Department of Energy
Washington, DC 20585
September 3, 2004

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W., Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

The purpose of this letter is to provide the Department of Energy (DOE) program plan requested in your letter of July 29, 2004. The enclosed program plan is for reassessment of the predicted Hanford seismic ground motion, particularly related to resolving uncertainty in shear wave velocity at different depths under the Waste Treatment Plant. The program plan is structured to identify how each of the seven specific technical issues raised in the Staff Issue Report will be addressed.

As requested, DOE will provide a report to the Board upon completion of this work. The report will include the findings of the field studies, analysis of the field data, conclusions regarding the adequacy of the current Hanford ground motion criteria, and assessment of the impact, if any, on the design of WTP structures and components.

Thank you for the assessment of this important area. If you have further questions, please call me at (202) 586-7709.

Sincerely,

Paul M. Golan
Acting Assistant Secretary for
Environmental Management

Enclosure

cc:
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Program Plan for Analysis of Shear Wave Velocity Data to Address Uncertainties in Estimates of Hanford Ground Motion Waste Treatment Project

August 27, 2004

In a letter to the Department of Energy (DOE) dated July 29, 2004, the Defense Nuclear Facilities Safety Board (DNFSB) requested a Program Plan specifying how specific ground motion issues relating to the design of the Waste Treatment Plant (WTP) will be addressed. These issues are described in the DNFSB Staff Issue Report that was enclosed in that letter. Seven bulleted issues in the DNFSB report are repeated below, followed by a response that states DOE's plan to address them.

Issue #1: *Comparison of the geology and the intervening paleo-channel between the Integrated Disposal Facility (IDF) site and the WTP site; the overall thickness of soil (depth to bedrock); the thickness of individual soil layers (Hanford and Ringold formations); Vs for all layers (soil, basalt bedrock, sedimentary interbeds); and potential lateral variation in Vs.*

> **Response:** (Note: The response to Issue #1 will focus on the upper soil layers above basalt, while the response to Issue # 3 will focus on the basalt and interbeds).
>
> The detailed supra-basalt (sediment above the basalt) geology in the area surrounding and within the WTP site will be assembled and presented, using data from numerous boreholes that have been drilled and logged as part of the IDF site (adjacent to WTP) and other previous studies in the nearby area (see Figure 1). These data provide the thickness of each individual soil layer in the Hanford and Ringold formations, and depth to basalt bedrock, at numerous geographic locations surrounding and within the WTP site. Lateral variations in some of the lower sedimentary layers (Ringold formation), such as the paleo-channel that lies between the IDF site and the WTP site are known, but the sedimentary structures outside of this erosional channel are the same as those at the IDF and WTP sites, and addition to other nearby locations outside of this erosional channel. The paleo-channel does not affect the structure within the basalt sequence (see Figure 2).
>
> The IDF site is the location of the "shear-wave" borehole (SWVB, see Figure 3). This borehole was constructed at the location of an existing borehole previously logged for geologic information. Measurements of Vs (and Vp) were made from the surface to the top of basalt at 540 feet depth by a team of Redpath Geophysics and Northland Geophysics in June, 2004 using the downhole technique. To evaluate anisotropy, shear wave velocity measurement were made at four different shear-wave polarizations to detect whether anisotropy might contribute to the variability in Vs. To confirm the downhole measurement and to detect any

soft layer in between hard layers (Issue #2 below), the P-S logging technique was used by Geovision to log the velocity profile.

In addition to the borehole at IDF site, additional Vs velocity measurements were made at four other locations (Figure 3) surrounding the WTP site where borehole geologic control was available, to depths of about 300 feet (the depth that was accessible). This set of Vs measurements is currently being analyzed and a report is expected by August 30, 2004.

Another set of 10 Vs profiles will be produced for the area surrounding the WTP using the Spectral Analysis of Shear Waves (SASW) method by Ken Stokoe of the University of Texas, Austin, beginning August 30, 2004. These measurements will be made at the locations of the boreholes logged as described above, and at additional locations closer to the WTP (Figure 3). These data will be evaluated for consistency with the borehole data at those locations. Another SASW measurement will be made at a location 6 miles northwest of the WTP, where the basalt outcrops. This may provide additional control on the velocities in the uppermost basalt and interbed layers (Issue #3 below).

