U.S. NUCLEAR REGULATORY COMMISSION
NOTICE OF GRANT/ASSISTANCE AWARD

1. GRANT/AGREEMENT NO.	2. MODIFICATION NO.	3. PERIOD OF PERFORMANCE	4. AUTHORITY
NRC-04-10-128		FROM: 08/01/2010 TO: 07/31/2013	Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended

5. TYPE OF AWARD	6. ORGANIZATION TYPE	7. RECIPIENT NAME, ADDRESS, and EMAIL ADDRESS
☐ GRANT ☒ COOPERATIVE AGREEMENT	124726725	REGENTS OF THE UNIVERSITY OF CALIFORNIA, THE UNIVERSITY OF CALIFORNIA, BERKELEY 2150 SHATTUCK AVE RM 313 BERKELEY CA 947045940

8. PROJECT TITLE:
Engineering Evaluation of Post-Liquefaction Residual Strength

9. PROJECT WILL BE CONDUCTED	10. TECHNICAL REPORTS ARE REQUIRED	11. PRINCIPAL INVESTIGATOR(S) NAME, ADDRESS and EMAIL ADDRESS
PER GOVERNMENT'S/RECIPIENT'S PROPOSAL(S) DATED See Program Descript AND APPENDIX A-PROJECT GRANT PROVISIONS	☒ PROGRESS AND FINAL ☐ FINAL ONLY ☐ OTHER (Conference Proceedings)	Dr. Raymond Seed University of California, Berkeley 423 Davis Hall Berkeley, CA 94720-8438 RMSeed6@aol.com

12. NRC PROGRAM OFFICE (NAME and ADDRESS)	13. ACCOUNTING and APPROPRIATION DATA	14. METHOD OF PAYMENT
U.S, Nuclear Regulatory Commission Attn. Mr. Richard Rivera-Lugo Office of Research Mail Stop CSB-5A24M 21 Church Street Rockville, MD 20850	APPN. NO: 31X0200.060 B&R NO: 060-15-171-277 JOB CODE: K6936 BOC NO: 4110 OFFICE ID NO: RFPA:RES-10-128	☐ ADVANCE BY TREASURY CHECK ☐ REIMBURSEMENT BY TREASURY CHECK ☐ LETTER OF CREDIT ☒ OTHER (SPECIFY) Electronic ASAP.gov (See Remarks in Item #20 "Payment Information")

15. NRC OBLIGATION FUNDS		16. TOTAL FUNDING AGREEMENT		
THIS ACTION	$75,000.00	NRC	$413,339.00	This action provides funds for Fiscal Year in the amount of Refer to page 2
PREVIOUS OBLIGATION		RECIPIENT	$0.00	
TOTAL	$75,000.00	TOTAL	$413,339.00	

17. NRC ISSUING OFFICE (NAME, ADDRESS and EMAIL ADDRESS)

U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: Mr. Michael Mills
Mail Stop: TWB-01-B10M
Washington, DC 20555

18.	19. NRC CONTRACTING OFFICER
Acceptance of or objections to the Terms and Conditions of Award must be Emailed to the NRC Issuing Office (Block #17) within three (3) business days following the Award issue date. NRC considers lack of response as acceptance by the grantee of the terms and conditions of award.	Sheila Bumpass 7/29/2010 (Signature) (Date) NAME (TYPED) Sheila Bumpass TITLE Contracting Officer TELEPHONE NO. 301-492-3484

20. PAYMENT INFORMATION

Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110).

21. *Attached is a copy of the "NRC General Provisions for Grants and Cooperative Agreements Awarded to Non-Government Recipients.*
Acceptance of these terms and conditions is acknowledged when Federal funds are used on this project.

22. ORDER OF PRECEDENCE
In the event of a conflict between the recipient's proposal and this award, the terms of the Award shall prevail.

23. By this award, the Recipient certifies that payment of any audit-related debt will not reduce the level of performance of any Federal Program.

TEMPLATE - ADM002

SUNSI REVIEW COMPLETE AUG 02 2010

ADM002

ATTACHMENT A - SCHEDULE

A.1 PURPOSE OF COOPERATIVE AGREEMENT

The purpose of this Cooperative Agreement is to provide support to the University of California, Berkeley for the research project entitled "Engineering Evaluation of Post-Liquefaction Residual Strength" as described in Attachment B entitled "Program Description."

A.2 PERIOD OF COOPERATIVE AGREEMENT

1. The effective date of this Cooperative Agreement is August 1, 2010. The estimated completion date of this Cooperative Agreement is July 31, 2013; however, funding after year one is subject to the availability of funding.

2. Funds obligated hereunder are available for program expenditures for the estimated period: August 1, 2010 – November 30, 2010.

A. GENERAL

1. Total Estimated NRC Amount:	$413,339
2. Total Obligated Amount:	$ 75,000
3. Cost-Sharing Amount:	$ 0
4. Activity Title:	"Engineering Evaluation of Post-Liquefaction Residual Strength"
5. NRC Project Officer:	Richard Rivera-Lugo
6. DUNS No.	124726725

B. SPECIFIC

RFPA No.	RES-10-128
FFS:	RES-C10-499
Job Code:	K6936
BOC:	4110
B&R Number:	060-15-171-277
Appropriation #:	31X0200.060
Amount Obligated:	$75,000

A.3 BUDGET

Revisions to the budget shall be made in accordance with Revision of Grant Budget in accordance with 2 CFR 215.25.

	Year 1	Year 2	Year 3
Total Personnel & Benefits	$66,510.00	$69,845.00	$73,380.00
Travel	$ 2,000.00	$ 3,000.00	$ 3,000.00
Other Direct Costs	$33,500.00	$15,500.00	$15,500.00
Subtotal	$102,010.00	$88,345.00	$91,880.00
Indirect Costs (25% MTDC)	$ 48,566.00	$40,654.00	$41,884.00
Yearly Total	**$150,576.00**	**$128,999.00**	**$133,764.00**

All travel must be in accordance with the Regents of the University of California, University of California, Berkeley Travel Regulations or the US Government Travel Policy absent recipient travel regulation.

A.4 AMOUNT OF AWARD AND PAYMENT PROCEDURES

1. The total estimated amount of this Award is $413,339 for the three year period. Years two – three are subject to the availability of funding.

2. NRC hereby obligates the amount of $75,000 for program expenditures during the period set forth above and in support of the Budget above. The recipient will be given written notice by the Contracting Officer when additional funds will be added. NRC is not obligated to reimburse the recipient for the expenditure of amounts in excess of the total obligated amount.

3. Payment shall be made to the Recipient in accordance with procedures set forth in the Automated Standard Application For Payments (ASAP) Procedures set forth below.

Attachment B – Program Description

PROGRAM DESCRIPTION

The U.S. Nuclear Regulatory Commission (NRC), an independent agenc created by Congress in 1974, regulates the nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment.

The NRC's Office of Nuclear Regulatory Research (RES) furthers the agency's mission by providing technical advice, technical tools and information for identifying and resolving safety issues, making regulatory decisions, and promulgating regulations and guidance.

RES may support institutions or organizations, through grants and cooperative agreements, that conduct independent experiments and analyses, develop technical bases for supporting realistic safety decisions by the agency, and evaluate safety issues involving current and new designs and mechanisms

UNIVERSITY OF CALIFORNIA, BERKELEY

"ENGINEERING EVALUATION OF POST LIQUEFACTION RESIDUAL STRENGTH"

INTRODUCTION

This is a proposal for jointly funded studies to develop improved methods, and improved expert consensus, for assessment of post-liquefaction residual strengths with broad applications to a wide range of seismic engineering problems.

Seismically induced soil liquefaction is a major risk for a wide range of structures and facilities. The two most fundamental issues involved in any geotechnical earthquake engineering problem associated with potential liquefaction hazard are: (1) assessment of the likelihood of initiation (or "triggering") of soil liquefaction, and (2) assessment of the expected post-liquefaction consequences.

