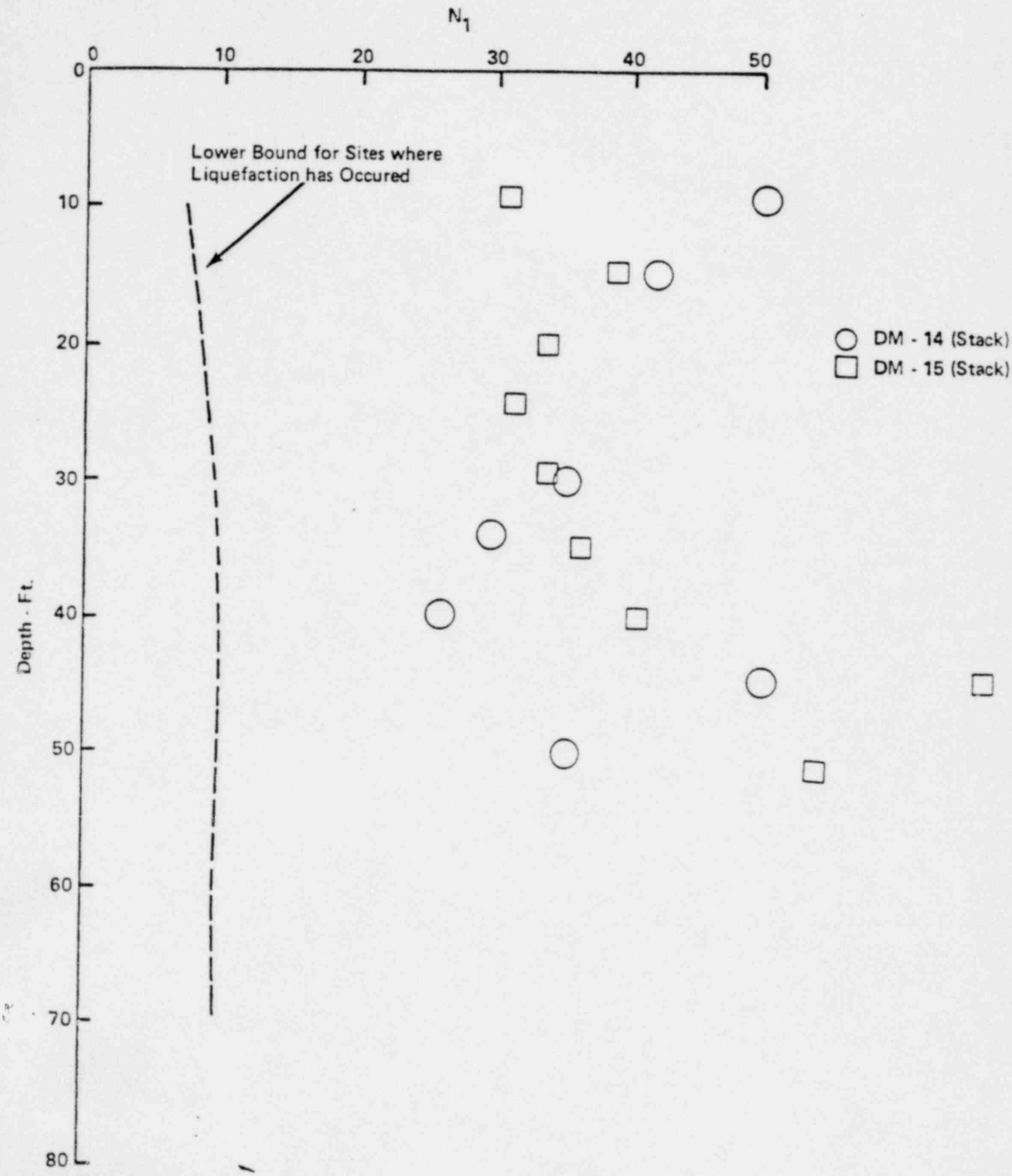
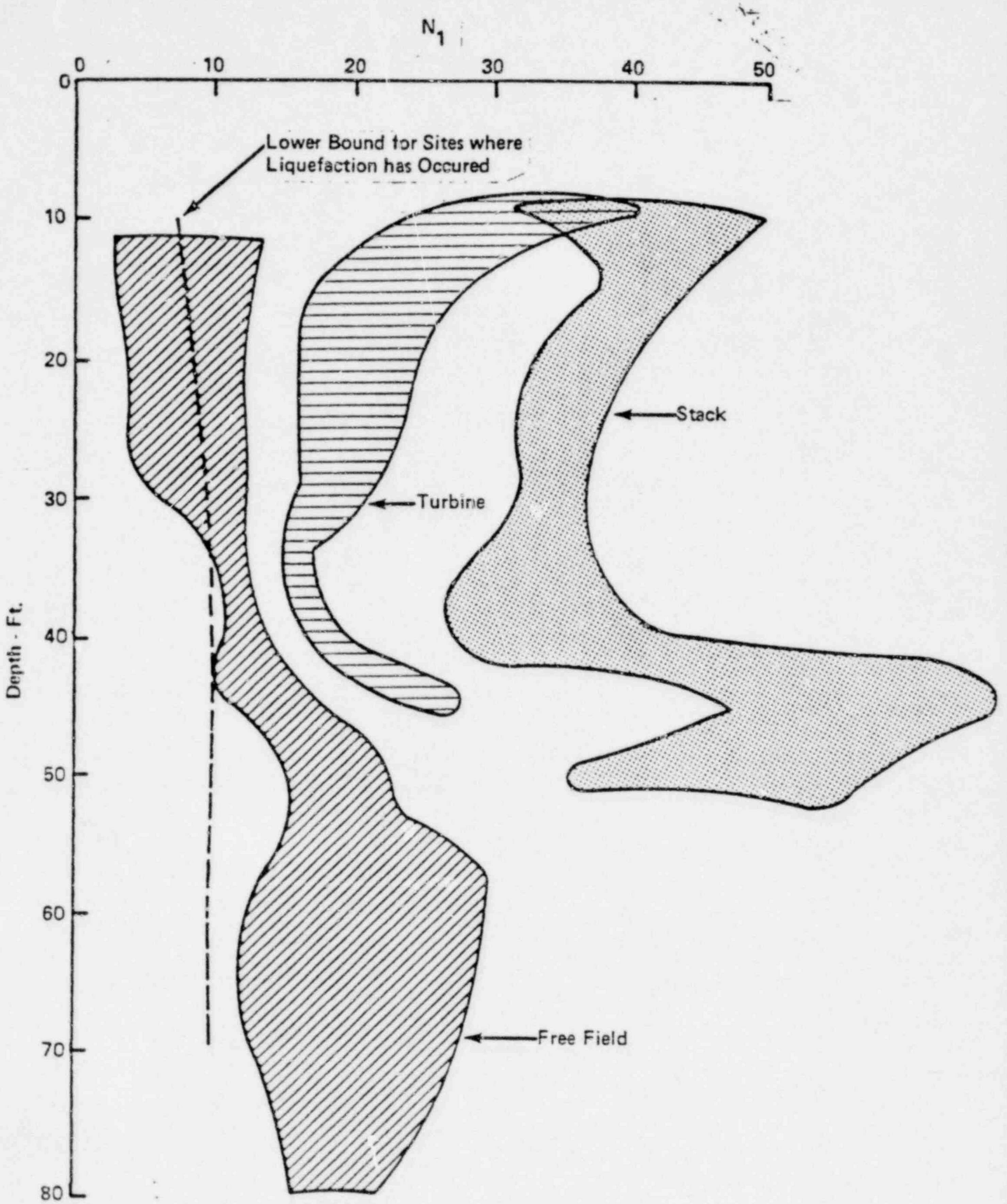