In addition, as part of geotechnical investigations for WTP, Shannon and Wilson performed a series of geophysical investigation consisting of downhole measurement, seismic cone penetrometer, and seismic refraction. These data will also be collected and combined with the new data.

A team, composed of Alan Rohay, Steve Reidel, Jim Cameron, Richard Lee, and Walt Silva, will review the data and summarize the velocity profiles in terms of its mean and variation including layer thicknesses. The data will be used in site response analysis to evaluate the soil amplification effects and evaluate the sensitivity of the results to the change of properties.

Issue #2: *The accuracy of downhole Vs measurements given the potential effects of intermediate "hard" layers that may mask or cause surface-generated waves to bypass underlying, "softer" layers.*

Response: The effects of intermediate "hard" layers are typically associated with measurement geometries different from those being used here. However, with the use of multiple geophysical methods, the accuracy of the measurements and whether such effects are possible will be evaluated. The method of using a surface source and down hole receiver is different from the in-hole method, where the source is below the sensors and within the same borehole. The SASW method uses horizontally-propagating surface waves to invert dispersion curves for the Vs versus depth profiles. Any inconsistencies between the results of these measurement techniques will be evaluated to ensure the accuracy and completeness of the velocity profiles. A search for other sources of data contamination, such as might result from grout invasion of the formation during well cementing operations, that might create similar difficulties in making accurate measurements of Vs will be performed. In addition, the boring logs and blow count data at the WTP site will be reviewed to ensure that all layers in the upper Hanford formations are considered.

Issue #3: *How Vs in the basalt and sedimentary interbeds is derived from borehole logs and laboratory data; how laboratory data were corrected to account for deep confining pressures, and the uncertainty in how laboratory data are extrapolated to derive Vs representative of the expected depth. This issue is particularly pertinent if it is decided that no deep borehole is necessary.*

Response: Available Vp data in basalt from at least five 3000-4000 foot deep wells within 15 km of the site will be converted to Vs using laboratory data that reasonably constrains the ratio of Vp/Vs. (The laboratory data and the Vp/Vs ratio derived from earthquake travel times are consistent.) In addition to using laboratory data to constrain Vp/Vs in interbed sediments, the Vp/Vs ratios measured in the "shear wave" borehole within the 5-8 million year old Ringold formation (at up to 500 foot depths), will be considered. Based on all available data, Vp/Vs ratios will be developed.

Geologic data from these deep boreholes will be used to determine the thickness of each basalt flow and sedimentary interbed in the area of the WTP. The characteristics of alternating high-velocity basalt and lower-velocity sedimentary interbeds as observed in the current model (derived from an industry borehole 30 km north of the WTP site) will be used in combination with the layer thicknesses determined to be appropriate to the WTP site and the Vp fluctuations observed there, constrained by the Vp measurements made in the closer boreholes.

In addition, the currently planned SASW geophysical exploration program has been modified to provide additional Vp and Vs data for the first few layers of the basalt/interbed stack at a location where the basalt sequence reaches the surface on Gable Butte, approximately 6 miles northwest of the WTP site. Borehole density logs, made at depth, will be used to determine how Vs, Vp and the Vp/Vs ratios might change from 500 foot to 2000 foot depths. A realistic range of Vs estimates will be evaluated in the basalts and interbeds, which account for the variability observed in the input information, and the uncertainty associated with the indirect estimation approach (through the Vp/Vs ratio).

An investigation of whether there are sufficient existing data available from nearby seismograph stations located on basalt outcrop to directly measure the attenuation effects of the multiple velocity contrasts within the basalt/interbed section will be performed. If sufficient data exist, this investigation may provide a constraint on the average magnitude of damping by determining the attenuation parameter "kappa" in the upper 1 to 2 km.

Issue #4: *The justification for selection of damping and modulus degradation curves and the final dynamic strain levels. This information is necessary to understand the degree of nonlinear response that is being modeled.*

> **Response:** The most recent strain-dependent soil properties (damping and modulus degradation curves) will be used considering the properties of the supra-basalt sediments. The material types and gradation properties are available from the Shannon & Wilson WTP site investigation. In addition to these site-specific Shannon and Wilson data, there are currently available generic data that include EPRI published curves, Rollins for gravel, and site-specific Shannon and Wilson data. The sensitivity of the results to nonlinear soil properties will be evaluated. (In the basalt/interbed sediments, it is expected that strain levels will be too small to warrant consideration of strain degradation of shear modulus and damping. This assumption will be verified by evaluating the strain level in the interbeds.). The damping obtained from evaluation of kappa, if available, will be used to constrain the damping values at low strain levels.

