SEISMIC CONFIRMATORY PROGRAM

FOR

EQUIPMENT AND COMPONENTS

VIRGIL C. SUMMER NUCLEAR STATION

South Carolina Electric & Gas Co.

September 24, 1982

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I. INTRODUCTION

In its Partial Initial Decision (PID) dated July 20, 1982 (Docket No. 50-395 OL) in the matter of South Carolina Electric and Gas Co. et al. (Virgil C. Summer Nuclear Station, Unit 1), the Atomic Safety and Licensing Board (ASLB) required two licensing conditions to be met by the Applicants. The first is a requirement to continue seismic monitoring. The second condition involves a confirmatory program on plant equipment and components, to ensure seismic safety during shallow reservoir-induced earthquakes.

Additionally, as a result of Advisory Committee on Reactor Safeguards (ACRS) meetings held in early 1981, there is also a commitment of the Licensees (contained in a letter from T.C. Nichols to H.R. Denton, dated 4/15/81) to continue seismic margin analysis for equipment and components necessary for continued heat removal. At the time of the ACRS commitment, the response spectrum of concern was the ML 4.5 response spectrum proposed by the Licensees for the Monticello Reservoir Induced Seismicity (RIS). This spectrum (ML 4.5) applies to normal depth RIS

The procedures and analyses described herein constitute the Licensees' program to satisfy the ASLB licensing condition. This program will also provide information useful for meeting the ACRS commitment.

The confirmatory program consists of three steps which logically follow from the PID referenced above. In that PID, the ASLB specified the spectral envelope of ground motion recorded at the Monticello Reservoir dam abutment instrument as an adequate and conservative representation of motion for shallow reservoir-induced earthquakes.

The first step in the program is to determine the effects which the soil-instrument pad system have had on the recorded ground motion. This experiment and analysis is described below in Section III, "Pad Response Test." The result will be a spectral envelope which represents free-field soil-surface conditions (without pad amplification) equivalent to the instrument pad motion spectrum envelope specified in the PID.

The second step consists of investigating and determining the reduction of ground motion from the free-field soil surface condition to the foundation level of large structures at the plant. This reduction may be attributed to soil, embedment, massive foundations, and other effects. Two lines of investigation will be pursued to determine this reduction. First, data from the 1981 active field experiment will be re-analyzed to quantitatively answer questions raised at the ASLB hearings regarding that experiment and the inferred reduction of ground motion therefrom. This re-analysis is described below in Section IV-A, "Analysis of 1981 Data." Second, an additional field experiment will be designed and performed to demonstrate and quantify soil-structure interaction* (SSI) and its effect on reducing high frequency ground motion. This is described below in Section IV-B, "Additional SSI Experiment." The result of these tests and analyses will be a quantitative procedure to compute the reduction of ground motion from the free-field (at the soil surface) to the foundation level of the nuclear plant structures. This procedure will be applied to the free-field spectral envelope (determined in Section III) to calculate a spectral envelope representing ground motion at the basement of plant structures for the maximum shallow reservoir-induced earthquake.

The third step in the confirmatory program is to examine the effects of shallow reservoir-induced earthquake motion on plant equipment and components necessary for cold shutdown. This step is described below in Section V, "Equipment Safety Margin Analysis." If the Virgil C. Summer Nuclear Station SSE ground motion spectrum is not exceeded by the calculated shallow reservoir-induced earthquake at the foundation level, no further analysis is required. If the SSE spectrum is exceeded, all designated components and equipment will be examined in detail to ensure that adequate safety margins exist.

The schedule for completion of this confirmatory program is described below in Section VI. This schedule allows adequate input to the program by the NRC staff, time for review of the results, and assurance that the program will be completed in time to meet the conditions of the ASLB Partial Initial Decision.

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*The term "soil-structure interaction" is used here in the sense of a large, rigid structure embedded in soil rather than the usual sense of a large structure founded on soil.

II. GUIDELINES OF ASLB FINDINGS ON SEISMICITY

License condition 25 states that:

> "During the first year of operation, SCE&G shall successfully complete the confirmatory program on plant equipment and components within the guidelines established in the findings contained in the ASLB Partial Initial Decision dated July 20, 1982, to demonstrate to the NRC staff's satisfaction that explicit safety margins exist for each component necessary for shutdown and continued heat removal in the event of the maximum potential shallow earthquake".

The program described in this document, as outlined above in the Introduction, meets the guidelines established in the PID. Relevant details of the PID, and the manner in which they are satisfied by the Licensees' program, are described below.

Response Spectrum Envelope

For earthquakes (including reservoir-induced events) occurring at normal tectonic depths, "Applicants and Staff have demonstrated that there will be no damage to the nuclear plant structures or equipment from a maximum magnitude earthquake occurring at normal tectonic depths" (Find. 113 at 72). For shallow reservoir-induced seismicity (RIS), the Board finds that the envelope of response spectra from data already recorded at Monticello is a reasonable and conservative designation of the largest ground motion (Find. 86 at 59). This envelope represents motion at the soil surface at the dam abutment (Staff Sup. Test. foll. Tr. 5758 at 44 as referenced in Find. 86 at 59). The Licensees use this envelope of ground motion, as designated, as the starting point for their analyses.

Pad-Soil Interaction

The Board finds that amplification of recorded motions due to accelerometer pad-soil interaction was "unlikely" (Find. 49 at 43-44) and not demonstrated (Find. 112 at 71) by testimony presented in the hearings. However, the Board does not rule that this effect is impossible, nor that, in principle, it is improper to consider this effect in determining appropriate reductions of recorded ground motion.

The Board does rule out the use of evidence adduced in the proceeding to quantify any amplification of ground motion due to pad-soil interaction. Accordingly, the Licensees will not rely on results from the pad experiment conducted in January, 1982, and reported at hearings during January 11-16, 1982.

The Licensees will conduct new tests to examine pad-soil interaction and to quantify the effect of that interaction on the records obtained, if appropriate. The purpose is to estimate a "free-field" (without pad-soil interaction) ground motion envelope (for the soil surface) from the envelope specified by the Board, which was obtained from recc.dings on an instrument pad on soil. The pursuance of such tests and results by the Licensees is within the guidelines established by the Board, i.e., the tests and results are not specifically disallowed (although the Board finds that any potential effect is unlikely, as noted above).

