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TECHNICAL BASIS DOCUMENT FORCRITERIA AND PROCESSES FOR THE CERTIFICATION OF NON-RADIOACTIVE HAZARDOUS AND NON-HAZARDOUS WASTES

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I. INTRODUCTION

This Technical Basis Document (TBD) identifies how the values presented in the *Criteria and Processes for the Certification of Non-Radioactive Hazardous and Non-Hazardous Wastes* were derived.

The original moratorium document (UCRL-AR-109662) applied only to hazardous wastes generated in Radioactive Materials Management Areas (RMMAs) that were destined for off-site Treatment, Storage, and Disposal Facilities (TSDFs) that did not possess a radioactive materials license. Since its inception, the original moratorium document has become the *de facto* free-release procedure for potentially volumetrically contaminated materials of all varieties. This was promulgated in a February 4, 1992 memo from Jyle Lytle, Deputy Assistant Secretary for Waste Management, entitled *Update: Moratorium on Shipment of Potentially Radioactive Hazardous and Toxic Wastes.* In this memo, Ms. Lytle states, "While the moratorium does not apply to non-hazardous/non-TSCA solid wastes and non-waste materials, the same release criteria apply."

Over the past few years, a considerable quantity of data and operating experience has been developed, which has shown the limitations of UCRL-AR-109662. The original Moratorium is out of date, and many of the organizations and procedures that it references are no longer in existence. In addition, the original document lacked sufficient detail to be used as an LLNL-wide procedure for free release, as it only addressed hazardous wastes. The original moratorium document also used highly optimistic "action limits," which were based on theoretically achievable minimum detectable activity (MDA) levels for various matrices. Years of operating experience has shown that these action limits are simply not achievable for certain analyses in certain matrices, either due to limitations in sample size, or underestimates of the contribution of naturally-occurring radioactive materials, resulting in the mis-characterization of samples of these matrices as radioactive, when no radioactivity was added by LLNL operations.

The new moratorium document updates the organizations involved in Moratorium Declarations, specifically addresses non-hazardous waste matrices, and allows for alternative types of analysis. The new moratorium document formalizes the process of release of potentially volumetrically-contaminated waste materials from radiological controls at LLNL.

II. ACRONYMS AND DEFINITIONS

ASTM	American Society for Testing Materials
DOE	Department of Energy
EPA	Environmental Protection Agency
HEPA	High Efficiency Particulate Air
HPS	Health Physics Society
IAEA	International Atomic Energy Agency
NRC	Nuclear Regulatory Commission
RHWM	Radioactive and Hazardous Waste Management

Action Limit	A limit for radioactivity in a specified matrix below which the waste may be released from radiological controls. Derived from, but typically not equal to, the Minimum Detectable Concentration (MDC) for a specified type of analysis.
MDA	Minimum Detectable Activity. For the purposes of this document, this is defined as Currie's L_D. A calculated value of the lowest activity that can be detected in a specific sample within a 95% confidence interval, given a specified background count rate, efficiency, chemical yield, and sample size.
MDC	Minimum Detectable Concentration. The MDA corrected for sample size.
NORM	Naturally-Occurring Radioactive Material. An example is K-40 or Th-232 present in soil with no contribution from man-made sources.
NRA	No Radioactivity Added. A waste that has met the requirements of this document for release from radiological controls.
RMA	Radiological Materials Area. Any area within a controlled area, accessible to individuals, where items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in the ES&H Manual, Document 20.2, Appendix E, *Values for Establishing Sealed Radioactive Source Accountability and Radioactive Materials Posting and Labeling Requirements.*
RMMA	Radioactive Materials Management Area. A workspace at LLNL in which the potential exists for contamination due to the presence of un-encapsulated or unconfined radioactive material, or an area that is exposed to beams or other sources of particles capable of causing activation.

III. USE OF EXISTING REGULATIONS, ORDERS, AND STANDARDS

Wastes for disposal which satisfy the requirements of the following regulations and Department of Energy (DOE) Orders may be released from radiological controls:

1. Are of a form and history of use such that only surface contamination is possible, and meet the surface contamination release limits of DOE Order 5400.5. Materials with known surface contamination shall be decontaminated to levels that are as low as is reasonably achievable. LLNL promulgates these regulations and describes their implementation in the ES&H Manual, Document 20.2, *LLNL Radiological Safety Program for Radioactive Materials.*

2. Meet the City of Livermore Wastewater Discharge Permit for wastewaters sent to the sanitary sewer (Publicly Owned Treatment Works).

3. Meet radioactivity limits established by federal or state regulatory agencies (Nuclear Regulatory Commission [NRC], Environmental Protection Agency [EPA], and/or State Department of Health Services), and approved by DOE. See Memo from Nakahara to Crawford (1993), approving the use of 10 CFR 20.2005 (See Reference No. 10).

IV. REQUIREMENTS FOR ANALYSIS OF RADIOACTIVITY

Sampling of bulk wastes shall be performed by technicians under the direction of the Radioactive and Hazardous Waste Management (RHWM) Sampling Team. Sampling activities shall be documented.

The process described in this document applies to a specific sample, not a waste stream. Application of the results of a given sample to multiple containers, or a complete waste stream, requires additional analysis and control which is beyond the scope of this document, but is provided in the waste specific characterization documentation package.

For the purposes of this document, analysis of bulk samples for radioactivity shall be performed by laboratories that can meet the detection limits identified in Table 1, *Historical LLNL Action Limits*. Off-site commercial analytical laboratories under contract with LLNL work to an approved Statement of Work for Analytical Services, which includes documented requirements for analytical methods and the associated detection limits. Samples may also be analyzed by on-site LLNL laboratories that operate under an approved quality assurance plan and operating procedures, and produce data that is scientifically valid, defensible, and of known precision and accuracy. All analyses are performed in accordance with established procedures from recognized organizations such as the American

Society for Testing Materials (ASTM)/DOE/EPA. Transmitted results shall include measured values, total propagated uncertainties, and sample-specific minimum detectable activity values for each analysis.