Issue #5: *The relative significance of the upper crustal rock site response, particularly with respect to model assumptions for both the basalt and the interbeds. Site response modeling should attempt to provide clarification regarding which geologic layer assumptions control which frequency ranges. For example, for frequencies between 4 and 10 hertz, the analysis should determine the overall proportion of site response associated with attenuation within the interbeds versus amplification that may result from the bedrock soil impedance contrast. This issue encompasses the justification of the site response model relative to the conditions being modeled, such as the alternating Vs within the upper crust. The sensitivity of rock site responses to model assumptions (gradient versus alternating velocities) should be explored. This issue is particularly pertinent if the Vs for the basalt layers is decreased.*

> **Response:** The numerical site response modeling will include sensitivity studies that determine the effect of the various basalt/interbed layer properties on site amplification. The source of any significant amplification or de-amplification across the frequency range of interest will be determined by modifying features of the model until the part of the model that controls the amplification or de-amplification can be assigned. Particular attention will be paid to the effect of the velocity contrasts and layer thicknesses of the interbeds, and the effect of the basalt/supra-basalt velocity contrast. The specific types of numerical modeling and sensitivity studies to be employed will be discussed with the Board staff to ensure the staff's concerns are addressed, including meeting with the staff as the evaluation proceeds.

Issue #6: *The relative significance of the soil site response with respect to model assumptions for the Ringold and Hanford formations.*

> **Response:** A parallel sensitivity study will be applied to the soil response, similar to the rock sensitivity of Issue #5 above. In the Hanford and Ringold formations,

particular attention will be paid to the presence of larger velocity contrasts and velocity inversions in the Ringold. Assumptions about the statistical variability of the shallower Hanford sediment velocities (characterized by "sigma"), and the degree to which these might vary systematically as a function of location will be studied based on the limited borehole geological information.

Issue #7: *Vs comparisons between expected upper crustal velocities at WTP are very different than those generally associated with California rock Vs profiles. Given the basalt interbed Vs profile, the analyst should address how rock ground motion attenuation models for WTP or Hanford can be developed.*

Response: Additional site-specific strong ground motion data and new strong motion rock attenuation relations have been developed since the original Hanford studies in the mid-1990's. The new attenuation relations are expected to be released by the Pacific Earthquake Engineering Research (PEER) group in December, 2004. If considered appropriate, DOE plans to use these to make any modifications to the attenuation relationships considered appropriate for use at Hanford. Subsequently, a re-evaluation of site-specific PSHA analysis following the procedures of U. S. Nuclear Regulatory Commission Regulatory Guide 1.165 (*Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion*) and NUREG/CR- 6728 (*Technical Basis for Revision of Regulatory Guidance on Design Ground Motions*) based on rock-outcrop motion will be conducted. This approach will address how the velocity profiles used to create the attenuation relationships for rock are different from the velocity profiles at the WTP site, and will model the expected relative responses between them.

Status and Schedule

The results of the borehole Vs measurements, both down-hole and in-hole, are expected by August 31, 2004. The SASW measurements will be completed by September 6, 2004, with preliminary results expected September 20. A contract is in place beginning September 1 with Pacific Engineering and Analysis to assist with developing the velocity models and variation of properties for the purpose of site response analysis. Preliminary versions are expected to be available by September 30 (Issues # 1, #2, and #3). A second contract is in place with Geomatrix Consultants, also to begin work September 1, to produce preliminary results and sensitivity studies by September 30 (Issues #4, #5, and #6). Both of these efforts will be need to be extended through October 31, 2004 to complete the final reports. These reports will be reviewed by DOE, and independently by Carl Constantino, and transmitted to the DNFSB by November 15, 2004. (Costantino's focus will be independent review of the modeling.) The November 15 deliverable will include a determination concerning whether a deep (to 2000 feet) borehole is necessary, and reach an interim conclusion (pending completion of Issue #7) regarding the adequacy of the current ground motion assumptions. It is expected that the new attenuation data needed to adopt the rock site approach (Issue #7) will be available in December, 2004, and new contracts will be established with DOE's consultants for this later effort. It is expected that the additional modeling results will be available by the end of February, 2005. DOE expects to meet with the DNFSB staff at intervals starting within 60 days as the new data is acquired and evaluated to ensure that the staff is kept current on the progress of this work.