Embedment and Foundation Effects

The Board finds it likely that motion in the nuclear plant structures will be reduced from the free-field motion (Find. 49 at 43-44, Find. 87 at 59, Find. 112 at 71, Find. 115 at 72-73). The reasons for this are scattering of waves and rigidity of the foundations (Find. 112 at 71), embedment of structures on rock (Find. 49 at 43-44), and effects of rock-foundation interaction (Tr. 5609 referenced in Find. 49 at 43-44). The Board specifically disallows the use of evidence adduced in the proceeding to establish amplification factors for recorded ground motion due to soil, topography, and pad-soil interaction (as discussed and referenced above).

The first part of the Licensees' program to determine embedment and foundation effects is described below under "Analysis of 1981 Data". Although these data (previously referred to as explosion test data) were presented in the ASLB hearings, this analysis falls within the guidelines established in the PID. That is, the Board accepted the explosion tests as tending to show the effects of embedment, wave scattering, foundation rigidity, and rock-foundation interaction (as referenced in the preceding paragraph). Our analyses will examine the effects by comparing free-field motion to foundation motion. The effects of soil on the motion are unlikely (Find. 40 at 43-44), at least at high frequencies. The primary purposes of analyzing these data are (a) to answer questions raised in the proceeding about foundation motion reductions demonstrated by the 1981 data, and (b) to provide confirmatory results for new tests to be conducted. Both purposes are within the scope of the confirmatory program outlined by the Board.

The second part of the program for embedment and large foundations is the collection and analysis of new data, described below under "Additional SSI Experiments". This will directly address the reduction factors appropriate to quantify foundation motion, for the reasons found likely by the Board (as referenced above).

Equipment Analysis

The analysis of equipment safety margins to be conducted by the Licensees responds directly to the Board's description of the confirmatory program (Op. at 15, Finding 115 at 72-73).

Summary

The ASLB Seismic Confirmatory Program entails tests and analyses within the guidelines described by the Board in its PID. The successful completion of this program will ensure that License condition 25 regarding seismic safety margins will be met.

III. PAD RESPONSE TEST

Objectives

The objectives of the Pad Response Test are to: (1) quantify the interaction between the instrument shelter (concrete pad and wooden hut) and the foundation soil at the Monticello Reservoir dam abutment SMA-1 accelerograph station, and (2) determine the effect of this interaction on the earthquake motions recorded at this station, by comparing the response spectra for the accelerations recorded on the pad with the response spectra for the computed free-field accelerations.

Background

In January 1982, the firm of Stoll, Evans, Woods and Associates conducted plucking tests on the concrete pad at the SMA-1 accelerograph station to determine the natural frequencies of the soil-pad system. Their results showed coupled rocking and translational motion in both EW and NS horizontal directions. Whereas, there was some uncertainty in distinguishing between rocking and translational degrees of freedom, it was judged that the predominantly rocking modes had natural frequencies of 18-20 Hz and 12 Hz in the EW and NS directions, respectively. The predominantly translational mode had similar natural frequencies between 40 and 50 Hz in each direction.

These results suggested that soil-pad interaction may have significantly influenced the earthquake motions recorded by the SMA-1 accelerograph, which is bolted to the concrete pad. This conclusion was based on the observation that the natural frequencies measured during the plucking tests were in the frequency range where significant energy is contained in the SMA-1 accelerograms. However, additional field tests can be used to accurately quantify this interaction. The most reliable field tests for this purpose are forced vibration tests of the pad. In these tests eccentric-mass shakers will be used to provide harmonic excitation to the pad over a frequency range of 1 to 60 Hz. Accelerometers placed on the pad will measure the amplitudes and phases of the horizontal and vertical motions. These measurements will be used to determine the frequency-dependent transfer functions between the applied forces and measured translational (NS, EW, and vertical) and rocking accelerations. These transfer functions and the recorded earthquake motions will in turn be used to estimate the free-field ground motions and corresponding response spectra.

Technical Approach - Pad Response Test Program

The vibration generation equipment to be used for the pad-response test consists of an eccentric mass shaker capable of producing force levels similar to those experienced by the pad during the recorded earthquakes. To determine the frequency-dependent transfer functions for coupled translation and rocking response, two independent forced-vibration tests are required for each horizontal direction, that is in the NS and EW directions (see Appendix A for theory).

For one test in the NS direction, for example, an MK-12 eccentric mass shaker will be mounted on the top of the pad over the center of gravity (c.g.) and will excite the pad with a unidirectional NS horizontal harmonic force at a fixed frequency. The coupled translational and rocking motions will be measured with triaxial accelerometer packages (either strain gauge or piezoelectric) placed at the corners of the pad. The tests will be repeated over a range of frequencies from 1 to 60 Hz. Although the applied force will vary directly as mef^2 (m = mass of eccentric weight; e = eccentricity; f = frequency), roughly constant force levels will be maintained by adjusting the eccentricity. The MK-12 shaker weighs 70 pounds and is about 1 cubic foot in size. It can be easily positioned to produce vector forces in any direction. The amplitudes and phase angles of the applied forces and resulting accelerations will be recorded on magnetic tape and strip chart recorders. The strip chart data will be used to monitor the results during the course of the testing to ensure that the equipment is performing properly and the test results are reasonable.

For the other independent test, the shaker will be moved from over the c.g. to a point about half way between the c.g. and the end of the pad. The shaker will then be oriented to produce a force in the vertical direction. This will induce a moment to the pad, and the coupled rocking and translational motions will be measured in the same manner as in the first test.

A further test will be required to determine the frequency-dependent transfer functions for vertical response. Theoretically, the second test described above would also provide response data to determine the vertical transfer functions. However, because of the asymmetric stress distribution that will result beneath the pad during this test, the shaker will be placed over the c.g. for the vertical test.

Three confirmation tests, one for each direction (NS, EW, vertical), will be conducted to verify the experimental results. One confirmation test will consist of repeating the test where the shaker provides a vertical eccentric force. However, in the verification test, the shaker will be moved to the same location on the other side of the c.g. Through a comparison with the original vertical eccentric force test, this test will also indicate the effect, if any, of the asymmetric stress distribution beneath the pad.

The entire test procedure described above (comprising a total of 8 tests) will be repeated twice: first at low force levels and then at high force levels comparable to those the pad experienced during the earthquakes. The results of the two tests will indicate whether or not non-linear response is significant.