V. ANALYSIS OF TRUE DETECTION LIMITS, AS COMPARED TO CALCULATED MORATORIUM ACTION LIMITS

When the original Moratorium document was written in 1991, the action limits for no-rad-added (NRA) were based on calculated limits of sensitivity for two types of radioactivity analysis; gas proportional counting for gross alpha and beta activity, and liquid scintillation counting for tritium. While there are a great deal of methods used in the calculation of detection limits, Currie's L_D is probably the most commonly accepted method. This is defined as the true net signal level that may be expected *a priori* to lead to detection. In cases where the background count time is similar to the sample count time, this detection limit, often called Minimum Detectable Activity (MDA) is given at the 95% confidence limit as follows:

$$MDA = \frac{2.71 + 4.66 * \sqrt{B}}{t * E}$$

B = Total background counts
t = Counting time in minutes
E = Counting efficiency as a fraction. Note that this includes both counting efficiency, and the effects of sample self-absorption, if present.

When the MDA is divided by the sample size, the result is the Minimum Detectable Concentration (MDC).

In order to determine the detection limits for these types of analyses, the following information is required:

- Count Time
- Background Count Rate
- Sample Size
- Detection Efficiency (including both detector-specific, and sample-specific effects)

The original action limits were calculated for five matrices (aqueous, oils, solvents, coolants, and solids/sludges) using measured values for background count rates, but *assumed* values for sample size and detection efficiency. Both liquid scintillation counting and gas proportional counting have real physical limits on the sample size.

In liquid scintillation counting, overly large samples can result in immiscible sample-cocktail mixtures (the sample coming out of solution in the cocktail), or the cocktail becoming colored to the point where the detection efficiency drops to zero. In gas proportional counting, overly large sample sizes result in a high residual mass, and therefore a high attenuation of alpha particles. Operating experience from years of waste analysis has shown that the achievable counting sample size and detection efficiency were both lower than originally assumed, while the background count rates have remained roughly constant. This means that the true achievable detection limits for waste samples are generally higher, sometimes by a large factor, than the original calculated moratorium action limits.

In the original Moratorium document, in cases where the action limits could not be achieved for a particular sample, the limits defaulted to the actual sample-specific MDA. The tables below show action limits in **bold**, along with the assumed sample sizes for each matrix in *italics*.

Table 1: Historical Calculated LLNL Moratorium Action Limits (from 1991 Moratorium document).

Matrix	Gross α	Grossβ	Tritium
Aqueous (AQ)	**20 picoCi/L** *25 ml Sample* 100 min count	**60 picoCi/L** *25 ml Sample* 100 min count	**3000 picoCi/L** *5 ml Sample* 50 min count
Oil (OI)	**500 picoCi/L** *5 ml Sample* 100 min count	**2000 picoCi/L** *5 ml Sample* 100 min count	**20,000 picoCi/L** *0.1 ml Sample* 50 min count
Solids, Sludges (SO, SL)	**1 picoCi/gm** *0.5 gm Sample* 100 min count	**3 picoCi/gm** *0.5 gm Sample* 100 min count	**5 picoCi/gm** *1 gm Sample* 50 min count
Solvents (SV)	**100 picoCi/L** *5 ml Sample* 100 min count	**300 picoCi/L** *5 ml Sample* 100 min count	**20,000 picoCi/L** *0.1 ml Sample* 50 min count
Coolants (CO)	**20 picoCi/L** *25 ml Sample* 100 min count	**60 picoCi/L** *25 ml Sample* 100 min count	**20,000 picoCi/L** *5 ml Sample* 0.1 ml Sample

In order to determine the true detection limits for real samples, a large sample of data from the past three years of waste analysis was analyzed to determine the average sample size, detection efficiency, and MDC for different matrices. These samples were analyzed at Chemistry and Material Science Environmental Services, LLNL's state-certified on-site environmental analysis lab. Table 2 summarizes the data from 106 Aqueous samples, 121 Solid/Sludge samples, 21 Oils, and 30 Solvents was analyzed. Results are discussed below.

Aqueous Samples: Aqueous samples analyzed for gamma, alpha, and beta radioactivity show two distinct populations: a group of "clean matrix" retention tanks, berm waters and rain waters, which make up 64% of the total aqueous samples; and a group of "dirty matrix" mop waters, spent chemicals, and liquids high in dissolved solids which make up 36% of the aqueous samples. For the "clean matrix" samples, the average sample size was 26.5 mls, the average residual sample mass was 14 mg, and the average alpha and beta MDAs were 17 picoCi/L and 29 picoCi/L, respectively, in good agreement with the 1991 action limits. In contrast, the "dirty matrix" group of samples had an average sample size of 1.1 mls and a residual mass of 41 mg. For this group of samples, the average alpha detection limit was significantly higher at 1039 picoCi/L, and the average beta MDA was 1411 picoCi/L. For tritium analysis for both groups of samples, the action limit sample size of 5 mls and detection limit of 3000 picoCi/L were readily achievable.

Oil Samples: Oil samples analyzed for radioactivity had an average sample size of 0.2 mls, an average residual sample mass of 9 mg, and the average alpha and beta detection limits were 4937 picoCi/L and 9093 picoCi/L, respectively. These values are significantly higher than the original moratorium limits. For tritium analysis, the average sample size was only 0.1 ml, and the counting efficiency was significantly less than the assumed value in the 1991 action limit, leading to a detection limit of 35,000 picoCi/L.

Solid/Sludge Samples: Solid and sludge samples analyzed for radioactivity had an average sample size of 0.21 grams, and an average residual sample mass of 41 mg. The average alpha and beta detection limits were 5.8 picoCi/gm and 7.5 picoCi/gm, both of which are higher than the 1991 action limits. For tritium analysis, the 1-gram sample size resulting in a 5 picoCi/gm detection limit was readily achieved.

Solvent Samples: Solvent samples analyzed for radioactivity had an average sample size of 1.2 mls, an average residual sample mass of 30 mg, and the average alpha and beta detection limits were 1117 picoCi/L and 1647 picoCi/L. These values are slightly higher than the original moratorium limits. For tritium analysis, the average sample size was only 0.1 ml, and the counting efficiency was significantly less than the assumed value in the 1991 action limit, leading to a detection limit of 35,000 picoCi/L.

Coolant Samples: For the collection period, very few coolant samples have been received for radioactivity analysis, as much of this waste stream is now recycled. Coolants that are analyzed are treated as "dirty matrix" aqueous samples, and have MDCs similar to this group.

Table 2: Historically achieved Minimum Detectable Concentrations at LLNL.

