DAIRYLAND POWER COOPERATIVE • P.O. BOX 817 • 2615 EAST AV. SOUTH • LA CROSSE, WISCONSIN 54601
(608) 788-4000

July 25, 1980

In reply, please
refer to LAC-7055

DOCKET NO. 50-409

P

Director of Nuclear Reactor Regulation
ATTN: Mr. Dennis M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

SUBJECT: DAIRYLAND POWER COOPERATIVE
LA CROSSE BOILING WATER REACTOR (LACBWR)
PROVISIONAL OPERATING LICENSE NO. DPR-45
LIQUEFACTION POTENTIAL AND SEISMIC ANALYSIS OF
SYSTEMS AND STRUCTURES AT LACBWR (SEP TOPICS
II-4 AND III-6) - RESPONSE TO REVIEW QUESTIONS

Reference: (1) NRC Letter, Ziemann to Linder,
dated April 25, 1980.

Gentlemen:

In response to Question 2-d which was contained in your letter (Reference 1), we are submitting, as Enclosure 1, a description of a field testing program and results which were obtained from the tests. The program was conducted during the period July 14-18, 1980.

If there are any questions regarding this submittal, please contact us.

Very truly yours,

DAIRYLAND POWER COOPERATIVE

Frank Linder

Frank Linder, General Manager

FL:RES:af
Enclosure

cc: J. Keppler, Reg. Dir., NRC-DRO III

July 25, 1980

LaCrosse Boiling Water Reactor
Dairyland Power Cooperative
Post Office Box 135
Genoa, Wisconsin 54632

Attention: Mr. R. E. Shimshak
Plant Superintendent

RE: Response to NRC Review Questions

Gentlemen:

We have enclosed 10 copies of our report, "Final Assessment of Liquefaction Potential at LACBWR site, near Genoa, Vernon County, Wisconsin," for your use. This report contains the data collected at your plant site during our recent test boring program. This test boring program was proposed in partial fulfillment of responses to review questions posed by the Nuclear Regulatory Commission (NRC).

NRC technical staff participated in the planning of the test boring program and also witnessed most of the drilling and testing performed at your site. The data obtained at the site mainly consist of results of Standard Penetration Tests (SPT) performed in four locations within the developed area of the site. The SPT data obtained are consistent with the predictions made by us and are so convincing that the margin of safety against potential for liquefaction at the LACBWR site under an SSE producing 0.12 g acceleration at the surface is much higher than those shown by any of our previous analyses.

We strongly believe that, with the data presented in this report, we have justified all our previously expressed opinions on the liquefaction aspect of the LACBWR site and substantiated by means of hard on-site data our past predictions of existing foundation conditions under the developed area of the plant site.

1980. Even on the basis of Dr. Seed's review, NRC felt that several concerns remained, and the liquefaction issue at the LACBWR site remained unresolved.

3 pg intro from previous reports

As a result of the review of the D&M report of September 28, 1979, and the ensuing technical discussions, NRC issued to DPC on February 25, 1980, an "Order to Show Cause" why DPC should not plan and implement a site dewatering system to preclude liquefaction in the event of an earthquake with peak ground surface accelerations of .12 g or less (Ref. 12). NRC's conclusion that liquefaction can occur down to a depth of 40 feet was based on a comparison of the LACBWR site with other sites where liquefaction has occurred and on the use of laboratory strength data.

In accordance with the deadline specified in the "Order to Show Cause" on March 21, 1980, DPC responded with a D&M report enumerating several [illegible] considered in previous analyses (Ref. 13). A probabilistic analysis of seismicity at the site was also presented, indicating an anticipated return period of 10,000 years for an earthquake producing .11g ground surface acceleration. Based on these considerations and on previous analyses, the D&M response of March 1980 reiterated the conclusion that the site is safe against liquefaction under the designated acceleration and that mitigative measures are unnecessary.

Upon reviewing the response to the show cause order, NRC posed several review questions (Ref. 14). The answers were provided to NRC in draft form in May and June, 1980, and compiled in final form on July 11, 1980 (Ref. 15). One of the review questions required site-specific data to substantiate the prediction of improved conditions under the structures supported by driven piles. Subsequently, questions were also raised by NRC regarding the safety of the turbine building during an SSE. This report documents the testing undertaken at the LACBWR site between July 14 and 18, 1980, to provide substantiation for the predictions made by D&M and also to assess the liquefaction potential under the [illegible]

2.0 FIELD TESTING

Question 2-d of the NRC Review Questions required that site-specific Standard Penetration Test data be provided to verify the predicted surface conditions under the developed area of the LACBWR site. Five potential boring locations were identified and evaluated in Reference 15. Upon agreement with NRC, four borings were actually drilled, at the locations indicated on the Plot Plan, Plate 1.