Over the past five decades major efforts have been devoted to the development of methods for assessment of the likelihood of triggering of liquefaction, as a function of ground conditions, levels and duration of shaking, etc. Methods for this purpose are now well evolved for most cohesionless soils, and for silty soils of low plasticity.

Methods for assessment of the expected consequences of liquefaction are not as well developed. That results in significant uncertainty, entailing the need for conservative assumptions both for risk assessment and for design of mitigation works; resulting in major costs that might be expected to be reduced if better methods and/or better expert consensus can be achieved. The single largest source of uncertainty and controversy in most significant liquefaction-related efforts is the assessment of post-liquefaction residual strengths. This tends to be the dominant factor in both assessment of the overall expected consequences of liquefaction during risk assessment phases of such works, and it also tends to be the dominant factor/issue with regard to the extent and costs of mitigation required.

The State of California is now embarking on massive programs to upgrade the safety and reliability of its flood protection and water systems infrastructure. The difficulties associated with post-liquefaction strength assessment have long been a pivotal issue for the State's dams; now it will be a pivotal issue for thousands of miles of levees and canals as well. In addition, this is also a pivotal issue for numerous other applications, including: shallow-founded buildings and facilities, highways and bridges, lifelines (water, power, telecommunications, sewerage, etc.) in liquefiable ground, and many more. It is suggested, however that the massive and urgent needs for improved methods associated with the State's rapidly moving new flood protection and water infrastructure programs alone more than warrant the efforts proposed here.

The interests of NRC are similar; seismic risk to dams and levees potentially threatens inundation of nuclear sites, and the seismic fragility of dams, levees, canals, and lifeline systems pose threats to needed cooling water, utilities, etc. Any seismic geotechnical works undertaken in the coming years will continue to require an improved methodology for dealing with post-liquefaction strength assessment.

GENERAL FRAMEWORK AND APPROACH: ANALOGOUS STUDIES

Beginning in the aftermath of the two disastrous earthquakes in Niigata and Alaska in 1964, a bit more than five decades have now been devoted to the development of methods for assessment of the risk of "triggering" of soil liquefaction during earthquakes. Numerous methods were developed; and competition between methods, and resulting controversy, was common.

A major effort was made in the period from 1996 to 2000 to draw together 21 leading national and international experts to jointly review the evolving state of knowledge at that time. The results (Youd et al., 2001) were a landmark step forward as they began to establish the beginnings of consensus within what was just beginning to be a maturing field of practice.

A second important effort was undertaken over the period from 1999 through 2005 to resolve issues of continuing uncertainty identified by the effort above. A program was initiated to obtain increased field data regarding initiation (and non-initiation) of liquefaction during actual earthquakes. More than 800 field case histories were investigated and back-analyzed, and methods for assessment of the probability of initiation of liquefaction for given shaking levels were developed based on three different in situ field tests: the Standard Penetration Test (SPT), the cone penetration test (CPT), and in situ shear wave velocity measurements (V_S). The number of high quality field case histories collected for the already fairly well established SPT-based approaches was more than doubled, and the proportional increases in field case histories achieved for the CPT and V_S based approaches were significantly higher.

Prior to this effort, there had been four principal issues of concern as follow: (1) Different methods, developed by different researchers, led to clearly different levels of conservatism. As a result, practitioners learned which methods/correlations were more (or less) conservative, and chose accordingly for their situation. (2) There were wide divergences between the results provided by the different types of in situ test methods (SPT, CPT and V_S), raising both controversy and concern when more than one approach was employed and the results then disagreed. (3) Adjustments for "fines content" and the character of fines within the overall soil matrices were not well established, and appeared to some to be unconservatively treated in a number of widely used methods. (4) None of the methods provided a rigorous and fully defensible basis for quantitatively evaluating the probability of liquefaction occurrence; of vital necessity for risk-based engineering such as will be required for both NRC works and State of California water infrastructure works.

The new studies (1999 – 2005) took a significantly different set of approaches than had previously been undertaken. A team of senior national and international experts was established to oversee the work, and to "referee" and debate difficult aspects, including challenging technical judgments required at many interim stages of the work. The many field case histories were

processed far more carefully than had previously been attempted, and the uncertainties in each parameter were assessed, not just the best-estimated values. All of the massive efforts involved in these back analyses were then reviewed, and iterated, with the senior expert panel. Finally, very high-order Bayesian regression methods were employed to extract maximum possible insight from the now well-vetted case history database.

The principal results of this process are presented in Figure 1(a) through (c), which show the "triggering" probability relationships for the SPT, CPT and V_S based methods, respectively. Agreement between the three different in situ tests methods is now excellent, and overall uncertainly has been reduced by more than half relative to previous efforts at development of rigorously probabilistic correlations. In addition, not illustrated in Figure 1: (1) fines adjustments have been better defined (and it turned out that previous approaches had, indeed, been unconservative on this issue), (2) new magnitude-correlated duration weighting factors were developed to account for duration effects in characterization of seismic loading (and the prior approaches in use were shown to have been variably unconservative there as well).

This has led to revisions in the "triggering" methods of other investigators, with most now moving towards close agreement with the results shown in Figure 1 (e.g. the recent non-probabilistic relationships of Idriss and Boulanger, 2005), including even the long controversial issues of fines adjustments and shaking duration factors.

Thus, reasonable consensus has been largely achieved, and the methods available now provide a suitable basis for both probabilistic and deterministic assessment of the likelihood of triggering of soil liquefaction.

BACKGROUND FOR THE PROPOSED WORK

What is now needed is an improved set of tools and methods for engineering assessment of post-liquefaction residual strength. It is proposed to undertake a similar set of studies, again (1) guided and overseen (and discussed/debated) by a team of top experts, (2) making maximum possible use of available field and laboratory data, and (3) employing high-order Bayesian regression methods to extract all possible insight from the available data, as well as from the experts. There are a number of difficulties associated with this problem that will lend a very different flavor to the post-liquefaction residual strength work, however, and these are explained in the following sections.

Brief Background and the Current Situation:

The issue of post-liquefaction residual strength and deformation potential began to develop quietly in the mid-1970's, and the first useful expressions were the post-liquefaction shear strain "potentials" proposed by Seed, et al (1985), and by Ishihara and Yoshimini (1990). These early strain potential estimates were useful only on a largely judgmental (non-quantitative) basis, and so had relatively little impact on practice, despite their importance.

Things then came quickly to a boil in the 1980's when Poulos et al. (1985) proposed a laboratory-based "steady state" methodology for post-liquefaction strength assessment. This steady state method generally provided strength estimates that were significantly higher than those calculated by back-analysis of full scale field case histories, as shown in Figure 2 which shows the in situ steady state strengths assessed using the approach of Poulos et al. for various soil strata on a series of seismic dam projects undertaken by the U.S. Bureau of Reclamation vs. the ranges of strengths back-calculated by Seed (1987) from a suite of full scale field failure case histories.

The discrepancies between the steady state method, and back-calculated field strengths led to a research program funded by the U.S. Army Corps of Engineers (USACE). The findings of that study (e.g. Seed et al, 1989; Castro, Seed and Seed, 1992) were that there were at least four principal problems with the steady state method as follow:

1. The steady state method employed unconsolidated-undrained triaxial tests (UU-TX) to evaluate residual strengths as a function of initial sample void ratio (or density). These tests were performed at very high initial effective consolidation stresses, as that caused the samples to reach a relatively well-defined residual (or "steady state") strength at relatively moderate levels of strain. Unfortunately, it was found that consolidation to higher initial effective stresses also produces systematically higher undrained residual strengths in such tests. A partial solution would be to consolidate to the estimated in situ stress conditions, but (a) that often requires that samples be tested to such large strains that residual strengths cannot be well-evaluated, and (b) other problems (discussed below) render laboratory-based methods problematic anyway.