	Gross α	Gross β	Tritium
Aqueous (AQ) **"Clean Matrix"** **RT, Berms, Rain water**	**17 picoCi/L** *Avg=26.5 ml Sample* 100 min count	**29 picoCi/L** *Avg=26.5 ml Sample* 100 min count	**3000 picoCi/L** *5 ml Sample* 50 min count
Aqueous (AQ) **"Dirty Matrix"** **Spent chemicals, mop water** **Coolants**	**1039 picoCi/L** *Avg=1.1 ml Sample* 100 min count	**1411 picoCi/L** *Avg=1.1 ml Sample* 100 min count	**3000 picoCi/L** *5 ml Sample* 50 min count
Oil (OI)	**4937 picoCi/L** *Avg=0.19 ml Sample* *S.D.=(±0.32 ml)* 100 min count	**9093 picoCi/L** *Avg=0.19 ml Sample* *S.D.=(±0.32 ml)* 100 min count	**35,000 picoCi/L** *0.1 ml Sample* 50 min count
Solids, Sludges (SO, SL)	**5.8 picoCi/gm** *Avg=0.21 gm Sample* *S.D.=(±0.17 gm)* 100 min count	**7.5 picoCi/gm** *Avg=0.21 gm Sample* *S.D.=(±0.17 gm)* 100 min count	**5 picoCi/gm** *1 gm Sample* 50 min count
Solvents (SV)	**1117 picoCi/L** *Avg=1.2 gm Sample* *S.D.=(±0.76 gm)* 100 min count	**1647 picoCi/L** *Avg=1.2 gm Sample* *S.D.=(±0.76 gm)* 100 min count	**35,000 picoCi/L** *0.1 ml Sample* 50 min count

See Appendices A through E for raw data.

Based on the above analysis, LLNL proposes to use the following action limits to determine if samples analyzed for radioactivity are “rad-added” or “no-radioactivity added.” It should be noted that while these values are higher than the original (1991) Moratorium action limits, this does not imply that higher levels of radioactivity are being released by LLNL. Both the original 1991 Moratorium document and this revision allow the use of the actual MDC for a sample in cases where the action limits cannot be achieved. Since the numbers below are derived from the actual detection limits for real samples, this is not a true increase, but merely an adjustment of the action limits to reflect detection limits that can actually be achieved with real samples.

Table 3. New LLNL Action Limits for NRA analysis.

	Gross α	Gross β	Tritium
Aqueous (AQ) "Clean Matrix" RT, Berms, Rain water	**20 picoCi/L** 100 min count	**60 picoCi/L** 100 min count	**3000 picoCi/L** 50 min count
Aqueous (AQ) "Dirty Matrix" Spent chemicals, mop water Coolants	**1500 picoCi/L** 100 min count	**2000 picoCi/L** 100 min count	**3000 picoCi/L** 50 min count
Oil (OI)	**5000 picoCi/L** 100 min count	**10,000 picoCi/L** 100 min count	**40,000 picoCi/L** 50 min count
Solids, Sludges (SO, SL)	**10 picoCi/gm** 100 min count	**10 picoCi/gm** 100 min count	**5 picoCi/gm** 50 min count
Solvents (SV)	**1500 picoCi/L** 100 min count	**2000 picoCi/L** 100 min count	**40,000 picoCi/L** 50 min count

VI. COMPARISON OF LLNL ACTION LIMITS TO CURRENT EXEMPTION/CLEARANCE STANDARDS

This document maintains the philosophy and approach of the original Moratorium, which defined “No Rad Added” material as being below detection limits for certain specified analytical methods. The analytical methods specified are sensitive, commonly available techniques, not heroic or research-oriented techniques. This approach may be termed “detection-limit based,” as opposed to

"dose-based" or "risk-based" approaches. Dose-based approaches commonly start with scenarios for waste disposal that include transportation, handling at waste disposal sites, and eventual transport of the radioactive materials to the environment where members of exposed groups are then exposed by both external and internal pathways. Computer models then give relationships between radioactivity of the waste for given isotopes, and dose to individuals in these exposed groups. A primary dose criterion is then chosen, which results in activity concentration limits for the chosen isotopes for the waste material that are protective of the primary dose criterion.

This dose-based method of deriving exemption/clearance standards for radioactivity in solid waste materials is used in two commonly cited and reviewed reports: the American National Standards Institute (ANSI), in collaboration with the Health Physics Society (HPS), released ANSI/HPS Standard N13.12 *Surface and Volume Radioactivity Standards for Clearance* in August of 1999, while the International Atomic Energy Agency (IAEA), in 1996, issued an interim report entitled *Clearance Levels for Radionuclides in Solid Materials: Application of Exemption Principles*. Both of these reports only deal with **solid** materials disposed of to sanitary landfills, and both utilize a primary dose criterion of one mrem/year. **Table 4** shows a comparison of the LLNL Action Limits from this document with the ANSI and IAEA derived limits.

Table 4. Comparison of LLNL Action Limits with Exemption/Clearance Standards.

Nuclide	ANSI standard	IAEA report	LLNL Action Limits
High-dose alpha emitter (eg. Pu-239)	3 pCi/gm	2.7 - 27 pCi/gm	10 pCi/gm
High-dose beta emitter (eg. Cs-137)	30 pCi/gm	2.7 - 27 pCi/gm	10 pCi/gm
Uranium (natural or depleted)	30 pCi/gm	2.7 - 27 pCi/gm	10 pCi/gm
Tritium	3000 pCi/gm	27,000 - 270,000 pCi/gm	5 pCi/gm

It can be seen that the LLNL action limits are substantially in agreement with currently accepted dose-based limits. It can further be seen that the LLNL action limits are significantly below any dose-based limits for potentially tritium contaminated objects.

VII. SPECIAL CASE WASTES

Highly Toxic or Potentially Reactive Wastes

If a sample is of such high toxicity and/or reactivity to preclude sample digestion for routine gross alpha/beta analysis via the gas proportional counting method due to increased personnel and infrastructure hazards, the sample may be analyzed via a combination of generator knowledge and other techniques, including liquid scintillation counting and/or gamma spectroscopy (in cases where all expected contaminants are gamma emitters). Liquid mercury and high explosive residues are examples of matrices commonly analyzed via this method.