Procedures followed in the test boring program were as provided in the Project Plan submitted to DPC and NRC on July 3, 1980 (Ref. 16). The two borings in the truck bay at the northwest corner of the turbine building (DM-12 and DM-13) were drilled through the surface concrete slab by an Acker Ace skid-mounted rig, using the rotary wash method. Both borings extended to a depth of [illegible] feet below grade. DM-14 and DM-15 were drilled through the 4-foot foundation slab of the chimney by a Mobile B-61 truck-mounted rig and the Acker Ace skid rig, respectively. Both of these borings were advanced to 51 feet below ground surface. (The smaller skid rig-Acker Ace had to be used for drilling DM-12, 13 and 15 because the test holes were inaccessible to the truck-mounted drill rig.)

Borings DM-14 and DM-15 were carefully located between piles under the chimney slab in order to show the densifying effect of driven piles. DM-15 was placed between the chimney and reactor containment vessel so that the blow counts would be expected to reflect the influence of the reactor piles below about 30 feet. DM-13 was located within several feet of an isolated group of 7 piles in the turbine building truck bay, but its proximity to the group was [illegible] obstructions at the surface. DM-12 was located between isolated pile groups and was not expected to reflect any influence from driven piles.

Once soil was encountered below the concrete in each boring, Standard Penetration Tests (SPT) were performed at 5-foot intervals in accordance with ASTM Procedure D1586. Care was taken to [illegible] testing, using a flexible unlubricated rope wrapped twice around the cathead. The soil samples were retained for limited laboratory testing [illegible] classifications. Each hole was grouted to the surface [illegible] completion of the boring.

3.0 ANALYSIS AND DISCUSSION

As discussed in previous reports, one of the approaches to analysis of liquefaction potential is a simplified empirical one of correlating blow counts to those at sites whose past performance during earthquakes is known. Evaluating the blow counts from the SPT's in the 1980 borings yields factors of safety much greater than 1 for all depths of concern, as shown in Plates 3, 4 and 5. These plots show a line representing a factor of safety of 1 at each depth under a ground surface acceleration of .12g from a local earthquake, according to Seed's simplified procedure (Refs. 6, 13, 17).

It should be noted that the low blow counts obtained at depths of 20 to 25 feet in some of these and previous borings were in a non-liquefiable layer of sandy silt. (Percent finer than a #200 sieve is typically between 40 to 60 for these silts. Representative particle size curves are shown in the appendix.) The above fact was presented in all our earlier reports, but was not strongly emphasized. Because of the high percentage of fines these silts are considered nonliquefiable.

In the March, 1980 Response (Ref. 13) an estimate of increased soil density resulting from the driving of piles under the reactor was quantified. While these estimates could not be directly verified without drilling under the reactor containment itself, the effect of the piles below the reactor can clearly be seen in the dramatic increase in blow counts beginning about 40 feet below grade in DM-13. The high N-values in DM-14 as compared to nearby free-field borings also indicate the densifying influence of driven piles. Although these two borings showed the influence of the piles under the chimney rather than the reactor, it can be concluded that a similar effect and probably better conditions exist under the reactor and other structures supported by driven piles.