2. The steady state method requires testing a suite of fully disturbed (reconstituted) samples to produce a steady state line (analogous to a Critical State Line) plotted as void ratio vs. logarithm of residual effective confining stress (σ_3'), and then testing of carefully obtained "relatively" undisturbed samples, with unavoidable sampling densification and subsequent laboratory reconsolidation densification being carefully measured. The nearly undisturbed samples are, of course, unavoidably tested at a somewhat denser condition than had been their in situ condition prior to sampling. Accordingly, the measured laboratory strengths for the relatively undisturbed samples are then corrected, by moving them parallel to the Steady State Line established (Based on fully reconstituted samples) as illustrated in Figure 3 to develop estimates of the in situ undrained residual strengths. As shown in Figure 3 (which shows results for the critical stratum at the base of the upstream shell of the Lower San Fernando Dam, which suffered a liquefaction induced slope failure during the 1971 San Fernando Earthquake), the resulting corrections in strength are very large, and it has never been established that the "parallel" correction is valid.

3. The method fails to account for the effects of local void redistribution within a given sub-stratum that may behave as "globally" undrained, but which is able to rearrange its void ratio internally during earthquake loading and subsequent large deformations. This third issue cannot be resolved by any laboratory test-based approach, and will be discussed in more detail in the sections that follow.

4. The use of U-U triaxial compression tests also turns out to be systematically unconservative: significantly lower undrained residual shear strengths are measured in direct simple shear tests (DSS), and DSS-type deformation modes and strain paths tend to dominate most field situations of interest.

Problems #2 and #3 above are insurmountable, and as a result it is not currently possible to develop useful and reliable estimates of post-liquefaction in situ residual strengths for existing soils based on laboratory testing. Laboratory testing can be useful for fills "to be placed", but we are well able to compact such future fills so as to preclude any possibility of liquefaction, so that is of little practical use.

As a result, the current state of practice is based on the estimation of post-liquefaction residual undrained strengths based on back-analyses of field case histories (as with the most

widely used liquefaction "triggering" analysis methods, as discussed previously). Unfortunately, there are massive uncertainties due to a relative paucity of well-defined field case histories, and due also to a number of important nuances in the overall mechanics of the phenomena that lead to the undrained residual strength behaviors in question.

Prof. H. B. Seed (1987) developed the first correlation for estimation of post-liquefaction residual strengths ($S_{u,r}$) based on back-analyses of field (failure) case histories. Ishihara et al. (1990) quickly followed suit, and produced a very similar correlation, except that it could be accessed with either SPT or CPT data. Seed and Harder recognized that these early correlations were based on back-analyses that underestimated the effects of momentum on the residual strengths necessary to bring moving slopes back to rest, and so re-analyzed the field case histories available at that time and published the correlation presented in Figure 4 in the memorial symposium in honor of Prof. H.B. Seed (Seed and Harder, 1990). This continues to be one of the most widely used correlations, but it is lacking in several important regards and is thus badly in need of updating/replacement.

The correlations of Seed (1987), Ishihara et al. (1990) and Seed and Harder (1990) all assume that post-liquefaction residual strength is a function primarily of void ratio (or density), as is implied by classic Critical State theory. Stark and Mesri (1992) observed that laboratory test-based undrained residual strengths appeared to increase with increased initial effective consolidation stress, and so re-analyzed the available field (failure) case histories assuming that post liquefaction undrained residual strengths would conform to a constant ratio of $S_{u,r}/P$; analogous to undrained shear strengths of clays. Their resulting relationship between $S_{u,r}/P$ and $N_{1,60}$ showed very large scatter, but it also initiated a very important and still ongoing debate between (1) methods that make the classic Critical State assumption and develop relationships between $S_{u,r}$ and $N_{1,60}$, and (2) methods that assume that effective consolidation stress is of paramount importance and thus develop correlations between $S_{u,r}/P$ and $N_{1,60}$.

Olsen and Stark (2002) have recently analyzed additional field case histories, and have proposed an updated relationship between $S_{u,r}/P$ and fines adjusted penetration resistance ($N_{1,60}$). Scatter and uncertainty in the updated relationship both increased, and are still excessively large. This updated relationship was recently formally assessed by the team developing analytical tools and protocols for California's new levee and flood protection programs, and it was judged that:

(1) not all of the case histories definitively reached a quantifiable and fully developed residual condition, (2) significant judgment is necessarily involved in back-analyses of the field case histories, and (3) the overall correlation is diffuse and carries large uncertainty. Accordingly, the State has resolved (for now) to continue to use the Seed and Harder (1990) correlation, but with a minor adjustment for effective overburden stress; using values that fall at approximately the lower quartile range of the band shown in Figure 4 in recognition that initial effective consolidation (overburden) stresses are lower for levees than for most of the field failure case histories back-analyzed.

That is a very daunting for the Principal Investigator, who feels that there are significant shortcomings to this now ageing correlation (of which he is an author), and that it is now outdated and in need of replacement.

Idriss and Boulanger (2005) have also proposed a recent correlation based on the $S_{u,r}/P$ assumption, and this correlation begins to address one two of the shortcomings of the Seed and Harder correlation: (1) the need for a rational basis for extrapolation to $N_{1,60,CS}$ values higher than about 15 blows/foot, and (2) accommodation of the likely effects of sub-layering and associated void redistribution effects. Both of these are treated judgementally, however, and cannot be quantitatively supported. In addition, the correlation carries no underlying probabilistic framework (or capability), and the suite of back-analyzed case histories fall into two divergent categories; those that well fit the proposed correlation, and those that do not and so are left largely unaddressed as "outliers".

Where We are Today:

As a result of the evolution described above, the use of laboratory-based methods has been largely discontinued, and the use of empirical (and semi-empirical) methods based on back-analyses of field case histories has been sub-divided into two separate schools of thought: (1) "Critical State" methods that assume that $S_{u,r}$ is a function of pre-earthquake void ration (or density), and (2) "$S_{u,r}/P$" methods that assume that initial effective overburden stress is of paramount importance.

Neither of these two polar extremes is likely accurate.

Riemer (1992) performed an extensive series of laboratory tests to assess post-liquefaction residual strengths of clean, fine sands. Figure 6 shows the results of IC-U TX tests on a suite of four samples of Sacramento River Sand that had identical void ratios after consolidation (to three decimal places); a trial and error sample formation exercise that required numerous attempts. Figure 6(b) shows a plot of the stress paths for the UU-TX tests of these four samples, each of which was initially isotropically consolidated to different initial effective stresses prior to undrained testing. In this figure, it can readily be seen why many feel that a linear relationship between $S_{u,r}$ and P should be assumed. Figure 6(b) shows, however, that when the final residual values of $S_{u,r}$ /P are plotted as a function of initial effective consolidation stress, the actual relationship is anything but constant. Initial effective consolidation stress affects $S_{u,r}$, but it does not linearly control it.

So it appears that the truth lies between the $S_{u,r}$ vs density, and the $S_{u,r}$ /P vs. density camps.

Two of the important reasons for that can be intuited. One of the two key issues is the phenomenon of void redistribution. Figure 7 shows a photo of the critical hydraulic fill material at the base of the upstream shell of Lower san Fernando Dam; the material that liquefied and produced the observed failure. As shown in this photo, the material is visibly "layered". A closer view of the lighter bands in this photo would show these, too, to be visibly "varved" or sub-stratified. Such sub-stratification is the norm for most cohesionless soils, given the environments and variable conditions under which they are deposited. The "Critical State" model assumes that an element of soil is homogenous and continues to behave in that manner during undrained loading. Actual field behavior is far more complicated than that. While a sub-stratum may indeed be effectively globally undrained during short-term seismic loading, experiencing no overall volume change, it is not locally undrained. During cyclic loading, and during significant shear deformations, solid particles tend to "settle" a bit within the sub-stratum, causing the void ratio at the base of the stratum to decreae (local densification), and the void ratio near the top to increase. As illustrated in Figure 3, even a very small increase in void ratio can lead to a major decrease in residual strength.