Due to limitations in the sample aliquot size that may be safely processed for difficult matrices, the Action Limits identified in Table 1 may not be achievable for some wastes, particularly those with large amounts of dissolved solids. In these cases, the actual sample-specific MDC will be used for determining whether the sample is radioactive or not. The limits for declaration of added radioactivity will default to the sample-specific MDC. Samples with an MDC greater than 100 times the Table 3 value for the matrix of concern will not be used for NRA determinations.

Wastes Containing Naturally-Occurring Radioactive Materials (NORM)

Many elements have naturally occurring primordial and/or cosmogenic radioisotopes, which contribute to the radioactivity in waste samples. The majority of these wastes do not contain “DOE added radioactivity.” Examples of these include potassium chloride, a common salt substitute, which produces an easily measurable radiation field, or Be-7, a short-lived cosmogenic nuclide, in High Efficiency Particulate Air (HEPA) filters. NORM, which is incidental to the matrix being analyzed, may be subtracted from the total radioactivity and treated as background when making the determination of “DOE added radioactivity.” One way to do this is to take the potassium concentration of the sample, from total metals analysis, and calculate the expected gross beta activity, then determine if the measured gross beta can be accounted for by the quantity of potassium. An alternative method is based on the analysis of “virgin” or “blank” materials, of the same or similar matrix to the waste, but known to be uncontaminated and determining the incidental natural occurring radioactivity for each matrix or material type.

For commonly-measured matrices where NORM or sample size make it difficult to determine whether radioactivity was added, such as mop water and machine oils, a blank material study may be performed by analyzing at least five samples from areas known to have never been associated with radioactive materials work. The average value and standard deviation of the gross alpha, beta, and tritium will be calculated for this set of samples. These results will be

documented in a memo to file, attached to the requisition, and these limits will be used to determine if the waste contains added radioactivity.

Discarded "source material" as defined by the Atomic Energy Act, which includes uranium and thorium, or chemical compounds or commercial articles with identified uranium or thorium content are to be treated as radioactive regardless of how they were procured, stored, or handled. While specific exemptions may apply, the use of such exemptions must be approved by RHWM, and documented on a case-by-case basis.

Soils and Soil-Analogues

Table 5. Action Limits for Soils and Soil-analogues

Criteria	Action Limit
Gross Alpha	≤15 pCi/gm
Gross Beta	≤25pCi/gm
Tritium	≤5pCi/gm

Soil values for Gross Alpha of 15 pCi/g and Gross Beta of 25pCi/g are first identified by Bill Isherwood (Attachment 1) and are based upon analysis means plus two standard deviations for a population of 184 pre-construction samples from non-suspect sites in the Environmental Protection Department database. The attachment also identifies that known contamination areas will require special attention. This attachment makes no recommendation on tritium.

The Gross Alpha and Gross Beta results are endorsed in a memo from Howard L. Hall (Attachment 2) and a tritium value of 5 pCi/g in soil is put forth for unrestricted release based upon the Limit Of Sensitivity (LOS) of tritium in soil. This memo also identifies that soil with a tritium concentration between 5-60 pCi/g may not be landfilled but may be reused on site. Soils with tritium concentrations exceeding 60pCi/g must be handled as radioactive waste. The attachment also recommends bulk analysis of concrete and asphalt specifically for the identification of Pu.

HEPA Filters

HEPA filters are a particularly difficult matrix to safely analyze destructively. The level of rigor required for determining if a HEPA is to be managed as radioactive depends upon the level of generator knowledge available for the particular ventilation system with which the HEPA is associated. Filters with documented histories of use in facilities known to work only with natural and/or depleted uranium and/or thorium isotopes may be analyzed for radioactivity via a combination of swipe sampling, and gamma spectroscopy. If a swipe sample of the filter inlet shows no removable activity above ES&H Manual Document 20.2,

Appendix D limits, and a gamma count of the filter shows no detectable activity (with an MDA for 238-Uranium of 1 microCi or less), the filter will be declared non-radioactive. Filters from facilities that either have a poorly-known operating history, or have a history of using isotopes other than uranium or thorium may not be analyzed via this method, and shall either be sampled destructively, or declared radioactive.

VIII. ATTACHMENTS

1. Memorandum, From Bill Isherwood to Steve Hunt, *Disposition of excess soil based on pre-construction soil sampling.*, August 26, 1991.
2. Environmental Protection Department, Memo from Howard L. Hall to Bill Isherwood, *Report on the ad hoc committee on radiological analysis of soils and preconstruction debris.*, April 15, 1992.

IX. APPENDICES

A. Aqueous – Clean Matrix (AQ-CM), Raw Data
B. Aqueous – Dirty matrix (AQ-DM), Raw Data
C. Oil (OI), Raw Data
D. Solids, Sludges (SO,SL), Raw Data
E. Solvents (SV), Raw Data

X. REFERENCES

1. Code of Federal Regulations, 10 CFR 835, *Occupational Radiation Protection*, Appendix D, *Surface Contamination Values*, latest revision.
2. DOE Order 5400.5, Chg 2, *Radiation Protection of the Public and the Environment*, latest revision.
3. Lawrence Livermore National Laboratory. *Criteria and Procedures for the Certification of Nonradioactive Hazardous Waste*, UCRL-AR-109662.
4. Lawrence Livermore National Laboratory. ES&H Manual, Document 20.2, *LLNL Radiological Safety Program for Radioactive Materials.*
5. U.S. Department of Energy (DOE) document, *Performance Objective for Certification of Non-Radioactive Hazardous Waste* (EM-30, 1995).
6. U.S. Department of Energy (DOE) document, *Guide to Good Practice for Establishing Authorized Limits for the Release of Waste and Property Contaminated with Residual Radioactivity* (March 1999).

7. Statement of Work for Analytical Services in Support of Lawrence Livermore National Laboratory and Lawrence Livermore National Laboratory, February 2004.

8. U.S. Department of Energy, Research and Development Laboratory Working Group (RADWG) Analytical Chemistry Laboratory Committee, Document No. DOE/CH-9403., September 14, 1993.

9. Environmental Protection Department, Environmental Monitoring and Analysis Division, Radiation Analytical Sciences Section, Memo from Howard Hall to Bill Isherwood, Subject: *Report of the ad hoc committee on radiological analyses of soils and preconstruction debris*, April 15, 1992.