4.0 SUMMARY AND CONCLUSIONS

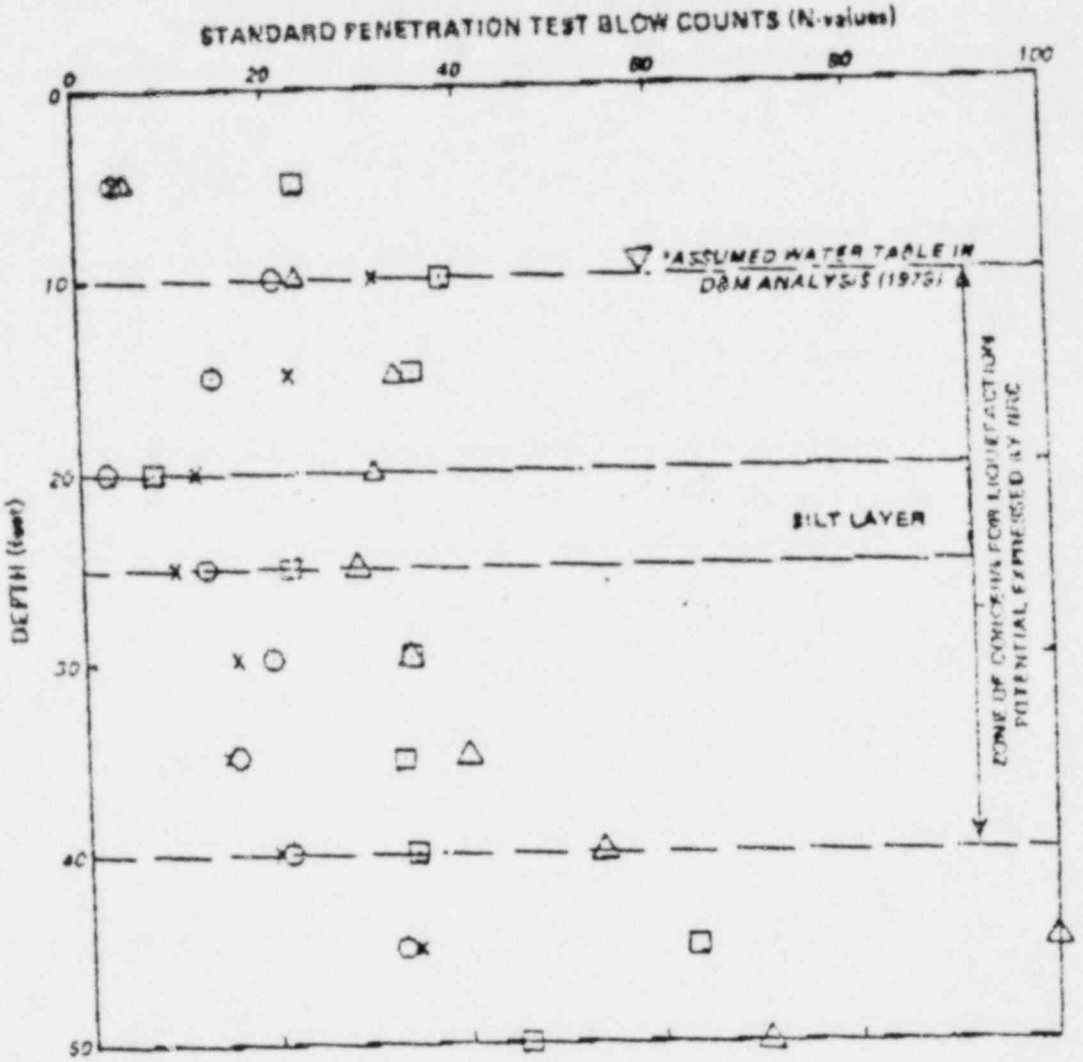
In 1973, 1978, 1979 and 1980 D&M has performed extensive studies of the geology, seismology, and liquefaction potential at the LACBWR site. Each of these studies yielded essentially consistent conclusions that the site was safe against liquefaction under the designated SSE. Summaries of the conclusions of each study are given below.

In 1973, as part of LACBWR application for an operating license, D&M made a study of geology and engineering seismology, investigated static and cyclic soil properties and evaluated liquefaction potential (Ref. 1). The study concluded that the SSE should be a MM Intensity VI shock with its epicenter near the site and that the associated maximum horizontal ground surface acceleration would be less than .12g. An analysis of liquefaction potential indicated a factor of safety greater than about 1.47 for an induced ground motion of ten significant stress cycles.

In 1979 D&M undertook a review of the liquefaction potential (Ref. 4) in response to NRC's Systematic Evaluation Program. It was concluded that although the 1973 report was consistent with state-of-the-art of the time, it was appropriate at this time to make some modifications. The reevaluation of the 1973 data resulted in a minimum factor of safety against liquefaction of 1.45, which compared closely to that calculated in 1973. It was also recommended at this time that a limited program of undisturbed sampling and cyclic triaxial testing be undertaken to substantiate earlier conclusions.

Such a sampling and testing program was implemented and was documented in the D&M report of September 28, 1979 (Ref. 6). Using three approaches to liquefaction--one of sophisticated testing and analysis, one of empirical correlation to past performance at other sites, and a semi-empirical one based on laboratory case histories--all yielded factors of safety greater than 1.0 for a surface acceleration of .12g. (D&M weighted most heavily the analysis-testing approach which yielded a minimum factor of safety of 1.45.)