In addition to the pad-response measurements, other quantities are also required: (1) the dimensions, density, mass, moment of inertia and location of the c.g. of the pad, (2) the location of the applied force within the MK-12 shaker, (3) the heights of the transducer elements within the SMA-1 instrument that recorded the earthquake ground motions, and (4) the heights above the pad of the accelerometers recording the motions generated during the vibrations tests. All of these quantities can be measured directly, obtained from specification sheets, or computed.

Analysis and Results

The field-test data will be used to determine the transfer functions between the applied harmonic forces and measured responses. The frequencies where predominant peaks occur in the modulus of these transfer functions are the natural frequencies of the soil-pad system. The modal damping ratios will be estimated from the peaks in the response curves. Likewise, mode shapes and participation factors will be computed.

The theoretical free-field earthquake motions can be computed by two methods. The first and most direct approach involves the deconvolution in the frequency domain of the accelerograms recorded by the SMA-1 instrument through the measured transfer functions. The inverse Fourier Transform gives the free-field motions input to the pad in the time domain. The second approach involves the straightforward use of the modal quantities (natural frequencies, dampings, mode shapes, and participation factors). Both approaches are well founded theoretically. The first approach, which will be the prime analysis tool, has the advantage of preserving all the information at each frequency. The second approach offers simplicity and will be utilized to check the first approach.

The response spectra of the theoretical free-field accelerograms will be computed and compared to the response spectra of the recorded motions. The response spectra computation will be carried out to 50 Hz for 2, 5, and 10 percent critical damping.

The ratio of the recorded spectra to the free-field spectra will indicate the influence of soil-pad interaction on the recorded earthquake motions.

IV. EXPERIMENTAL SOIL STRUCTURE INTERACTION (SSI)

A. Analysis of 1981 Data

Objectives

A re-analysis of the data obtained from the 1981 active field experiment will allow calculation of Auxiliary Building foundation to free-field Fourier spectral ratios for different wave types (P, S, and Rayleigh) from the seismograms recorded for Test #1.

Background

The analysis of the 1981 active field experiments presented in Applicants' Additional Seismic Testimony considered Fourier spectral ratios of the whole records, rather than of isolated wave types. In the January 11-16, 1982, ASLB hearing, Board witness Trifunac testified (Tr 5716) that the fundamental Rayleigh wave mode shape "could be very significant to the entire explanation for this reduction we see in the building" in comparison with the free-field. On rebuttal, Applicants' witness Alexander testified (Tr 5992-5994) that the observed reductions are comparable for the P-wave train and for the train of S waves, higher mode and fundamental mode surface waves, so that the reduction cannot be attributed entirely to the decrease with depth of the fundamental mode Rayleigh wave amplitude as claimed by Trifunac. Alexander also testified that, in any case, explosive tests reported in FSAR Section 2.5.4.4.4 indicate that fundamental mode waves are not generated to any observable extent by explosions in the Monticello Reservoir area. Further analysis of the 1981 active field experiment data is expected to confirm these points.

Technical Approach

The Test #1 signals can be decomposed into wave types by discriminating on the basis of particle motion and arrival time. Existing information on the seismic velocity-depth structure of the Monticello Reservoir region will assist interpretation of the seismograms.

(Note that Test #2 was not recorded in the Virgil C. Summer Nuclear Station: accelerograms recorded on the foundation of the Fairfield Pumped Storage Facility in Test #2 cannot be processed due to poor signal/noise ratio.)

Tasks

Tasks required to demonstrate free-field to building reduction of ground motions are:

1. Decompose Test #1 signals by wave type.
2. Compute Fourier transforms of the decomposed signals.
3. Compute Auxiliary Building foundation/free-field Fourier spectral ratios, and compare the results for different wave types.

Results

The results will be presented as Auxiliary Building foundation/free-field Fourier spectral ratios by wave type. As before (in Applicants' Additional Seismic Testimony), the spectral ratios are ratios of Fourier amplitude rather than complex transfer functions. Spectral ratios for different wave types will be compared.

B. Additional SSI Experiments

Objectives

Active field experiments will be performed at Monticello Reservoir to record seismic motion in foundations of the Virgil C. Summer Nuclear Station (VCSNS), at an array of free-field stations, and on the USGS accelerograph pad at the dam abutment.

Foundation to free-field Fourier spectral ratios for whole records and for different wave types (P, S, and Rayleigh) will be calculated.

As an end result, accelerograms and corresponding response spectra for VCSNS building foundations will be computed by filtering free-field accelerograms of recorded events (which are obtained by deconvolution of USGS accelerograms recorded on the dam abutment pad, as described in Section III).

Background

The 1981 explosion tests were designed primarily to investigate the possibility of anomalous site response at the USGS accelerograph station on the dam abutment. (Note that in these experiments seismometers were installed close to, but not on, the USGS accelerograph pad at the dam abutment.)

In addition to an array of free-field recordings near the dam abutment, records were obtained in the Auxiliary Building basement for Test #1 and in the Fairfield Pumped Storage Facility basement for Test #2. In both tests there were significant reductions in the high frequency foundation motions (above 5 Hz in the case of Test #1) relative to free-field motions recorded at equal distances.

Technical Approach

An array of 3-component seismographs will be deployed in the VCSNS foundations and in the free-field (at distances greater than three times the overall dimensions of the VCSNS foundations). The signals can be decomposed into wave types by discriminating on the basis of particle motion and travel time.

Having considered explosives, VIBROSEIS (Continental Oil Co. trademark), and pile-driver as possible seismic sources for additional testing, it appears that the optimum source would be a pile-driver. This option is as good as or better than the others in terms of source bandwidth, flexibility of location, ease of signal stacking to enhance signal/noise ratio, ease of data acquisition (including repeatability), analysis, interpretation, and logistics. A steel pile capped with steel disks at either end will be driven down to the granite bedrock. Repeated impacts on the pile will produce very limited further penetration of the pile due to rock crushing, so the pile driver will serve as an ideally repeatable seismic source. The pile driver source will permit essentially unlimited signal stacking to enhance signal/noise ratio, a major consideration for recording in the VCSNS foundations. A numerical experiment to illustrate signal/noise enhancement by signal stacking is shown in Figure 1. A synthetic signal is summed with random noise, with signal/noise ratio of 1/2. The lower two traces show results for 16 and 64 stacks, illustrating $\sqrt{N}$ signal/noise enhancement. To enable signal stacking in the field tests, a radiotelemetry link will be used to transmit a synchronization signal from a geophone at the pile driver to the recording station.