10. U.S. Department of Energy, Memo from Daniel Nakahara to Richard Crawford, *Use of Nuclear Regulatory Commission (NRC) Guidelines for Shipment of Hazardous Waste for Disposal*, December 27, 1993.

Attachment 1 - Memorandum from Isherwood to Hunt, 8/26/91 (page 1 of 5)

MEMORANDUM: August 26, 1991

To: Steve Hunt

From: Bill Isherwood

Disposition of excess soil based on pre-construction soil sampling.

Background:

Unconsolidated materials, loosely referred to as soils, are generated during construction projects on-site, and in lesser amounts from the environmental sampling and restoration programs. These materials usually consist of unconsolidated sedimentary materials, but may also include debris such as asphalt or imported fill materials. Excess soils are frequently disposed of off-site.

The objectives of sampling and analysis of the soils are (a) to ensure proper disposal of materials, (b) to protect workers exposed to the materials, and (c) to determine the need for restoration activities. Only the disposal issue is considered in this memo, as the protection of workers and need for restoration are adequately dealt with elsewhere.

There are no current regulations that provide radiological limits applicable to the disposal of soils. Laboratory policy, however, has been to perform radiological analyses on all soils prior to disposal; primarily to assure all parties that no materials from the Lab are placed in landfills in a manner that might subsequently be considered inappropriate or incur future liability (either legal of public relations). Disposal of soils that are not known or suspected to be contaminated are not controlled under RCRA. Disposal of the Environmental Restoration program's investigation-derived wastes (drill cuttings, core samples, and drilling mud) is covered by the Ground Water Project Quality Assurance Project Plan and Standard Operating Procedures, which have been reviewed and accepted by EPA and the California State agencies under their CERCLA oversight responsibilities.

DOE Order 5400.5 (IV, 4 a) provides guidance for residual concentrations of specific Ra and Th isotopes not to exceed 15 pCi/g in averaged soil more than 15 cm below the surface. This value should generally be comparable to a gross alpha value derived from our pre-construction soil samples, without identification of the responsible isotopes.

Historically, the actual decision on disposal of construction soils appears to have been made subjectively by the environmental

analyst in consultation with other experts in ORAD, based on gross alpha and gross beta counts, as well as chemical analyses performed off-site.

Problem:

Soils on- and off-site contain naturally occurring radioisotopes at levels generally exceeding the limits of sensitivity provided in LLNL's proposed Criteria and Procedures for the Identification and Management of Mixed Waste (Table 1, LLNL Criteria). A large increase in effort would be necessary to perform gamma spectrum and associated chemical analyses to verify individually that the observed activities result from natural (as opposed to "added") radioactivity and the increased workload is beyond the capabilities of LLNL at this time.

Historically, Hazards Control has provided some support in both sample preparation and counting. (By far, the most time consuming part of the process is the sample preparation.) HC does not see the analysis of these samples as within their mission and has minimal resources. This has resulted in low priority being given to such work, lack of committment to turn-around times, and an expressed desire to not perform this work in the future.

The use of off-site contract laboratories has had a checkered past. TMA Norcal is under contract to EPD, but has not been able to provide consistent turn-around times less than 90 days, although as of August 23, they claim 8 weeks (56 days). Their standard LOS's are also above those of our LLNL labs. A New Mexico lab, CEP, has been contacted and claims a 21 day standard turn-around, with a rush of 7 days available for a 50% surcharge. Their LOS's compare favorably with LLNL's. Although CEP is not under direct contract to LLNL, they do sub-contract to ETC, whose LLNL contract has just been reinstated.

A compounding factor in the length of time required to get results from off-site laboratories has been the protocols associated with "special nuclear handling" procedures used for sending samples to a laboratory for radiological analyses. Reportedly, several weeks have often been lost in getting the samples off the LLNL site.

The environmental analysts estimate an average of about 25 pre-construction soil samples per month are generated by the current procedures, but they may come sporadically in batches of 60 or 80. The EPD analytical laboratories (EAS and RAS) must now give first priority to compliance sample analysis for HWM, leaving no resources to analyze pre-construction soil samples. Failure to

provide timely decisions on soil disposal has the potential to delay major construction projects and jeopardize funding.

Natural Background Radioactivity

EPD's database of soil analyses has 184 results for gross alpha and gross beta. None of these samples comes from an area suspected to have contamination with a radioisotope which would elevate the gross alpha or beta activity nor, on cursory examination, appear to be outliers of a normal (log-normal) distribution of results. The averages, standard deviations, and LOS in the LLNL Criteria are as follows:

	Average	Standard Deviation	LOS
gross alpha	5.5 pCi/g	4.6 pCi/g	1 pCi/g
gross beta	14 pCi/g	5.8 pCi/g	3 pCi/g

(These vary slightly if done after log transformed.)

There are three areas on-site where tritium may have been added to the environment by specific LLNL activities: (1) near the solar evaporation ponds which were located near the present Building 5475, (2) surrounding the leaked tank at Building 292, and (3) by the waste handling facilities at Building 514. Other detectable levels of tritium activity in the LLNL vicinity could be the result of rain-out from LLNL's and SNL's atmospheric emissions.

By far the highest tritium activities measured in on-site soils have been at the Building 292 leak area, where 200,000,000 pCi/L of soil moisture was detected. If this concentration were maintained over a volume of one cubic meter, it would translate to 0.05 Ci/cubic meter; still far below the limit of 40 Ci/cubic meter given in 10 CFR, section 61.55, for classification as a Class A solid waste. The background for on-site soil has been estimated to average about 350 pCi/L of soil moisture (approximately 0.03 pCi/g of soil), which is below the LLNL LOS of 5 pCi/g.

Discussion:

None of the soil in questions is derived from an RMMA nor, except for three relatively well defined areas, is there any reason to believe that radioactivity has been added by LLNL activities. I have not discovered any cases where pre-construction soil analyses have yielded results which have in the past precluded off-site disposal of materials. Without explicit regulatory guidance and with clear indications that no health threat is involved, it appears reasonable to use background data to judge whether soils from on-site can be co-mingled with soils from other sources in public landfills without being liable for environmental insult.

With the site characterization now available from the Lab's Environmental Restoration Program and previous pre-construction sampling, much of the site may be adequately sampled already. Materials from areas of known contamination or potentially leaked underground tanks, of course, continue to require special attention.

Recommendation:

(1) Minimize new pre-construction sampling by utilizing pre-existing data and historical information about the area in question.