Nature has a choice, and so failure surfaces and major shear zones elect as best they can to pass through the looser tops of sub-strata, which have lower strengths that would have

occurred if the entire stratum had remained at its pre-earthquake density. In extreme cases, water films can form at the tops of loose strata; and these have negligible shear strength with regard to sliding on lateral planes (e.g.: Arulanandan et al., 1980; Kokusho, 1999; Kokusho and Kojima, 2002; Malik et al., 2006). This was first demonstrated in a centrifuge experiment in which a clay embankment with a sand core and lateral sand "drain" (capped by clay to prevent drainage) was shaken to induce a liquefaction-induced slope failure as illustrated in Figure 8 (Arulanandan et al., 1993). The internal sand stratum and core both behaved in a globally undrained manner during the shaking and slope failure, but they both densified at their bases and loosened at their tops. The slope failure resulted by shearing through the tops of these sand zones; the zones weakened by void redistribution. The Principal Investigator of this current proposal designed that early experiment, as part of the ongoing investigation of problems with the Steady State method of Poulos and Castro. Work on void redistribution has now progressed somewhat, but it continues to be true that we lack the capability to usefully pre-define the scale of in situ sub-stratification that will control potential for void redistribution in situ, and we are thus unable to usefully address this issue on a theoretical/analytical basis for real projects; especially when that would require a priori identification of the most critical in situ sub-stratum.

A second issue is the fact that even laboratory samples do not really continue to be ideal "homogenous" elements throughout testing to failure. When subjected to undrained shearing to large strains, these samples initially tend to behave in a manner largely constrained by Critical State theory, but as strains become large strain (and displacement) localization occurs; samples of cohesionless soils fail to achieve their theoretical "critical state" residual strengths (e.g. Riemer and Seed, 1997; Wu et al., 2003; Malik et al, 2006, Seid-Karbasi and Byrne, 2007). This can be addressed by both theoretical and constitutive/numerical modeling, but resolving these issues in laboratory samples provides only insight, not solutions, for the assessment of in situ residual strengths in the field.

The confluence of these two effects is such that there is some influence of initial effective overburden (consolidation) stress, but that it is not sufficiently dominant as to produce a linear relationship as assumed in the current $S_{u,r}/P$ approaches.

PROPOSED WORK

What is needed is a comprehensive effort to develop new methods, not wedded either to the "$S_{u,r}$" or the "$S_{u,r}/P$" approaches, for engineering evaluation of post-liquefaction residual strengths. These methods must account for difficult issues such as void redistribution, layering (and sub-stratification), etc. It is unlikely that these issues can be fully resolved, as there are significant limitations to the absolute pertinence and direct utility of laboratory testing, and field case histories are in limited supply, so it is expected that expert engineering judgment will play a significant role in the work proposed.

It is proposed to take an approach similar to that taken in development of the new liquefaction triggering relationships. An expert panel will be formed to oversee the work, and to debate key issues and also key details of analyses, etc. Maximum possible advantage will be taken of several potential sources of insight; (1) laboratory testing data, (2) field case history data, and (3) theory and constitutive frameworks. As expert judgment will be of paramount importance, it is important that a suitably diverse suite of top experts participate.

Existing case histories will be re-assessed to determine whether they provide valid and useful insight (e.g. whether or nor fully residual strengths were mobilized), and additional case histories will be added. The 1979 slope Failure at Nice, France can be added, and so can a suite of six failures at a large tailings impoundment in the western U.S. (these six are proprietary cases, but we can use them as long as the site is not indentified). Additional cases will be sought, but it is expected that the field case history database will continue to be frustratingly sparse.

There are significant disagreements with regard to the back-analyses of even the best-established field case histories. The Lower San Fernando Dan slide of 1971 is a good (and important) example. Figure 9 shows a pair of cross-sections through the dam before and after the earthquake. Critical topics of controversy regarding the back-calculation of $S_{u,r}$ for this slope failure include: (1) how to handle the effects of momentum and inertia; the moving slide mass had to be brought back to rest, and the maximum velocity of the movements which

developed (and thus the momentum) can be assessed by a number of methods, each with differing results in terms of the $S_{u,r}$ values back-calculated, (2) the shear strengths of the reservoir sediments that were over-ridden by the slide mass as it progressed into the reservoir are poorly defined, and (3) the sequence and timing of the individual block movements is not well defined; the more segmented and disparate in time these movements were, the lesser the momentum and thus the lower the value of $S_{u,r}$. Accordingly, multiple approaches will be taken to these back-analyses, and these analyses will be reviewed and debated in detail by the expert panel. Analysis methods will include (1) progressive (incremental) conventional calculations of limit equilibrium, with unbalanced forces at any point in time producing either acceleration or deceleration of the translating masses, and (2) finite element and finite difference analyses that can intrinsically handle momentum and inertia effects (using the programs PLAXIS and FLAC).

In performing these back analyses, variable suites of assumptions will be made regarding the effects of initial effective overburden stress on $S_{u,r}$. Both extreme views will of course be analyzed ($S_{u,r}$ fully independent of P, and $S_{u,r}/P$ = constant for a constant D_R). In addition various relationships for $S_{u,r}$ /P as a variable function of P will also be used in these back analyses. As an example, it could instead be assumed that $S_{u,r}$ varies with "P" in a manner similar to that shown in Figure 6(b); which produces a better "fit" for the overall suite of field case histories than do either of the currently available schools of thought. These assumed variable (with σ_v') relationships will be informed by available laboratory test data, and by constitutive theory, and it is expected that they will vary as a function of fines content and character. (It is generally expected that soils with sufficient fines as to be significantly compressible will likely behave very differently than relatively incompressible "clean" cohesionless soils.) In each case, all pertinent uncertainties will be evaluated, and estimated by expert consensus when necessary.

High-order Bayesian regression methods will then be used to attempt to draw all possible insight from the field case histories, and to assess the relationships between $S_{u,r}/P$ vs. P that provide the best overall explanation of the field case histories. These methods can simultaneously handle the effects of fines content and character, effective overburden stress variations, mode "triggering" of liquefaction, etc. and can also accommodate either rigorous or judgemental assessments of sub-stratification, etc. The resulting best-estimate relationships for assessment of $S_{u,r}$ will be probabilistically quantified as best can be accomplished at this time.

Throughout, several important questions that have not yet been formally addressed in any currently available approaches, but that weigh increasingly heavily on those of us who have to engineer actual projects, will be considered and weighed judgementally. These include:

1. The question as to whether the currently available "failure" case histories are a biased set, representing those sites that failed while other, similar sites exhibited higher residual strengths and so did not fail.
2. The degree to which increased sub-stratification affects residual strengths.
3. The degree to which mitigation methods (e.g. vibrodensification stone columns) would "vent" pore pressures associated with sub-stratified void redistribution.
4. How best to extrapolate the relationships to higher values of $N_{1,60,cs}$. The failure case histories currently available will fail to define this relationship at $N_{1,60,cs}$ values higher than about 15 to 17 blows/ft due to a lack of cases; but engineers working with design and implementation of mitigation and/or retrofit (and engineers working with high levels of required reliability for dams and nuclear projects) routinely need to extrapolate far beyond this range in order to estimate strengths for soils with $N_{1,60,cs}$ values up to 30 blows/ft.

In the end, this is expected to result in the best possible basis for assessment of in situ that can be accomplished at this time, and with the field data currently available. As only the occurrence of a significant number of additional field failures can add meaningfully to the field database: (1) significant judgment (and expert consensus) will be required, and (2) we cannot be in the business of waiting for such additional failures to occur.