Two source location and array configurations are envisaged for the experiments. For one (Test #3) the free-field stations are arrayed on an arc symmetric about the nuclear plant, while the other (Test #4) has a more distant source location equidistant from the VCSNS and the USGS accelerograph station on the dam abutment. For Tests #3 and #4, seismometers will be placed at foundation level or at elevations practicable in structures of three different foundation types: mat or fill concrete overlying bedrock, caissons through the saprolite to bedrock, and mat foundation on saprolite.

In an additional experiment (Test #5), a source location at the epicenter of the October 16, 1979, M_L 2.8 earthquake will serve to simulate wave propagation effects from that very shallow event to the dam abutment accelerograph site. For this experiment the free-field instruments will be arranged in a small-aperature array designed to assist data analysis by providing apparent velocity information.

Source locations for the 1981 Tests (#1, #2) and for the proposed new Tests (#3, #4, #5) are plotted in Figure 2 on the USGS quadrangle map. Proposed source and seismograph array configurations for Tests #3, #4, and #5 are shown in Figures 3, 4, and 5.

The instrumentation plan for the SSI experiments is described in Appendix B.

In addition to the seismograph array data, it may be possible to obtain usable signals from a down-hole accelerometer array recently installed near the Meteorological Tower. The array consists of two three-component digital strong-motion accelerometers (Kinemetrics DSA-1), one at the surface on saprolite and the other just below the bedrock interface at a depth of approximately 27 feet. The array was installed for the purpose of monitoring surface and bedrock motion for RIS events so that, should sufficient events be recorded, a surface/bedrock transfer function could be evaluated on a statistical basis for that site. The installation was not designed, and cannot be used, to resolve all of the wave propagation effects involved: surface wave mode shapes, body wave incidence angles, and reflection coefficients. Other corrections (such as for the free-surface effect) may be required to derive an equivalent motion representing the free-field rock surface.

Tasks

Tasks required for the additional field experiments are:

1. Select source and recording locations (see Figures 3, 4, and 5).
2. Examine source repeatability and signal/noise enhancement by stacking.
3. Conduct experiment and record data.
4. Decompose signals by wave type; for Test #5, analyze small-aperature array data.
5. Compute Fourier transforms.
6. For Tests #3 and #4, compute VCSNS foundation to free-field Fourier spectral ratios, and compare results for different wave types.
7. For Test #5, compare accelerograph pad to free-field Fourier spectral ratios with low-strain results from the accelerograph pad response test (Section II above).
8. By filtering free-field accelerograms (deconvolved from USGS accelerograms on the dam abutment pad), obtain corresponding accelerograms for VCSNS foundations, and compute their response spectra.

Results

Foundation to free-field Fourier spectral ratios will be computed for both whole records and separate wave type. These spectral ratios are ratios of Fourier amplitude rather than complex transfer functions: they will be used as zero phase filters of free-field accelerograms (deconvolved from USGS accelerograms on the dam abutment pad) to obtain corresponding accelerograms for the VCSNS foundations. Response spectra of these foundation accelerograms will be computed.