(2) Sample as early in the planning process as possible, to avoid last minute rush analysis requests. This should be possible for large jobs by triggering a request at the time NEPA documentation is being prepared. For small jobs, which may have short lead times, adequate space should be planned to store construction soils until analyses are complete.

(3) The Sampling Team at EAS should become the central clearing house for directing samples to the appropriate laboratory for sample prep and analysis. Environmental analysts with ORAD continue to be the liaison with the programs and will be responsible for "pre-screening" of the work site with a micro-R meter. The analysts will work closely with the Sampling Team Leader.

(4) Whenever on-site laboratories cannot commit to less than a 4 week turn-around, the Sampling Team Leader shall direct samples to off-site laboratories capable of meeting the specific analytical needs. In general this will require gross alpha, gross beta, and tritium analyses. LLNL should establish direct contracts with at least one laboratory capable of meeting these needs (e.g. CEP). Until such direct contract is in place, the ETC contract should be utilized, allowing them to sub-contract, as necessary.

(5) Special nuclear handling protocols should not be invoked, *unless* there is a specific reason to believe that the sample is contaminated with radionuclides. This should expedite shipping.

(6) The criteria for off-site disposal should be based on historical background activities. Specifically, I recommend that values of gross alpha less than 15 pCi/g and gross beta less than 25 pCi/g be cleared for unrestricted off-site disposal, as being within the natural range of radioactivity, without further requirement for gamma spectrum and chemical analyses to verify the primordial content. (These values are the means, plus two standard deviations, of the EPD database results.) Use of these values appears to be consistent with the approach used in DOE Order 5400.5.

(7) If the limits above are exceeded (and confirmed by re-analysis if warranted), then the same procedures as given in the

Criteria and Procedures for the Identification and Management of Mixed Waste would apply.

Attachment 2 - Memorandum from Hall to Isherwood, 4/15/92 (page 1 of 2)

Interdepartmental Letterhead
Mail Station L-233
Ext. 2-7446

ENVIRONMENTAL PROTECTION DEPARTMENT
Environmental Monitoring & Analysis Div.
Radiation Analytical Sciences Section

To: Bill Isherwood, EMAD Division Leader
From: Howard L. Hall, RAS Section Leader
Date: April 15, 1992
Subject: Report of the ad hoc committee on radiological analyses of soils and preconstruction debris.

As was requested in Steve Hunt's memo to you dated 9/9/91, a committee was formed to examine the issue of radiological analyses of soil and construction debris. The charge to the committee was to technically review the procedures proposed in your memo to Steve Hunt dated 8/26/91 and to obtain concurrence from RAS, Health Physics, and Environmental Operations Group. The members of the committee were:

Howard Hall	RAS, Chair
Price Russ	EAS
Joy Hirabayashi	EOG
Rich Michalik	EOG
Dave Myers	Health Physics
Dorothy Bishop	ERD
Amelia Hagen	HWM

The committee addressed two issues: first, we technically reviewed the proposed action levels; and second, we examined the issue of what construction debris should be sampled for bulk analyses. The recommendations of the committee are given below.

Proposed action levels:

The values proposed were:

gross alpha:	15 pCi/g soil
gross beta:	25 pCi/g soil
tritium:	No recommendation

The committee concurs with the recommendations for gross alpha and gross beta. Furthermore, the committee recommends a two-tiered action level for tritium in soils. This recommendation is:

Tritium Conc. (pCi/g soil)	Disposal
< 5	No restrictions - may be landfilled off-site
5-60	Cannot be landfilled, but may be re-used on-site
> 60	Soil must be treated as radioactive waste

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We based these values on the RAS LOS for tritium in soil (5 pCi/g) and the proposed drinking water limit from the EPA. We confirmed that these values are consistent with the values used by ERD for management decisions. The committee recommends that the value be measured as the concentration *in the soil, not in the soil moisture*. This should expedite analysis.

Samples to be analyzed by bulk methods:

Cement and asphalt are difficult to analyze by bulk methods due to the intractability of the sample matrix. The committee discussed other methods that might be used for analysis of these materials. Field counting is not sensitive enough to meet the above action levels. Swiping may reach the above levels, however, we had a number of reservations about the removal efficiency of swipes on concrete and other porous, ion-exchanging media. Low-level gamma counting would not detect Pu at the action levels, whereas gross alpha would. We believe failure to perform measurements that would detect Pu would compromise the legitimacy of analysis. Our recommendation is that these samples be analyzed by bulk methods and that the appropriate resources to perform these measurements be allocated.

Howard L. Hall

Howard L. Hall, Chair
Ad hoc committee on radiological analyses of soils and preconstruction debris.

Distribution:

Howard Hall
Price Russ
Joy Hirabayashi
Rich Michalik
Dave Myers
Dorothy Bishop
Amelia Hagen

Keith Gilbert
Susi Jackson
Fred Hoffman
Harry Galles

Appendix A – Aqueous Clean Matrix

Aqueous - Clean Matrix (AQ-CM)