WORK PLAN AND TIMELINE

The two Principal Investigators (PI's), and the two principal funding agencies (DWR and NRC) will jointly assemble a panel of five to seven experts to jointly oversee and review the work over a proposed two and a half year period. The panel will require high level expertise and experience in soil liquefaction engineering, and there will be special need of world class expertise in (1) evaluation and use of post-liquefaction residual strengths, (2) constitutive

modeling and analysis, and (3) high-order Bayesian regression for geotechnical applications. It is proposed to form a panel with up to seven members (including the two PI's) using the funding requested herein, and assuming that one of the funding agencies (DWR) will provide one of the expert panel members at their own expense.

The Technical Steering Panel (TSP) will meet twice in each of the first two years, and at at least once in the final half year, to (1) help guide the progress of the work, (2) review and comment on developments in progress as well as interim final results, and (3) to provide expert input (and judgment) throughout the process. It is noted that this topic is also a top priority for the U.S. Bureau of reclamation's Seismic Dam Safety Programs (Gillette, 2008) and it is planned to ask them to contribute an expert for the panel, and possibly some limited additional funding, but that this current proposal is not contingent upon that.

The initial meeting of the TSP will refine the plans for the overall program, and will help to initiate the process. After that, the TSP is expected to serve in a primarily technically expert mode; providing input, review and expert judgment as the work progresses and as challenging problems and issues arise.

Figure 10 shows an approximate timeline for the proposed 2.5 year effort. Year 1 will initially involve two types of efforts in parallel: (1) data and case history collection, and (2) development and refinement of methods for back-analyses of field failure case histories. The second year is expected to be dominated largely by the processing and back-analyses of field case histories, with work on Bayesian regression of the accumulating results beginning in the latter part of the year. Year 3 will be focused primarily on the development of best-possible bases for assessment of in situ post-liquefaction $S_{u,r}$ for a variety of soil conditions. The remaining time will be devoted to internal (and likely also external) review and refinement, and to report preparation and documentation. The intended starting date is February of 2010, but the proposal and overall budget are not contingent upon that precise starting date.

Deliverables:

1. Interim reports will be developed on an annual basis, and the two principal funding agencies will be invited to attend any of the multiple TSP meetings each year that they wish.
2. Throughout the process, noting the urgent need for insight associated with California's fast-moving flood protection and water infrastructure programs, interim findings and results will be communicated directly to both DWR and the NRC.
3. Draft final relationships and $S_{u,r}$ assessment recommendations will be developed by the end of Year 2.5.
4. Final reports, summarizing findings and recommendations and also documenting the case histories and the overall process for the benefit of others who will follow will also be developed for the end of the 2.5 year period.

Proposed Budget:

Two draft budgets are attached. Each covers the entire cost of the proposed work. Budget A employs an assumed State agency overhead rate of 25%, and Budget B employs an assumed Federal agency budget of approximately 53% for the first year, and 54% thereafter. It is proposed that the two agencies each pay for half of the overall research effort. If each was to pay half, then each would fund one-half of the amounts of Budget A (DWR) and Budget B (NRC), respectively. The draft budgets assume a panel of seven technical experts, including: (1,2) the two PI's, (3) an expert from DWR, (4) an expert on Bayesian regression and soil liquefaction, and (5-7) up to three additional experts to be selected.

Funding is provided for one (doctoral) Graduate Student Researcher (GSR).

The budget proposes acquisition of two software packages for the most current versions of the programs FLAC and PLAXIS. We have good contacts with colleagues associated with development of both of these codes, and the costs currently projected may be reduced somewhat if we are able to secure more favorable rates for these software packages.

Travel expenses reflect anticipated costs for TSP panel meetings. Presentations for DWR (In Sacramento) would entail no significant additional costs, and it is anticipated that NRC representatives might travel to Sacramento to join in any such presentations/briefings.

Personnel:

The Principal Investigator will be Professor Raymond Seed, of the University of California at Berkeley. Dr. Seed is a leading expert in the field of geotechnical earthquake engineering, with special emphasis on liquefaction engineering and on the seismic performance of dams and embankments. He has led or participated in major U.S. post-earthquake investigations for eight major events, both in the U.S. and abroad. He is also an expert on levees, and has served as an advisor to the California Dept. of Water Resources on both dams and levees for the past twenty years. He has performed significant previous work on the subject of post-liquefaction residual strength.

Professor Juan Pestana, of the University of California at Berkeley, will be the Co-Principal Investigator. Dr. Pestana is also an expert in geotechnical earthquake engineering, but more importantly for this project he is also a leading expert in constitutive modeling and analysis of complex soil behavior.

Abbreviated (one page) C.V.'s for both PI's are attached.

Attachment C – Standard Terms and Conditions

The Nuclear Regulatory Commission's Standard Terms and Conditions for U.S. Nongovernmental Grantees

Preface

This award is based on the application submitted to, and as approved by, the Nuclear Regulatory Commission (NRC) under the authorization 42 USC 2051(b) pursuant to section 31b and 141b of the Atomic Energy Act of 1954, as amended, and is subject to the terms and conditions incorporated either directly or by reference in the following:

- Grant program legislation and program regulation cited in this Notice of Grant Award.
- Restrictions on the expenditure of Federal funds in appropriation acts, to the extent those restrictions are pertinent to the award.
- Code of Federal Regulations/Regulatory Requirements - 2 CFR 215 Uniform Administrative Requirements For Grants And Agreements With Institutions Of Higher Education, Hospitals, And Other Non-Profit Organizations (OMB Circulars), as applicable.

To assist with finding additional guidance for selected items of cost as required in 2 CRF 220, 2 CFR 225, and 2 CFR 230 these URLs to the Office of Management and Budget Cost Circulars are included for reference:

A-21 (now 2CFR 220):	http://www.whitehouse.gov/omb/circulars/a021/print/a021.html
A-87 (now 2CFR 225:	http://www.whitehouse.gov/omb/circulars/a087/print/a087-all.html
A-122 (now2 CFR 230	http://www.whitehouse.gov/omb/circulars/a122/print/a122.html
A-102, SF 424:	http://www.whitehouse.gov/omb/circulars/a102/print/a102.html
Form 990:	http://www.irs.gov/pub/irs-pdf/i990-ez.pdf

Any inconsistency or conflict in terms and conditions specified in the award will be resolved according to the following order of precedence: public laws, regulations, applicable notices published in the Federal Register, Executive Orders (EOs), Office of Management and Budget (OMB) Circulars, the Nuclear Regulatory Commission's (NRC) Mandatory Standard Provisions, special award conditions, and standard award conditions.

By drawing funds from the Automated Standard Application for Payment system (ASAP), the recipient agrees to the terms and conditions of an award.

Certifications and representations. These terms incorporate the certifications and representations required by statute, executive order, or regulation that were submitted with the SF424B application through Grants.gov.

I. Mandatory General Requirements

The order of these requirements does not make one requirement more important than any other requirement.

1. Applicability of 2 CFR Part 215

a. All provisions of 2 CFR Part 215 and all Standard Provisions attached to this grant/cooperative agreement are applicable to the Grantee and to sub-recipients which meet the definition of "Grantee" in Part 215, unless a section specifically excludes a sub-recipient from coverage. The Grantee and any sub-recipients must, in addition to the assurances made as part of the application, comply and require each of its sub-awardees employed in the completion of the project to comply with Subpart C of 2 CFR 215 Part 180 and include this term in lower-tier (subaward) covered transactions.

b. Grantees must comply with monitoring procedures and audit requirements in accordance with OMB Circular A-133. < http://www.whitehouse.gov/omb/circulars/a133_compliance/08/08toc.aspx >

2. Award Package

Substantial Involvement

This award is issued as a Cooperative Agreement, a financial assistance mechanism in which substantial NRC programmatic involvement is anticipated in the performance of the activity. Under the cooperative agreement, the NRC purpose is to support and stimulate the recipients' activities by involvement in and otherwise working jointly with the award recipients in a partnership role; it is not to assume direction, prime responsibility, or a dominant role in the activities. Consistent with this concept, the dominant role and prime responsibility resides with the awardees for the project as a whole, although specific tasks and activities may be shared among the awardees and the NRC as defined below.