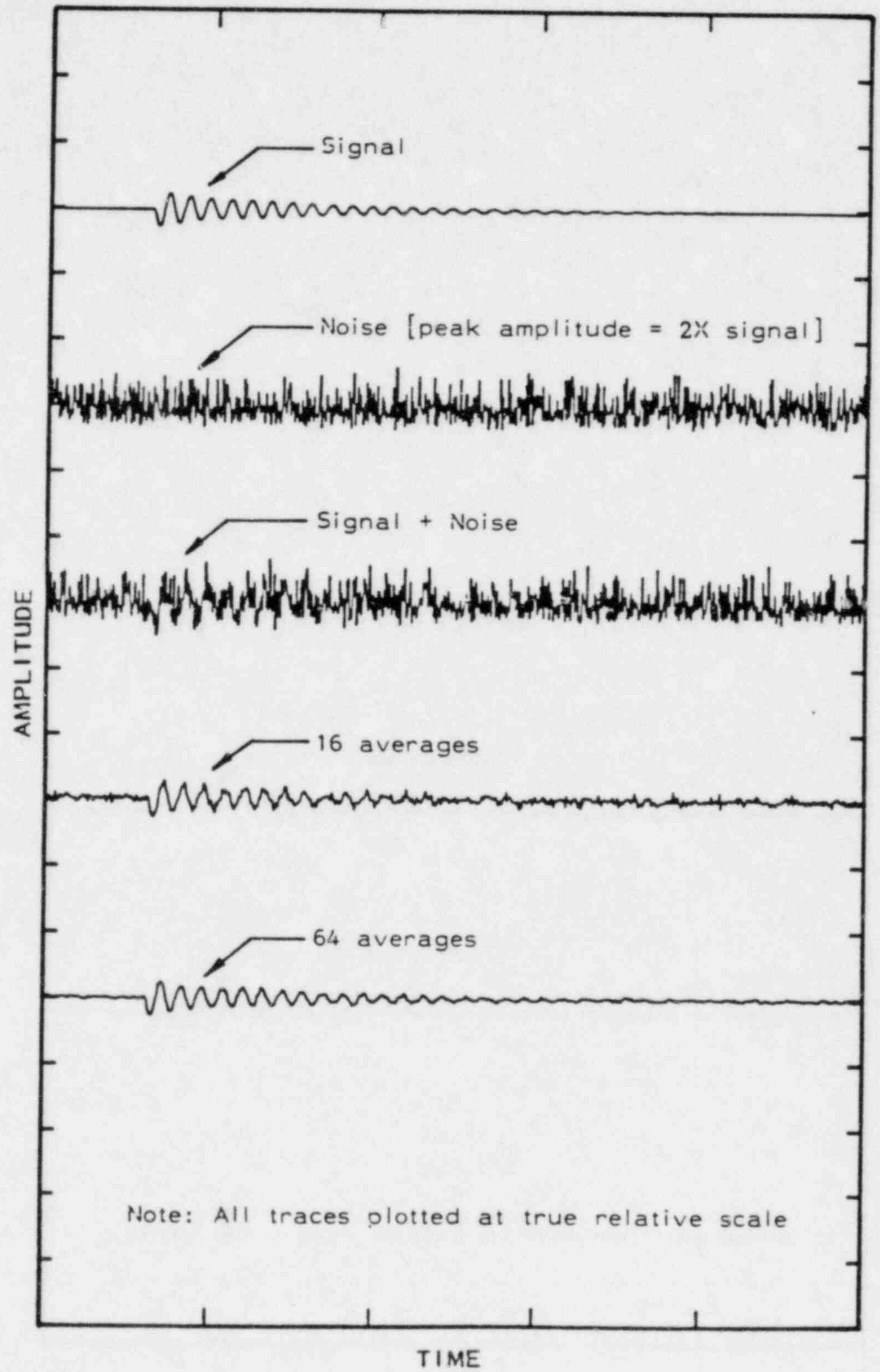

FIGURE 1
ILLUSTRATION OF RECOVERING SIGNAL FROM NOISE BY STACKING

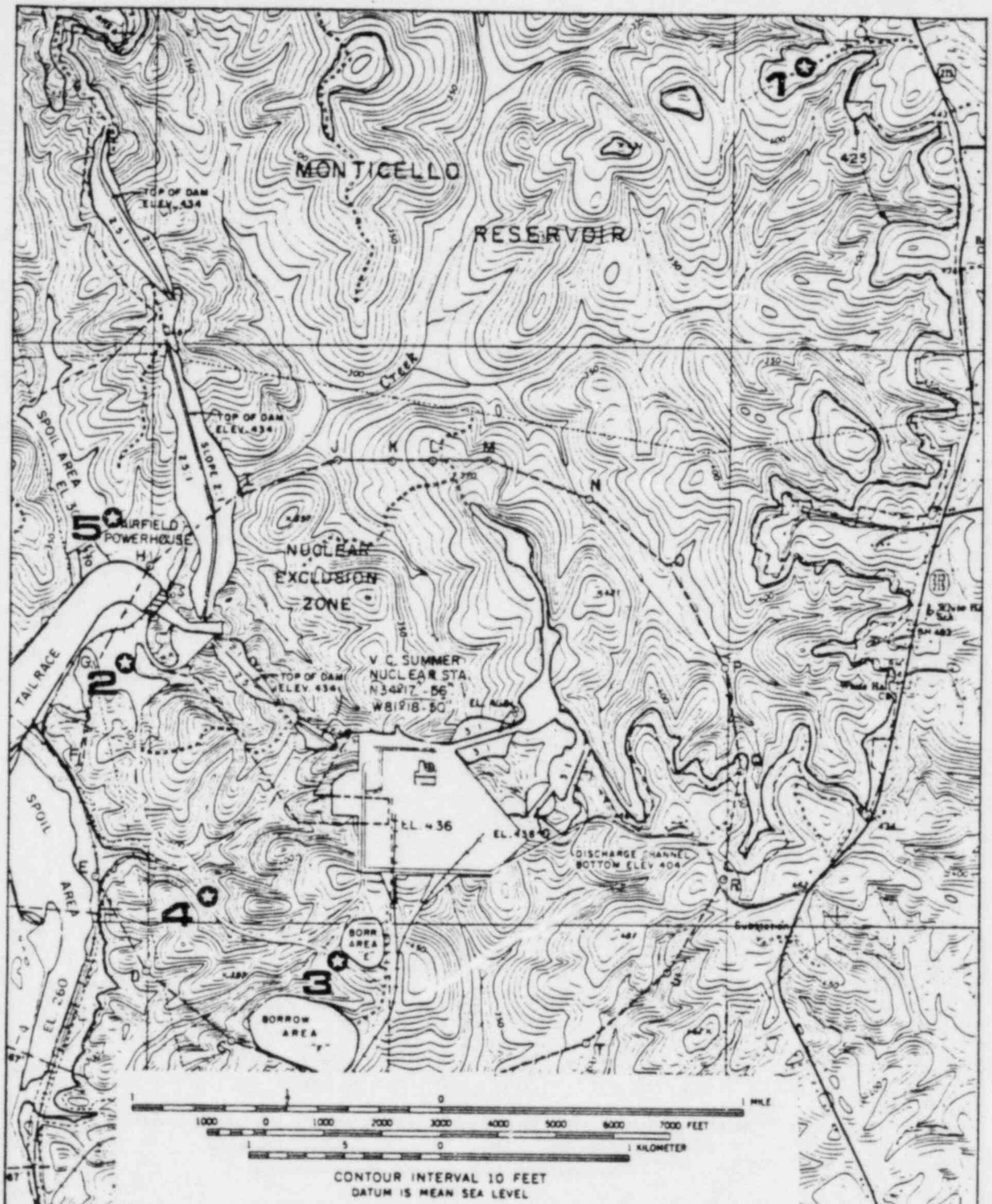

FIGURE 2
SOURCE LOCATIONS FOR 1981 EXPLOSION TESTS (1 & 2)
AND PROPOSED TESTS (3, 4 & 5)