Figure 7 Stack Foundation



N_1
0
10
20
30
40
50
0
10
20
30
40
50
60
70
80
Depth - Ft.
Lower Bound for Sites where
Liquefaction has Occured
Stack
Turbine
Free Field

Figure 8

TABLE 1

SUMMARY OF LIQUEFACTION ANALYSES

Depth (ft.)	Effective Overburden Pressure $\bar{\sigma}_o$ (kips/ft^2)	Critical Number of Cycles N_c	Average Cyclic Shear Stress for N_c Cycles τ_{ave} (kips/ft^2)	Average Cyclic Shear Stress Causing Liquefaction in N_c Cycles τ_{liq} (kips/ft^2)	Factor of Safety with Respect to Liquefaction τ_{liq}/τ_{ave}
6	0.693	10	0.054	0.104	1.93
13	1.500	10	0.113	0.225	1.99
18	1.830	10	0.160	0.275	1.72
22	2.083	10	0.196	0.312	1.59
26	2.336	10	0.231	0.350	1.52
30	2.590	10	0.262	0.389	1.49
40	3.259	10	0.332	0.483	1.47
50	3.928	10	0.379	0.589	1.55
60	4.597	10	0.417	0.690	1.66
70	5.266	10	0.434	0.790	1.92
80	5.935	10	0.434	0.890	2.05
90	6.604	10	0.445	0.991	2.23
100	7.270	10	0.475	1.091	2.30

References

1. Seed, H. B., "Soil Liquefaction and Cyclic Mobility Evaluation for Level Ground During Earthquakes," Journal of the Geotechnical Engineering Division, ASCE, Vol. 105, No. GT 2, Proceedings Paper 14380 (Feb. 1979).

2. U. S. Nuclear Regulatory Commission Letter from R. Denise to P. Hadala of Corps of Engineers, W. E. S. June 8, 1978.

3. Marcuson, W. F. and W. A. Bieganowsky, Liquefaction Analysis for La Crosse Nuclear Power Station, U. W. Army Engineer Waterways Experiment Station, Report to the U. S. Nuclear Regulatory Commission (December 1978).

4. Dames & Moore Liquefaction Potential at La Crosse Boiling Water Reactor (LACBWR) Site Near Genoa, Vernon Coutny, Wisconsin, Report to the Dairyland Power Cooperative (September 28, 1979).

5. Corps of Engineers, Letter from F. R. Brown to J. P. Knight of U. S. Nuclear Regulatory Commission. July 25, 1980.

ENCLOSURE 2

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of	)	Docker No. 50-409
DAIRYLAND POWER COOPERATIVE	)	Provisional Operating
(La Crosse Boiling Water Reactor)	)	License No. DPR-45

MOTION TO SUSPEND
PROVISIONAL OPERATING LICENSE
DPR-45

Pursuant to 10 CFR 2.206 we, the undersigned, do hereby request the Director of Reactor Regulation or Office of Inspection and Enforcement, as appropriate, to suspend Provisional Operating License DPR-45 for the operation of Dairyland Power Cooperative's Boiling Water Reactor (LACBWR), Docket No. 50-409. We submit this motion in the belief that the continued operation of said plant is inimical to the health and safety of the public.

This motion for suspension of Provisional Operating License DPR-45 is based on the following grounds:

1. Whereas, by Dairyland Power Cooperative's own admission (Reference 1). LACBWR's continued operation is dependent upon unlimited, continuous venting of the

Whereas, the NRC currentl

practice (Reference 2) and directed

limit said practice to a minimum of

DUPLICATE DOCUMENT

Entire document previously entered into system under:

ANO 7908030113

No. of pages: 8

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7908030113