Aqueous - Clean Matrix

CES Sample Number	Rep	Sample Phase	Counting Sample Size (ml)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/ml)	Alpha Action Limit	Corrected Alpha (uCi/ml)	Alpha Error (Percent)	Beta MDA (uCi/ml)	Beta Action Limit	Corrected Beta (uCi/ml)	Beta Error (Percent)
59078	A	AQ	25	0.6	1.29283E-08	2.00E-08	2.28047E-08	54.18503437	2.77697E-08	6.00E-08	6.66485E-08	7.525634024
59078	B	AQ	25	0.4	1.28919E-08	2.00E-08	1.7362E-08	67.28559216	2.77542E-08	6.00E-08	8.30686E-08	4.587181911
59079	0	AQ	25	8.1	1.43707E-08	2.00E-08	1.06529E-07	22.18737265	2.83416E-08	6.00E-08	2.3154E-07	4.751772573
59080	0	AQ	25	7.4	1.42295E-08	2.00E-08	2.17898E-07	14.84012988	2.82889E-08	6.00E-08	3.4661E-07	529707.2093
58570	A	AQ	25	1.3	1.77182E-08	2.00E-08	2.31902E-08	66.76597125	3.64929E-08	6.00E-08	6.42426E-08	241.4546523
58570	B	AQ	25	2.1	1.79192E-08	2.00E-08	8.24328E-09	146.8944235	3.65736E-08	6.00E-08	4.62302E-08	115.443567
58586	0	AQ	25	6.5	1.90662E-08	2.00E-08	1.0096E-08	131.416798	3.70137E-08	6.00E-08	5.07082E-08	384.1585652
58587	0	AQ	25	16.2	2.18642E-08	2.00E-08	1.18593E-06	9.924917773	3.79586E-08	6.00E-08	7.03223E-06	375.2366856
58627	0	AQ	25	48.8	3.47287E-08	2.00E-08	6.31092E-08	53.0633826	4.0833E-08	6.00E-08	6.83484E-08	-796.5995707
58640	0	AQ	25	69.6	3.44079E-08	2.00E-08	1.69383E-08	182.4928655	3.25781E-08	6.00E-08	3.09754E-07	1554.969757
58696	A	AQ	25	24.1	1.80161E-08	2.00E-08	-1.0962E-09	-1336.801593	2.95072E-08	6.00E-08	2.68021E-07	291.0213919
58696	B	AQ	25	15.7	1.59987E-08	2.00E-08	6.95304E-09	183.6452573	2.89051E-08	6.00E-08	1.38464E-07	399.3574049
58699	0	AQ	25	1.1	1.30197E-08	2.00E-08	1.29346E-08	81.27593749	2.78083E-08	6.00E-08	3.02122E-08	-431.0624085
58700	0	AQ	25	45	2.42429E-08	2.00E-08	2.61209E-08	75.73008978	3.08988E-08	6.00E-08	2.96419E-08	1317.694787
58704	0	AQ	25	4.5	1.36591E-08	2.00E-08	1.22843E-07	19.54131771	2.8069E-08	6.00E-08	1.66881E-07	380.8412176
58716	0	AQ	25	3.9	1.3544E-08	2.00E-08	3.40893E-08	41.99855145	2.80232E-08	6.00E-08	6.52372E-08	22.65567389
58720	0	AQ	25	9	2.77169E-08	2.00E-08	2.64764E-05	3.593068045	5.00386E-08	6.00E-08	2.65964E-05	28.43661942
58099	A	AQ	25	37.6	2.18117E-08	2.00E-08	7.54402E-10	1719.164197	3.04247E-08	6.00E-08	5.29988E-09	-1187.536225
58099	B	AQ	25	38.2	2.1998E-08	2.00E-08	-2.7499E-09	-450.6582245	3.0464E-08	6.00E-08	1.11318E-08	61.79914242
58222	0	AQ	25	19.7	1.69292E-08	2.00E-08	1.24105E-09	812.3529799	2.91946E-08	6.00E-08	-3.51634E-09	19.57919951
58247	0	AQ	25	1.7	1.31303E-08	2.00E-08	3.0411E-09	276.8444614	2.78545E-08	6.00E-08	5.95253E-09	15.7810577
58208	A	AQ	25	4.1	1.35823E-08	2.00E-08	1.62894E-08	70.10760735	2.80385E-08	6.00E-08	2.98037E-08	13.50060526
58208	B	AQ	25	5.2	1.37946E-08	2.00E-08	2.56901E-08	51.25899467	2.81223E-08	6.00E-08	4.67929E-08	11.27522268
58216	0	AQ	25	0.5	1.29101E-08	2.00E-08	6.84868E-09	131.2090807	2.77619E-08	6.00E-08	3.41557E-12	12.8779586
57998	A	AQ	25	3	1.33732E-08	2.00E-08	1.95808E-08	59.62802228	2.79543E-08	6.00E-08	1.67105E-08	9.831240089
57998	B	AQ	25	1.8	1.31488E-08	2.00E-08	2.22932E-09	369.6153134	2.78622E-08	6.00E-08	4.8049E-09	9.315504348
57957	0	AQ	25	9.4	1.46368E-08	2.00E-08	7.67922E-09	132.5898198	2.84392E-08	6.00E-08	1.19713E-09	9.165938536
57958	0	AQ	25	1.3	1.30565E-08	2.00E-08	9.1736E-09	104.5916577	2.78237E-08	6.00E-08	6.3722E-09	3.975364251
57959	0	AQ	25	3.4	1.34488E-08	2.00E-08	9.56202E-09	103.3321892	2.7985E-08	6.00E-08	4.64269E-09	4.029708795
55937	0	AQ	25	28	1.90384E-08	2.00E-08	2.93572E-10	4349.536035	2.97788E-08	6.00E-08	8.59073E-08	92.30711447
55905	0	AQ	25	38	2.19357E-08	2.00E-08	-1.5387E-08	-62.48798721	3.04509E-08	6.00E-08	3.56722E-08	109.1243029
55921	A	AQ	25	3.6	1.34868E-08	2.00E-08	-1.6661E-08	-34.46875078	2.80003E-08	6.00E-08	1.29371E-07	70.02215196
55921	B	AQ	25	2.8	1.33355E-08	2.00E-08	-1.9287E-08	-29.71085829	2.7939E-08	6.00E-08	1.73158E-07	72.11730437
55937	0	AQ	25	26.4	1.86121E-08	2.00E-08	-3.673E-08	-22.2593361	2.9668E-08	6.00E-08	3.05744E-07	32.45720769
55885	0	AQ	25	7.9	1.43302E-08	2.00E-08	-3.275E-08	-19.41597006	2.83266E-08	6.00E-08	3.54344E-07	78.40435656
55933	0	AQ	25	23	1.7738E-08	2.00E-08	-4.3597E-08	-18.23192758	2.94296E-08	6.00E-08	4.10399E-07	57.87650271
55953	0	AQ	25	10	1.47613E-08	2.00E-08	-3.6644E-08	-18.00144421	2.84841E-08	6.00E-08	3.98878E-07	61.59978925
60971	A	AQ	25	1.2	1.30381E-08	2.00E-08	7.10514E-09	132.6409452	2.7816E-08	6.00E-08	2.51142E-08	54.64840277
60971	B	AQ	25	1.2	1.30381E-08	2.00E-08	7.36447E-09	130.2643513	2.7816E-08	6.00E-08	3.5037E-08	25.78413767
60972	0	AQ	25	1.4	1.30749E-08	2.00E-08	7.53238E-09	127.7050588	2.78314E-08	6.00E-08	3.27151E-08	14.89639042
60973	0	AQ	25	2	1.3186E-08	2.00E-08	8.19255E-09	120.4290693	2.78776E-08	6.00E-08	3.74375E-08	47.47999583
60927	0	AQ	25	25.2	1.82987E-08	2.00E-08	3.26903E-08	54.4759061	2.95843E-08	6.00E-08	9.64897E-08	34.05991358
60960	0	AQ	25	5.4	1.38336E-08	2.00E-08	1.23832E-07	19.6778031	2.81375E-08	6.00E-08	1.90346E-07	27.12399369
60961	0	AQ	25	6	1.39512E-08	2.00E-08	9.18338E-09	115.5193545	2.8183E-08	6.00E-08	4.43473E-08	24.76641465
60970	0	AQ	25	27.5	1.89041E-08	2.00E-08	2.59148E-08	65.16833657	2.97443E-08	6.00E-08	6.90474E-08	35.48831186
60658	A	AQ	25	6.5	1.40499E-08	2.00E-08	3.6372E-09	279.9266568	2.82209E-08	6.00E-08	8.60306E-08	30.76803773
60658	B	AQ	25	5.7	1.38923E-08	2.00E-08	1.41745E-08	84.68352395	2.81603E-08	6.00E-08	9.62286E-08	25.00571803
60710	0	AQ	25	2.9	1.33544E-08	2.00E-08	7.66296E-09	132.6482688	2.79467E-08	6.00E-08	6.16078E-08	49.18296557
60566	A	AQ	25	7.8	1.431E-08	2.00E-08	8.37768E-09	129.9519511	2.83191E-08	6.00E-08	6.00508E-08	36.67141728
60566	B	AQ	25	7.8	1.431E-08	2.00E-08	1.42329E-08	84.61755031	2.83191E-08	6.00E-08	7.35884E-08	30.92910431
60648	0	AQ	25	16	1.60667E-08	2.00E-08	1.56801E-08	86.18740136	2.8927E-08	6.00E-08	7.94367E-08	30.13025177