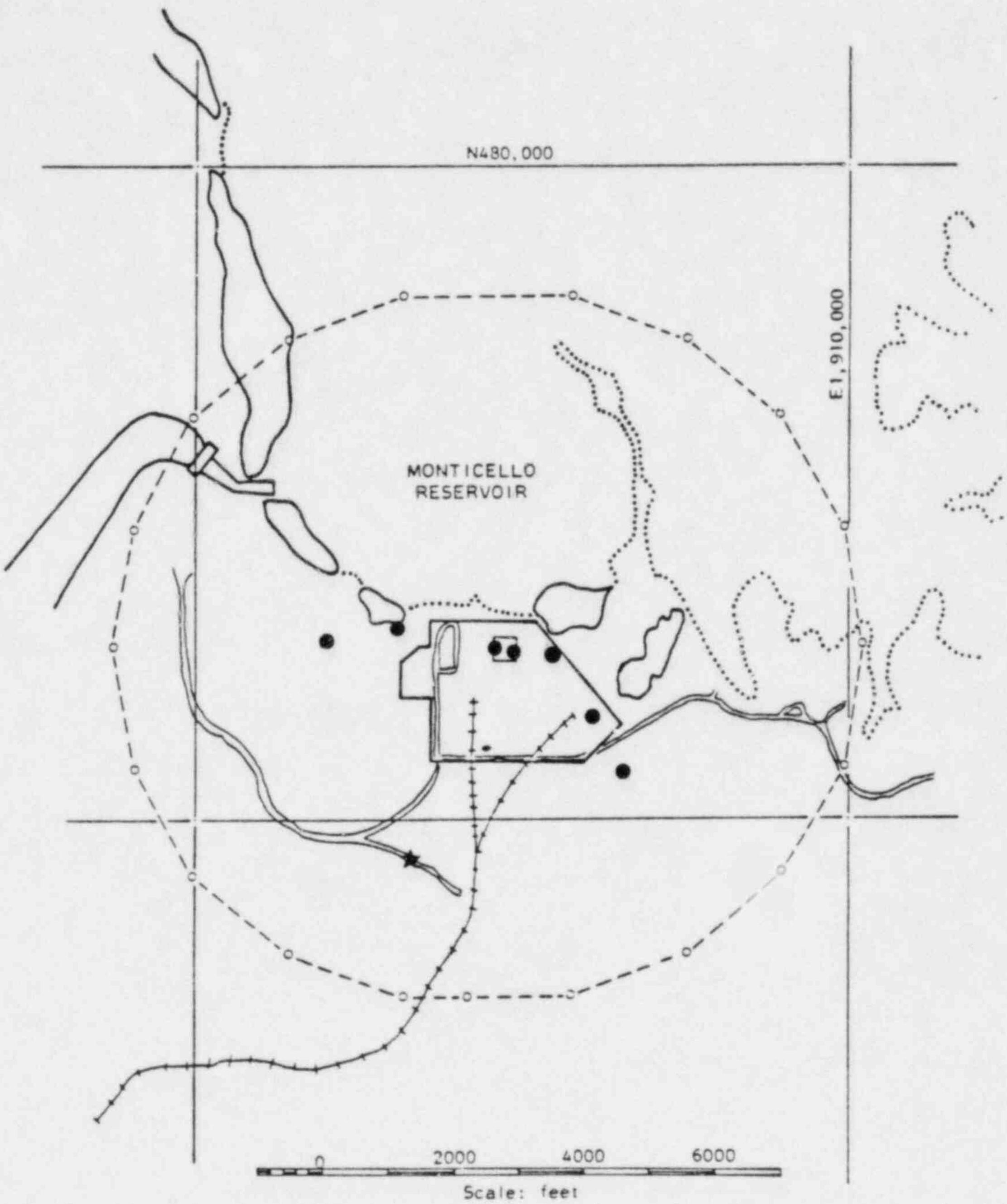

FIGURE 3
PROPOSED SOURCE [★] AND RECEIVER [●] LOCATIONS FOR TEST NO. 3

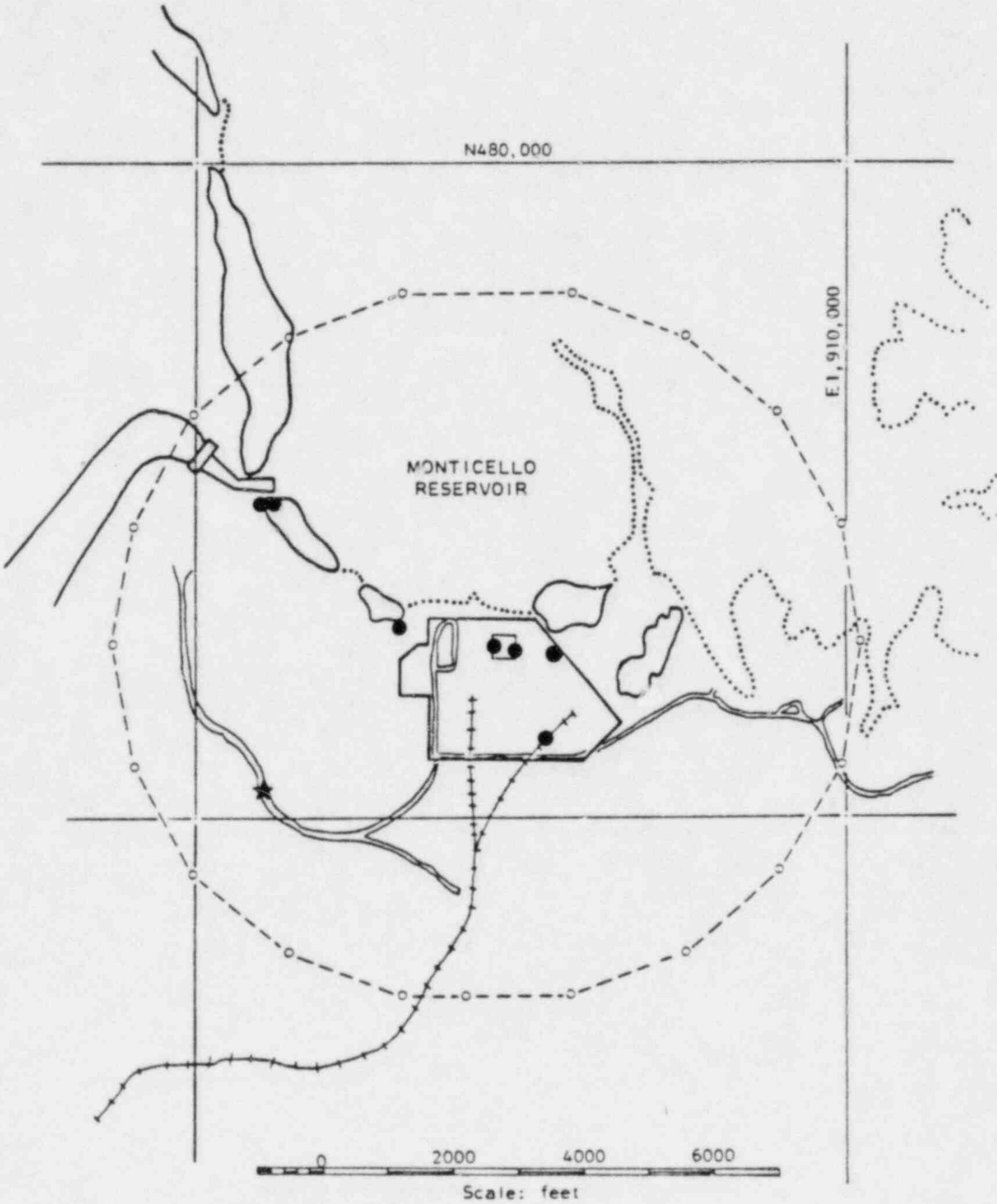

FIGURE 4
PROPOSED SOURCE [★] AND RECEIVER [●] LOCATIONS FOR TEST NO. 4

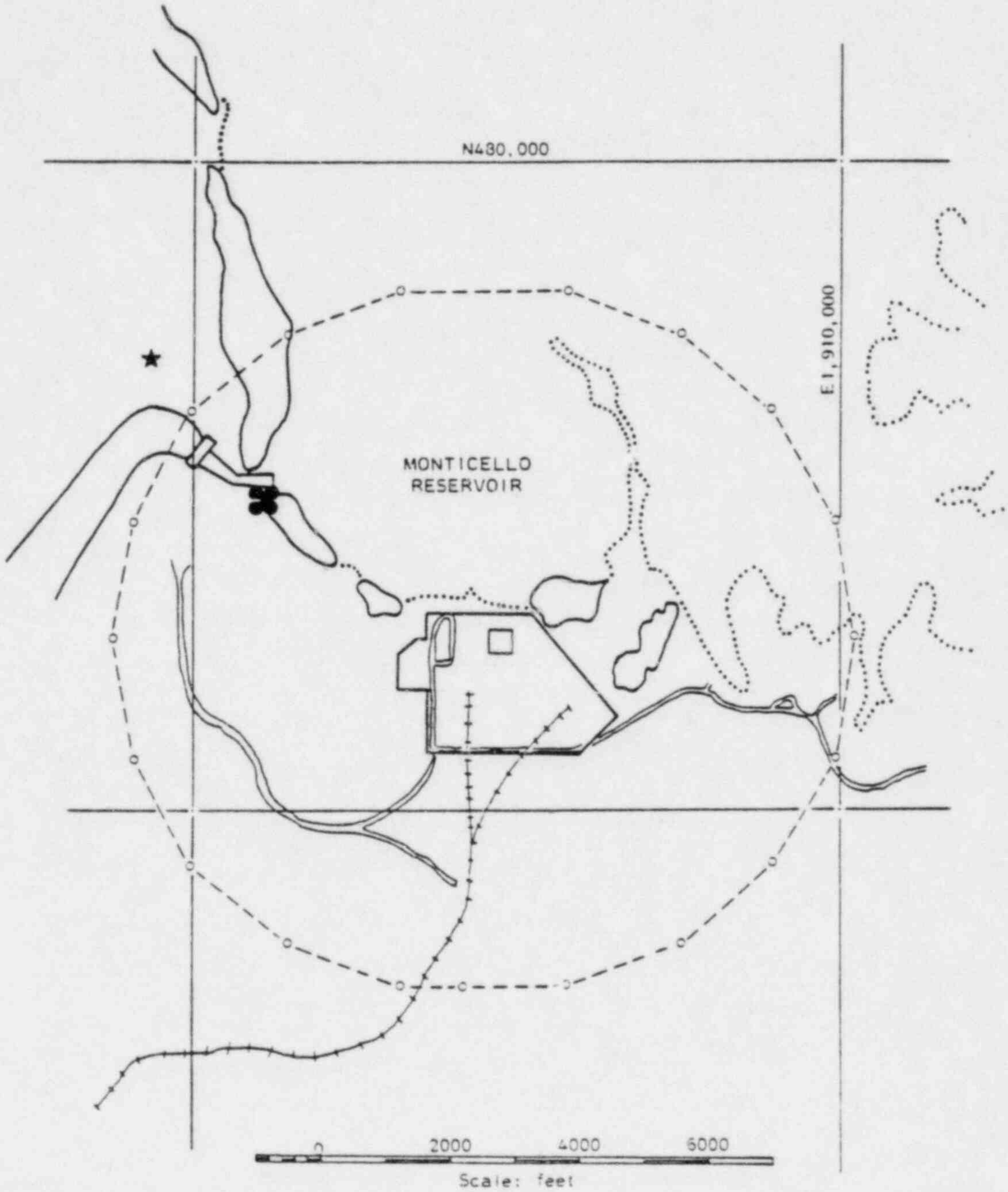

FIGURE 5

PROPOSED SOURCE [★] AND RECEIVER [●] LOCATIONS FOR TEST NO. 5

V. EQUIPMENT SAFETY MARGIN ANALYSIS

Objectives

The equipment safety margin analysis will demonstrate that essential equipment and components required for cold shutdown can perform their intended functions during and after the maximum potential shallow earthquake.

Technical Approach

The licensing condition requires that the maximum potential shallow earthquake be represented as ground motion at the dam abutment instrument pad by the envelope of ground motion recorded there since filling of the Monticello Reservoir. The results obtained from the pad response test (Section III above) will be used to obtain an equivalent free-field response spectrum representing the envelope of motion at the soil surface (without pad effects). The experimental soil-structure interaction (SSI) analysis (Section IV above) will be used to estimate a response spectrum envelope at the structural foundations. This foundation envelope spectrum will be compared to the Virgil C. Summer Nuclear Station SSE design spectrum. If the SSE spectrum is not exceeded, no further analysis is necessary because all safety-related equipment in the plant has already been qualified to the SSE design motion. If the SSE design spectrum is exceeded, floor spectra corresponding to the foundation's enveloping spectrum will be generated and compared to the SSE floor spectra. For equipment and components on