1. Recipient Responsibility.

a. The Recipient will bear primary responsibility for performance stated in the program description, within the limits of the Cooperative Agreement's terms and conditions.

b. The principal investigator has primary authorities and responsibilities to define objectives and approaches, and to plan, conduct, analyze, and publish results, interpretations, and conclusions of their research and other activities. The Principal Investigator should be prepared to work collaboratively with the NRC to achieve the goals of this cooperative agreement and agree to accept the participatory and cooperative nature of the group process.

2. NRC Responsibilities

a. The NRC Project Officer (PO) will have substantial involvement above and beyond the normal program stewardship of the award. The NRC PO will insert substantial involvement into the conference by actively participating as a speaking member.

b. Role of the NRC Grants Officer:

The NRC Grants Officer (GO) is responsible for all business management aspects of negotiation, award, financial and administrative aspects of the cooperative agreement. The GO utilizes information from site visits, reviews of expenditure and audit reports and other appropriate means to assure that the project is operated in compliance with all applicable Federal laws, regulations, guidelines and the terms and conditions of award. Questions concerning the applicability of regulations and policies to this cooperative agreement and all requests for required prior approvals such as requests for permission to expend funds for certain items should be directed to the GO. Required approvals must be provided in writing and the GO is the only person who may grant such required approvals. Written approvals granted by other officials are not binding on the government. All changes in the terms of the cooperative agreement award must be issued in writing by the GO.

§ 215.41 Recipient responsibilities.

The Recipient is obligated to conduct such project oversight as may be appropriate, to manage the funds with prudence, and to comply with the provisions outlined in 2 CFR 215.41 Within this framework, the Principal Investigator (PI) named on the award face page, Block 11, is responsible for the scientific or technical direction of the project and for preparation of the project performance reports. This award is funded on a cost reimbursement basis not to exceed the amount awarded as indicated on the face page, Block 16., and is subject to a refund of unexpended funds to NRC.

The standards contained in this section do not relieve the recipient of the contractual responsibilities arising under its contract(s). The recipient is the responsible authority, without recourse to the NRC, regarding the settlement and satisfaction of all contractual and administrative issues arising out of procurements entered into

in support of an award or other agreement. This includes disputes, claims, protests of award, source evaluation or other matters of a contractual nature. Matters concerning violation of statute are to be referred to such Federal, State or local authority as may have proper jurisdiction.

Subgrants
Appendix A to Part 215—Contract Provisions

Sub-recipients, sub-awardees, and contractors have no relationship with NRC under the terms of this grant/cooperative agreement. All required NRC approvals must be directed through the Grantee to NRC. See 2 CFR 215.180 and 215.41.

Nondiscrimination
(This provision is applicable when work under the grant/cooperative agreement is performed in the U.S. or when employees are recruited in the U.S.)

No U.S. citizen or legal resident shall be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity funded by this award on the basis of race, color, national origin, age, religion, handicap, or sex. The Grantee agrees to comply with the non-discrimination requirements below:

Title VI of the Civil Rights Act of 1964 (42 USC §§ 2000d et seq)
Title IX of the Education Amendments of 1972 (20 USC §§ 1681 et seq)
Section 504 of the Rehabilitation Act of 1973,as amended (29 USC § 794)
The Age Discrimination Act of 1975, as amended (42 USC §§ 6101 et seq)
The Americans with Disabilities Act of 1990 (42 USC §§ 12101 et seq)
Parts II and III of EO 11246 as amended by EO 11375 and 12086.
EO 13166, "Improving Access to Services for Persons with Limited English Proficiency."
Any other applicable non-discrimination law(s).

Generally, Title VII of the Civil Rights Act of 1964, 42 USC § 2000e et seq, provides that it shall be an unlawful employment practice for an employer to discharge any individual or otherwise to discriminate against an individual with respect to compensation, terms, conditions, or privileges of employment because of such individual's race, color, religion, sex, or national origin. However, Title VII, 42 USC § 2000e-1(a), expressly exempts from the prohibition against discrimination on the basis of religion, a religious corporation, association, educational institution, or society with respect to the employment of individuals of a particular religion to perform work connected with the carrying on by such corporation, association, educational institution, or society of its activities.

Modifications/Prior Approval
NRC prior written approval may be required before a Grantee makes certain budget modifications or undertakes particular activities. If NRC approval is required for changes in the grant or cooperative agreement, it must be requested of, and obtained from, the NRC Grants Officer in advance of the change or obligation of funds. All requests for NRC prior approval must be made, in writing (which includes submission by e-mail), to the designated Grants Specialist and Program Office no later than 30 days before the proposed change. The request must be signed by both the PI and the authorized organizational official. Failure to obtain prior approval, when required, from the NRC Grants Officer may result in the disallowance of costs, termination of the award, or other enforcement action within NRC's authority.

Lobbying Restrictions
The Grantee will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

The Grantee shall comply with provisions of 31 USC § 1352. This provision generally prohibits the use of Federal funds for lobbying in the Executive or Legislative Branches of the Federal Government in connection with the award, and requires disclosure of the use of non-Federal funds for lobbying.

The Grantee receiving in excess of $100,000 in Federal funding shall submit a completed Standard Form (SF) LLL, "Disclosure of Lobbying Activities," regarding the use of non-Federal funds for lobbying within 30 days following the end of the calendar quarter in which there occurs any event that requires disclosure or that materially affects the accuracy of the information contained in any disclosure form previously filed. The Grantee must submit the SF-LLL, including those received from sub-recipients, contractors, and subcontractors, to the Grants Officer.

§ 215.13 Debarment And Suspension.
The Grantee agrees to notify the Grants Officer immediately upon learning that it or any of its principals:

(1) Are presently excluded or disqualified from covered transactions by any Federal department or agency;

(2) Have been convicted within the preceding three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, tax evasion, receiving stolen property, making false claims, or obstruction of justice; commission of any other offense indicating a lack of business integrity or business honesty that seriously and directly affects your present responsibility;

(3) Are presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(b); and

(4) Have had one or more public transactions (Federal, State, or local) terminated for cause or default within the preceding three years.

b. The Grantee agrees that, unless authorized by the Grants Officer, it will not knowingly enter into any subgrant or contracts under this grant/cooperative agreement with a person or entity that is included on the Excluded Parties List System (http://epls.arnet.gov).

The Grantee further agrees to include the following provision in any subgrant or contracts entered into under this award:

'Debarment, Suspension, Ineligibility, and Voluntary Exclusion

The Grantee certifies that neither it nor its principals is presently excluded or disqualified from participation in this transaction by any Federal department or agency. The policies and procedures applicable to debarment, suspension, and ineligibility under NRC-financed transactions are set forth in 2 CFR Part 180.'

Drug-Free Workplace
The Grantee must be in compliance with The Federal Drug Free Workplace Act of 1988. The policies and procedures applicable to violations of these requirements are set forth in 41 USC 702.

Implementation of E.O. 13224 -- Executive Order On Terrorist Financing
The Grantee is reminded that U.S. Executive Orders and U.S. law prohibits transactions with, and the provision of resources and support to, individuals and organizations associated with terrorism. It is the legal responsibility of the Grantee to ensure compliance with these Executive Orders and laws. This provision must be included in all contracts/sub-awards issued under this grant/cooperative agreement.

Award Grantees must comply with Executive Order 13224, Blocking Property and Prohibiting Transactions with Persons who Commit, Threaten to Commit, or Support Terrorism. Information about this Executive Order can be found at: www.fas.org/irp/offdocs/eo/eo-13224.htm.