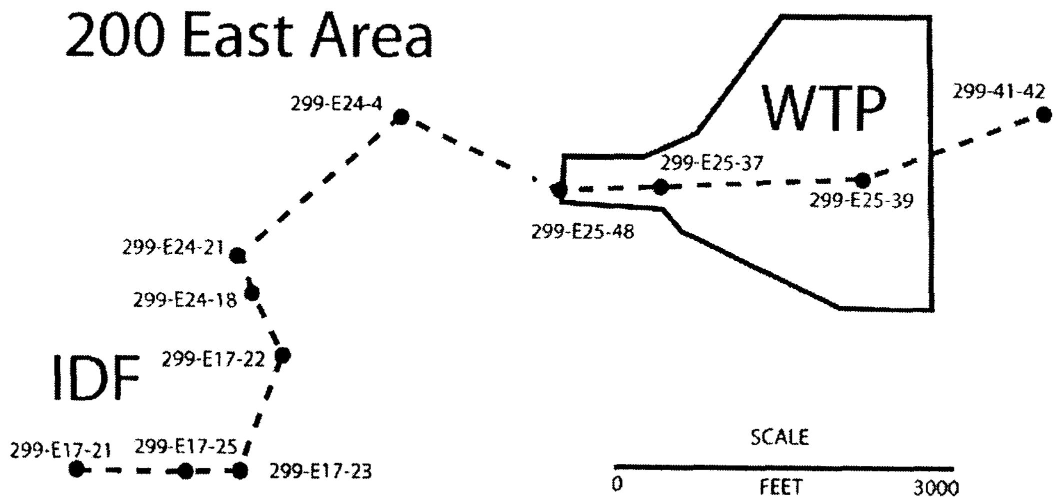

Figure 1. Location of Geologic Profile (on next page) from the IDF site through the WTP site.