floors where the SSE floor spectra are not exceeded, no further analysis is necessary. For equipment and components with dominant frequencies in the region where the SSE floor spectra <u>are</u> exceeded, equipment and components necessary for cold shutdown will be checked to ensure that adequate safety margins exist.

Tasks

Tasks required to complete the Equipment Safety Margin Analysis are as follows:

1. List all essential equipment and components required for cold shutdown.
2. Compare foundation envelope spectrum to the SSE design spectrum. Continue the Equipment Safety Margin Analysis only if the envelope spectrum exceeds the SSE spectrum.
3. Generate floor response spectra using ground motions representing the foundation envelope spectrum.
4. Compare floor response spectra with SSE floor response spectra.

5. Continue the following only for equipment and components on floors where the SSE floor response spectra are exceeded.

6. For safe shutdown equipment qualified by analysis:

   a. Identify dominant frequencies of each piece of equipment.

   b. If the dominant frequencies are outside the range where envelope-generated floor response spectrum exceeds the SSE floor response spectrum, no further analysis is required.

   c. If the dominant frequencies fall inside the region where envelope-generated floor response spectrum exceeds the SSE floor response spectrum, evaluate the reserve margin against allowable stress either by hand calculations or computer analysis.

   d. If the allowable stress is exceeded, the built-in conservatisms of allowable stress will be evaluated to determine the safety margins of components and equipment in performing their required functions for cold shutdown.