Procurement Standards, § 215.40
Sections 215.41 through 215.48 set forth standards for use by Grantees in establishing procedures for the procurement of supplies and other expendable property, equipment, real property and other services with Federal funds. These standards are furnished to ensure that such materials and services are obtained in an effective manner and in compliance with the provisions of applicable Federal statutes and executive orders. No additional procurement standards or requirements shall be imposed by the Federal awarding agencies upon Grantees, unless specifically required by Federal statute or executive order or approved by OMB.

Travel
Travel is an appropriate charge to this award and prior authorization for specific trips are not required, as long as the trip is identified in the Grantee's original program description and original budget. All other travel, domestic or international, must not increase the total estimated award amount. Trips that have not been identified in the approved budget require the written prior approval of the Grants Officer.

Travel will be in accordance with the US Government Travel Regulations at:
www.gsa.gov/federaltravelregulation and the per diem rates set forth at: www.gsa.gov/perdiem.

Travel costs to the grant must be consistent with provisions as established in Appendix A to 2 CFR 220 (J.53)

Property Management Standards
Property standards of this award shall follow provisions as established in 2 CFR 215.30.

Equipment procedures shall follow provision established in 2 CFR 215.34.

Procurement Standards
Procurement standards of this award shall follow provisions as established in 2 CFR 215.40.

Intangible and Intellectual Property
Intangible and intellectual property of this award shall generally follow provisions established in 2 CFR 215.36.

Inventions Report - The Bayh-Dole Act (P.L. 96-517) affords Grantees the right to elect title and retain ownership to inventions they develop with funding under an NRC grant award ("subject inventions"). In accepting an award, the Grantee agrees to comply with applicable NRC policies, the Bayh-Dole Act, and its Government-wide implementing regulations found at Title 37, Code of Federal Regulations (CFR) Part 401. A significant part of the regulations require that the Grantee report all subject inventions to the awarding agency (NRC) as well as include an acknowledgement of federal support in any patents. NRC participates in the trans-government Interagency Edison system (http://www.iedison.gov) and expects NRC funding Grantees to use this system to comply with Bayh-Dole and related intellectual property reporting requirements. The system allows for Grantees to submit reports electronically via the Internet. In addition, the invention must be reported in continuation applications (competing or non-competing).

Patent Notification Procedures- Pursuant to EO 12889, NRC is required to notify the owner of any valid patent covering technology whenever the NRC or its financial assistance Grantees, without making a patent search, knows (or has demonstrable reasonable grounds to know) that technology covered by a valid United States patent has been or will be used without a license from the owner. To ensure proper notification, if the Grantee uses or has used patented technology under this award without license or permission from the owner, the Grantee must notify the Grants Officer. This notice does not necessarily mean that the Government authorizes and consents to any copyright or patent infringement occurring under the financial assistance.

Data, Databases, and Software - The rights to any work produced or purchased under a NRC federal financial assistance award are determined by 2 CFR 215.36. Such works may include data, databases or software. The Grantee owns any work produced or purchased under a NRC federal financial assistance award subject to NRC's right to obtain, reproduce, publish or otherwise use the work or authorize others to receive, reproduce, publish or otherwise use the data for Government purposes.

Copyright - The Grantee may copyright any work produced under a NRC federal financial assistance award subject to NRC's royalty-free nonexclusive and irrevocable right to reproduce, publish or otherwise use the work or authorize others to do so for Government purposes. Works jointly authored by NRC and Grantee employees may be copyrighted but only the part authored by the Grantee is protected because, under 17 USC § 105, works produced by Government employees are not copyrightable in the United States. On occasion, NRC may ask the Grantee to transfer to NRC its copyright in a particular work when NRC is undertaking the primary dissemination of the work. Ownership of copyright by the Government through assignment is permitted under 17 USC § 105.

Records retention and access requirements for records of the Grantee shall follow established provisions in 2 CFR 215.53.

Organizational Prior Approval System

In order to carry out its responsibilities for monitoring project performance and for adhering to award terms and conditions, each Grantee organization shall have a system to ensure that appropriate authorized officials provide necessary organizational reviews and approvals in advance of any action that would result in either the performance or modification of an NRC supported activity where prior approvals are required, including the obligation or expenditure of funds where the governing cost principles either prescribe conditions or require approvals.

The Grantee shall designate an appropriate official or officials to review and approve the actions requiring NRC prior approval. Preferably, the authorized official(s) should be the same official(s) who sign(s) or countersign(s) those types of requests that require prior approval by NRC. The authorized organization official(s) shall not be the principal investigator or any official having direct responsibility for the actual conduct of the project, or a subordinate of such individual.

Conflict Of Interest Standards of this award shall follow provisions as established in 2 CFR 215.42 Codes of Conduct.

Dispute Review Procedures

a. Any request for review of a notice of termination or other adverse decision should be addressed to the Grants Officer. It must be postmarked or transmitted electronically no later than 30 days after the postmarked date of such termination or adverse decision from the Grants Officer.

b. The request for review must contain a full statement of the Grantee's position and the pertinent facts and reasons in support of such position.

c. The Grants Officer will promptly acknowledge receipt of the request for review and shall forward it to the Director, Office of Administration, who shall appoint a review committee consisting of a minimum of three persons.

d. Pending resolution of the request for review, the NRC may withhold or defer payments under the award during the review proceedings.

e. The review committee will request the Grants Officer who issued the notice of termination or adverse action to provide copies of all relevant background materials and documents. The committee may, at its discretion, invite representatives of the Grantee and the NRC program office to discuss pertinent issues and to

submit such additional information as it deems appropriate. The chairman of the review committee will insure that all review activities or proceedings are adequately documented.

f. Based on its review, the committee will prepare its recommendation to the Director, Office of Administration, who will advise the parties concerned of his/her decision.

Termination and Enforcement. Termination of this award by default or by mutual consent shall follow provisions as established in 2 CFR 215.60,

Monitoring and Reporting § 215.51

a. Grantee Financial Management systems must comply with the established provisions in 2 CFR 215.21

- Payment – 2 CFR 215.22
- Cost Share – 2 CFR 215.23
- Program Income – 2 CFR 215.24
  - Earned program income, if any, shall be added to funds committed to the project by the NRC and Grantee and used to further eligible project or program objectives.
- Budget Revision – 2 CFR 215.25
  - In accordance with 2 CFR 215.25(e), the NRC waives the prior approval requirement for items identified in sub-part (e)(1-4).
  - The Grantee is not authorized to rebudget between direct costs and indirect costs without written approval of the Grants Officer.
  - Allowable Costs – 2 CFR 215.27

b. **Federal Financial Reports**

Effective October 1, 2008, NRC transitioned from the SF–269, SF–269A, SF–272, and SF– 272A to the Federal Financial Report (SF-425) as required by OMB:
http://www.whitehouse.gov/omb/fedreg/2008/081308_ffr.pdf
http://www.whitehouse.gov/omb/grants/standard_forms/ffr.pdf
http://www.whitehouse.gov/omb/grants/standard_forms/ffr_instructions.pdf

The Grantee shall submit a "Federal Financial Report" (SF-425) on a quarterly basis for the periods ending 3/31, 6/30, 9/30, and 12/31 or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period. A final SF-425 shall be submitted within 90 days after expiration of the award.

Period of Availability of Funds 2 CFR § 215.28

a. Where a funding period is specified, a Grantee may charge to the grant only allowable costs resulting from obligations incurred during the funding period and any pre-award costs authorized by the NRC.

b. Unless otherwise authorized in 2 CFR 215.25(e)(2) or a special award condition, any extension of the award period can only be authorized by the Grants Officer in writing. Verbal or written assurances of funding from other than the Grants Officer shall not constitute authority to obligate funds for programmatic activities beyond the expiration date.

c. The NRC has no obligation to provide any additional prospective or incremental funding. Any modification of the award to increase funding and to extend the period of performance is at the sole discretion of the NRC.

d. Requests for extensions to the period of performance shall be sent to the Grants Officer at least 30 days prior to the grant/cooperative agreement expiration date. Any request for extension after the expiration date shall not be honored.