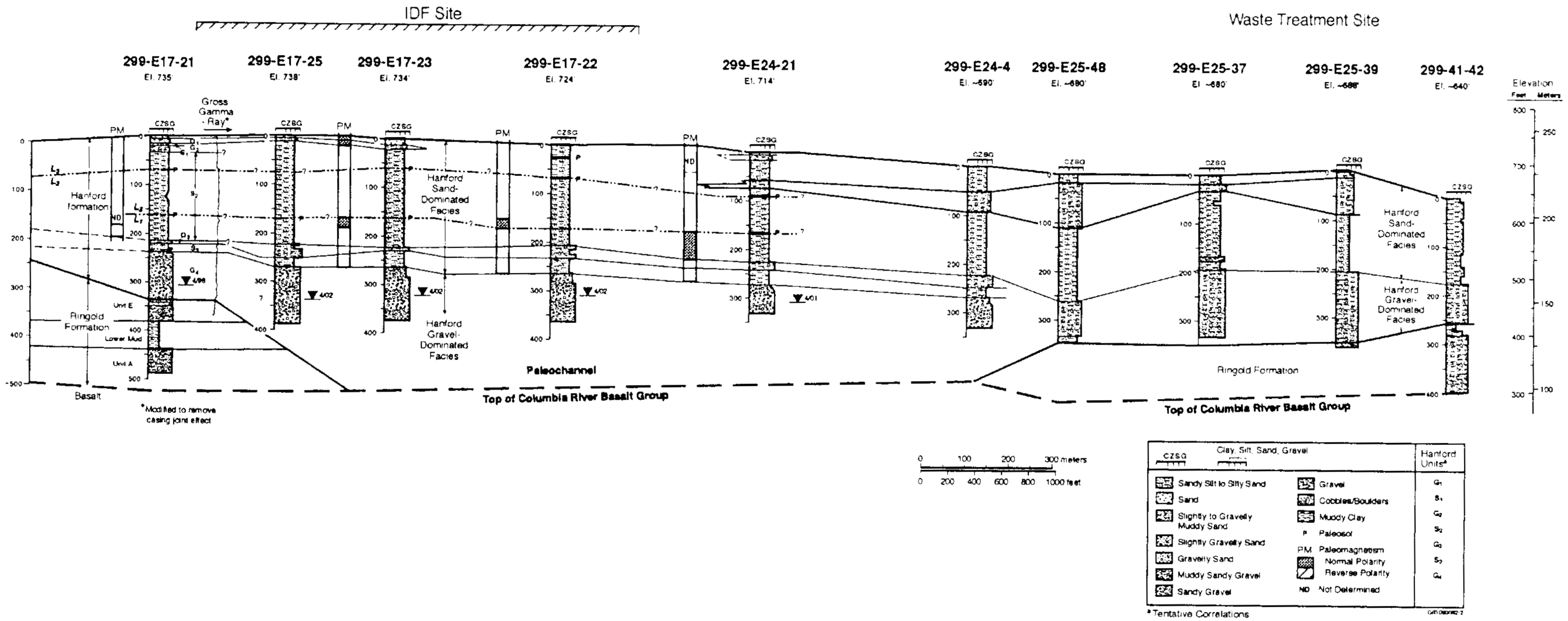

Figure 2. Geologic Cross Section from the IDF Site to the WTP Site.

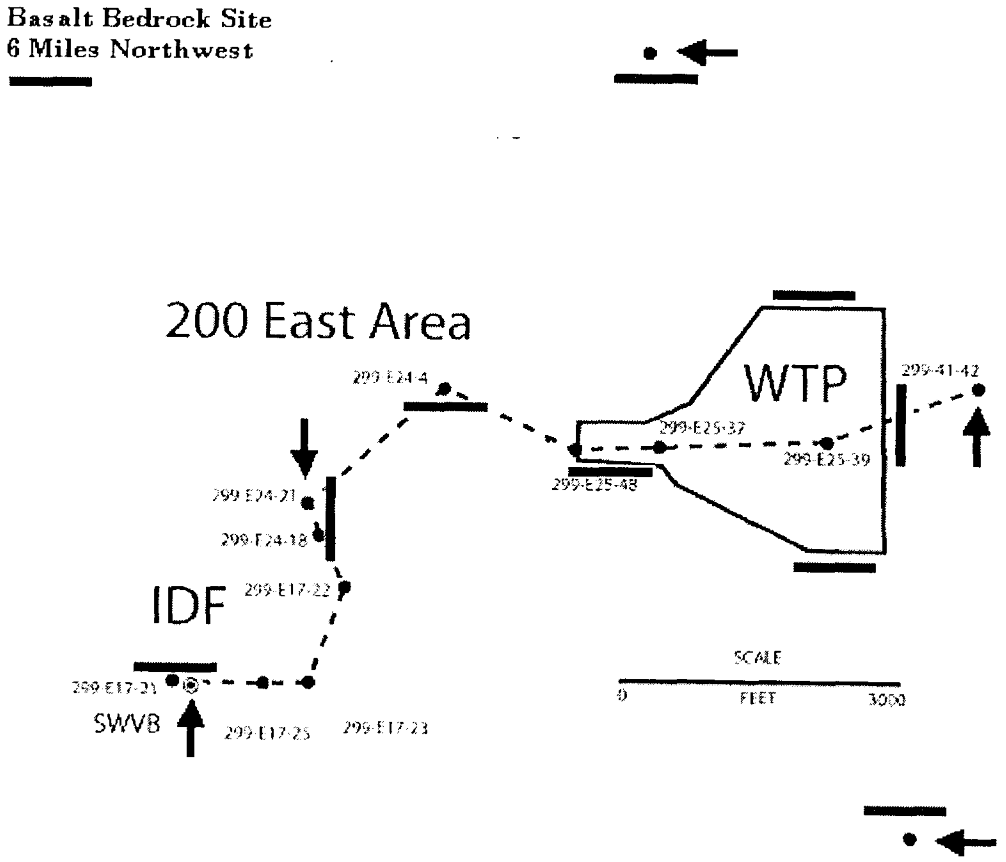

Figure 3. Locations of borehole and SASW Vs measurements. The Shear Wave Borehole (SWVB) is indicated at left. Locations of borehole Vs measurements are indicated by the blue arrows, and SASW Vs measurements are shown as red bars.