7. For safe shutdown equipment qualified by test:

   a. Compare the test response spectrum with the envelope-generated floor response spectrum. The equipment is qualified if the test response spectrum exceeds the envelope-generated floor response spectrum.

   b. If the resonance frequencies of the equipment are outside the region where the envelope-generated floor response spectrum exceeds the SSE spectrum, no further examination is required.

   c. If the fragility test data from the equipment vendor exceeds the envelope-generated floor response spectrum, no further examination is required.

   d. If the test response spectrum is exceeded and the fragility test data are not available, other methods of qualification will be pursued.

Results

This program will result in identified safety margins for all equipment and components required for safe shutdown and continued heat removal wherein the SSE is exceeded. Tables showing the equipment and components and their safety margins will be prepared and presented in the final report of this confirmatory program.

VI. SCHEDULE

A schedule for the ASLB seismic confirmatory program is shown in Figure 6. The bars on the figure denote time intervals wherein specific phases of the program are to be completed. Time blocks are provided for the design, performance, and analysis of experiments as well as suggested points for NRC review. The initial steps in the equipment safety margin analysis are already under way. The number of components and pieces of equipment to be examined is a function of the outcome of field experiments, as described above in Section V. In the schedule, a conservative amount of time is allotted for this analysis. The schedule for completion of the ACRS commitment has been established as first refueling after commercial operation of the Virgil C. Summer Nuclear Station.

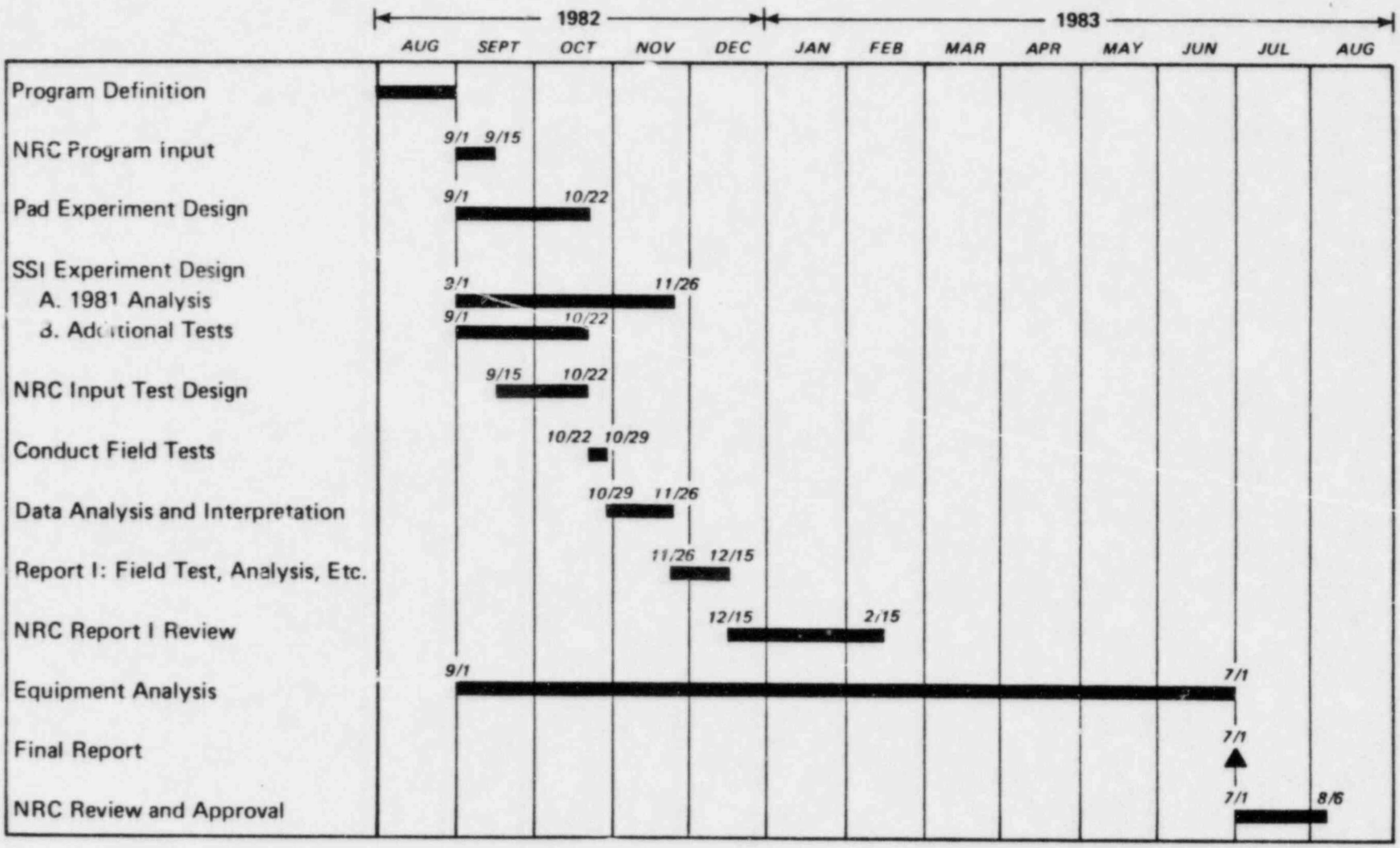

FIGURE 6
SEISMIC CONFIRMATORY PROGRAM SCHEDULE

VII. SUMMARY

The seismic confirmatory program outlined here is a comprehensive, multi-phase effort to satisfy the ASLB licensing condition. The program is designed to combine observational data with theoretical analysis to achieve an accurate engineering assessment of the several effects. The program is flexible and may be modified to reflect new data or methodology as necessary.

Key elements of the program are the quantified results of both the pad response test and the additional SSI tests. These are combined to produce a realistic transfer function for obtaining input motion for the foundation of the VCSNS from motion recorded at the accelerograph site at Monticello Reservoir. Equipment margin analysis will be based on comparison of the foundation envelope spectrum to the SSE design spectrum. The schedule includes target dates necessary for timely program completion. Additionally, this program will provide information useful for meeting the ACRS commitment.

South Carolina Electric & Gas Co. believes that completion of this program will result in satisfactory fulfillment of the licensing condition as required.