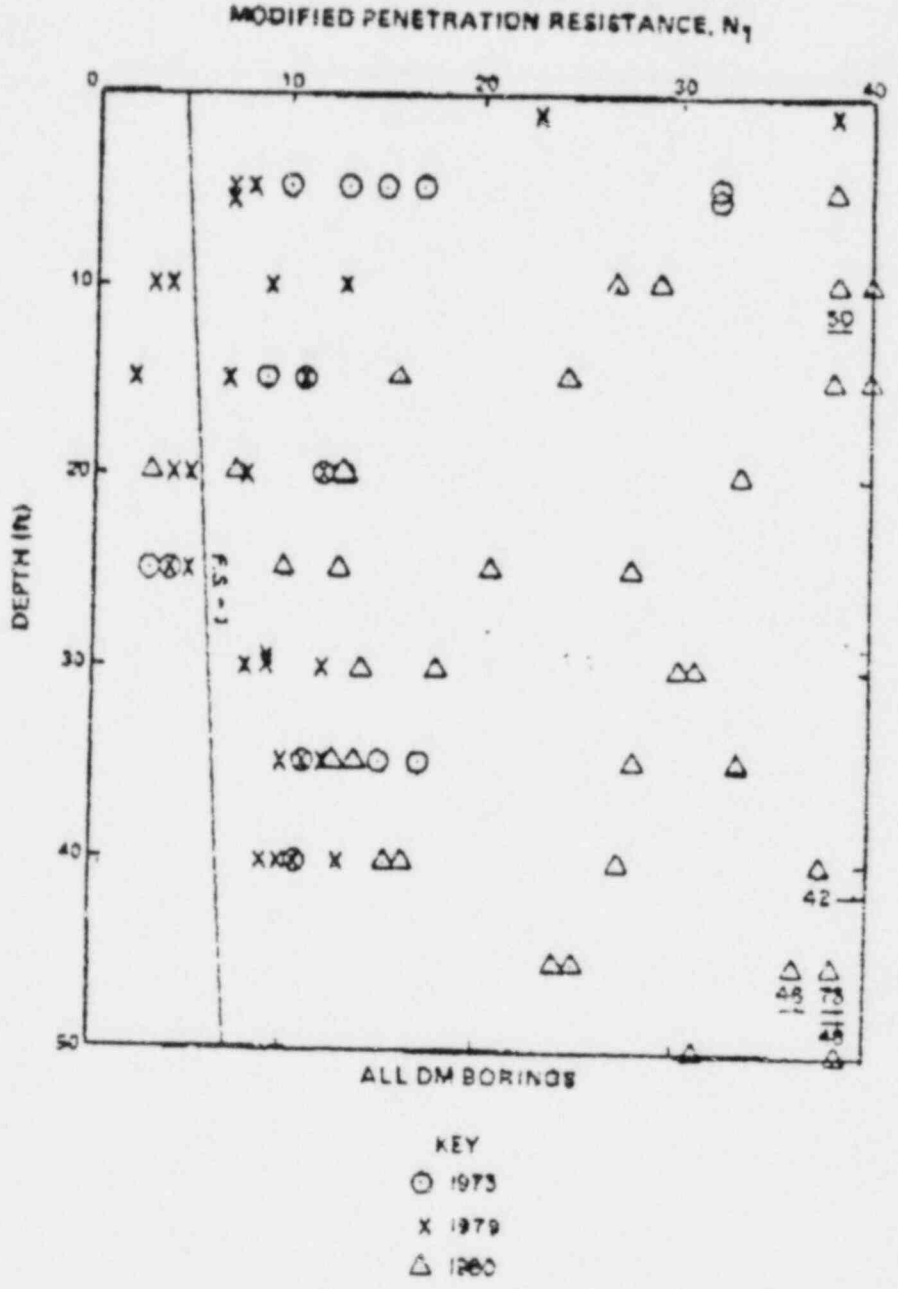
An independent review of the D&M conclusions was performed in September, 1979, by Dr. H.B. Seed of the University of California at Berkeley. His conclusion was that the site was safe against liquefaction during a local earthquake producing a peak horizontal surface acceleration of 0.12g with ten significant stress cycles of shaking.



*WATER TABLE DEPTH VARIED BETWEEN 8 TO 12 FEET BELOW GRADE IN 1973. DURING THE RECENT TEST BORING PROGRAM THE WATER TABLE WAS ABOUT 14 FEET BELOW GRADE.

KEY:
DM-12 ×
DM-13 ○
DM-14 □
DM-15 △

VARIATION OF PENETRATION RESISTANCE WITH DEPTH, ALL 1990 BORINGS



VARIATION OF MODIFIED PENETRATION RESISTANCE WITH DEPTH