Automated Standard Application For Payments (ASAP) Procedures

Unless otherwise provided for in the award document, payments under this award will be made using the Department of Treasury's Automated Standard Application for Payment (ASAP) system < http://www.fms.treas.gov/asap/ >. Under the ASAP system, payments are made through preauthorized electronic funds transfers, in accordance with the requirements of the Debt Collection Improvement Act of 1996. In order to receive payments under ASAP, Grantees are required to enroll with the Department of Treasury, Financial Management Service, and Regional Financial Centers, which allows them to use the on-line method of withdrawing funds from their ASAP established accounts. The following information will be required to make withdrawals under ASAP: (1) ASAP account number – the award number found on the cover sheet of the award; (2) Agency Location Code (ALC) – 31000001; and Region Code. Grantees enrolled in the ASAP system do not need to submit a "Request for Advance or Reimbursement" (SF-270), for payments relating to their award.

Audit Requirements

Organization-wide or program-specific audits shall be performed in accordance with the Single Audit Act Amendments of 1996, as implemented by OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations." http://www.whitehouse.gov/omb/circulars/a133/a133.html Grantees are subject to the provisions of OMB Circular A-133 if they expend $500,000 or more in a year in Federal awards.

The Form SF-SAC and the Single Audit Reporting packages for fiscal periods ending on or after January 1, 2008 must be submitted online.

1. Create your online report ID at http://harvester.census.gov/fac/collect/ddeindex.html
2. Complete the Form SF-SAC
3. Upload the Single Audit
4. Certify the Submission
5. Click "Submit."

Organizations expending less than $500,000 a year are not required to have an annual audit for that year but must make their grant-related records available to NRC or other designated officials for review or audit.

III. Programmatic Requirements

Performance (Technical) Reports

a. The Grantee shall submit performance (technical) reports electronically to the NRC Project Officer and Grants Officer as specified in the special award conditions in the same frequency as the Federal Financial Report unless otherwise authorized by the Grants Officer.

b. Unless otherwise specified in the award provisions, performance (technical) reports shall contain brief information as prescribed in the applicable uniform administrative requirements 2 CFR §215.51 which are incorporated in the award.

Unsatisfactory Performance

Failure to perform the work in accordance with the terms of the award and maintain at least a satisfactory performance rating or equivalent evaluation may result in designation of the Grantee as high risk and assignment of special award conditions or other further action as specified in the standard term and condition entitled "Termination".

Failure to comply with any or all of the provisions of the award may have a negative impact on future funding by NRC and may be considered grounds for any or all of the following actions: establishment of an accounts receivable, withholding of payments under any NRC award, changing the method of payment from advance to

reimbursement only, or the imposition of other special award conditions, suspension of any NRC active awards, and termination of any NRC award.

Other Federal Awards With Similar Programmatic Activities
The Grantee shall immediately provide written notification to the NRC Project Officer and the Grants Officer in the event that, subsequent to receipt of the NRC award, other financial assistance is received to support or fund any portion of the program description incorporated into the NRC award. NRC will not pay for costs that are funded by other sources.

Prohibition Against Assignment By The Grantee
The Grantee shall not transfer, pledge, mortgage, or otherwise assign the award, or any interest therein, or any claim arising thereunder, to any party or parties, banks, trust companies, or other financing or financial institutions without the express written approval of the Grants Officer.

Site Visits
The NRC, through authorized representatives, has the right, at all reasonable times, to make site visits to review project accomplishments and management control systems and to provide such technical assistance as may be required. If any site visit is made by the NRC on the premises of the Grantee or contractor under an award, the Grantee shall provide and shall require his/her contractors to provide all reasonable facilities and assistance for the safety and convenience of the Government representative in the performance of their duties. All site visits and evaluations shall be performed in such a manner as will not unduly delay the work.

IV. Miscellaneous Requirements

Criminal and Prohibited Activities

a. The Program Fraud Civil Remedies Act (31 USC §§ 3801-3812), provides for the imposition of civil penalties against persons who make false, fictitious, or fraudulent claims to the Federal government for money (including money representing grant/cooperative agreements, loans, or other benefits.)

b. False statements (18 USC § 287), provides that whoever makes or presents any false, fictitious, or fraudulent statements, representations, or claims against the United States shall be subject to imprisonment of not more than five years and shall be subject to a fine in the amount provided by 18 USC § 287.

c. False Claims Act (31 USC 3729 et seq), provides that suits under this Act can be brought by the government, or a person on behalf of the government, for false claims under federal assistance programs.

d. Copeland "Anti-Kickback" Act (18 USC § 874), prohibits a person or organization engaged in a federally supported project from enticing an employee working on the project from giving up a part of his compensation under an employment contract.

American-Made Equipment And Products
Grantees are herby notified that they are encouraged, to the greatest extent practicable, to purchase American-made equipment and products with funding provided under this award.

Increasing Seat Belt Use in the United States
Pursuant to EO 13043, Grantees should encourage employees and contractors to enforce on-the-job seat belt policies and programs when operating company-owned, rented or personally-owned vehicle.

Federal Employee Expenses
Federal agencies are generally barred from accepting funds from a Grantee to pay transportation, travel, or other expenses for any Federal employee unless specifically approved in the terms of the award. Use of award funds (Federal or non-Federal) or the Grantee's provision of in-kind goods or services, for the purposes of transportation, travel, or any other expenses for any Federal employee may raise appropriation

augmentation issues. In addition, NRC policy prohibits the acceptance of gifts, including travel payments for Federal employees, from Grantees or applicants regardless of the source.

Minority Serving Institutions (MSIs) Initiative

Pursuant to EOs 13256, 13230, and 13270, NRC is strongly committed to broadening the participation of MSIs in its financial assistance program. NRC's goals include achieving full participation of MSIs in order to advance the development of human potential, strengthen the Nation's capacity to provide high-quality education, and increase opportunities for MSIs to participate in and benefit form Federal financial assistance programs. NRC encourages all applicants and Grantees to include meaningful participations of MSIs. Institutions eligible to be considered MSIs are listed on the Department of Education website: http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html

Research Misconduct

Scientific or research misconduct refers to the fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. It does not include honest errors or differences of opinions. The Grantee organization has the primary responsibility to investigate allegations and provide reports to the Federal Government. Funds expended on an activity that is determined to be invalid or unreliable because of scientific misconduct may result in a disallowance of costs for which the institution may be liable for repayment to the awarding agency. The Office of Science and Technology Policy at the White House published in the Federal Register on December 6, 2000, a final policy that addressed research misconduct. The policy was developed by the National Science and Technology Council (65 FR 76260). The NRC requires that any allegation be submitted to the Grants Officer, who will also notify the OIG of such allegation. Generally, the Grantee organization shall investigate the allegation and submit its findings to the Grants Officer. The NRC may accept the Grantee's findings or proceed with its own investigation. The Grants Officer shall inform the Grantee of the NRC's final determination.

Publications, Videos, and Acknowledgment of Sponsorship

Publication of the results or findings of a research project in appropriate professional journals and production of video or other media is encouraged as an important method of recording and reporting scientific information. It is also a constructive means to expand access to federally funded research. The Grantee is required to submit a copy to the NRC and when releasing information related to a funded project include a statement that the project or effort undertaken was or is sponsored by the NRC. The Grantee is also responsible for assuring that every publication of material (including Internet sites and videos) based on or developed under an award, except scientific articles or papers appearing in scientific, technical or professional journals, contains the following disclaimer:

> "This [report/video] was prepared by [Grantee name] under award [number] from [name of operating unit], Nuclear Regulatory Commission. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the view of the [name of operating unit] or the US Nuclear Regulatory Commission."