Aqueous - Clean Matrix

CES Sample Number	Rep	Sample Phase	Counting Sample Size (ml)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/ml)	Alpha Action Limit	Corrected Alpha (uCi/ml)	Alpha Error (Percent)	Beta MDA (uCi/ml)	Beta Action Limit	Corrected Beta (uCi/ml)	Beta Error (Percent)
60489	A	AQ	25	0.4	1.28919E-08	2.00E-08	1.26625E-08	82.21967894	2.77542E-08	6.00E-08	3.24883E-08	3.592420152
60489	B	AQ	25	0.3	1.28737E-08	2.00E-08	-1.8799E-09	-398.7608364	2.77465E-08	6.00E-08	2.8195E-08	29.56835709
60444	0	AQ	25	26.6	1.86648E-08	2.00E-08	1.27776E-08	119.6851948	2.96819E-08	6.00E-08	1.17179E-07	61.85982252
58640	0	AQ	25	69.6	3.44E-08	1.694E-08	182.4928655		3.26E-08	3.0975E-07	13.46157289	
58696	A	AQ	25	24.1	1.80E-08	-1.096E-09	-1336.80159		2.95E-08	2.6802E-07	12.21468859	
58696	B	AQ	25	15.7	1.60E-08	6.953E-09	183.6452573		2.89E-08	1.3846E-07	19.08218807	
58699	0	AQ	25	1.1	1.30E-08	1.293E-08	81.27593749		2.78E-08	3.0212E-08	66.19298561	
58700	0	AQ	25	45	2.42E-08	2.612E-08	75.73008978		3.09E-08	2.9642E-08	74.30712698	
58704	0	AQ	25	4.5	1.37E-08	1.228E-07	19.54131771		2.81E-08	1.6688E-07	16.34475202	
58716	0	AQ	25	3.9	1.35E-08	3.409E-08	41.99855145		2.80E-08	6.5237E-08	33.94837015	
58720	0	AQ	25	9	2.77E-08	2.648E-05	3.593068045		5.00E-08	2.6596E-05	2.233703766	
66668	A	AQ	30	47.8	2.10275E-08	2.00E-08	2.96683E-06	7.789466036	2.58938E-08	6.00E-08	3.70682E-06	70.27912071
66668	B	AQ	30	48	2.10877E-08	2.00E-08	2.69751E-06	7.965493984	2.59041E-08	6.00E-08	3.47645E-06	22.18480888
66071	A	AQ	30	3.6	1.1239E-08	2.00E-08	4.82484E-09	162.2757322	2.33336E-08	6.00E-08	1.76703E-08	36.75141426
66071	B	AQ	30	3.4	1.12074E-08	2.00E-08	2.72455E-09	269.7444202	2.33208E-08	6.00E-08	1.47748E-08	2.335596676
66073		AQ	30	5.3	1.15118E-08	2.00E-08	1.30917E-08	72.94792931	2.34416E-08	6.00E-08	2.39505E-08	2.29704518
57917	0	AQ	100	6.1	3.49272E-09	2.00E-08	-5.8961E-10	-324.955427	7.04765E-09	6.00E-08	1.24439E-09	2.304180235
AQ-CM Average:			26.470588	14.13088235	1.66072E-08				2.93778E-08			
Std. Dev:			9.1447246	9.144724584	9.144724584				9.144724584			
AQ-CM Average:					16.60721857 pCi/L				29.37781851 pCi/L			

Total 68 Samples	Sample Size (ml)	
	>20	68

Notes:
- Data Provided by Reggie Gaylord 9/21/06.
- Sample sizes for AQ-CM are all >20ml.

Appendix B – Aqueous Dirty Matrix

Aqueous - Dirty Matrix (AQ-DM)

Aqueous - Dirty Matrix

CES Sample Number	Rep	Sample Phase	Counting Sample Size (ml)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/ml)	Alpha Action Limit	Corrected Alpha result (uCi/ml)	Alpha Error (Percent)	Beta MDA (uCi/ml)	Beta Action Limit	Corrected Beta result (uCi/ml)	Beta Error (Percent)
58787	0	AQ	0.108333333	17.8	3.80322E-06	2.00E-08	6.18347E-06	56.82612466	6.70562E-06	6.00E-08	1.28672E-05	3.050314788
62088	0	MOP	0.199	62.2	3.71527E-06	2.00E-08	1.57949E-06	163.9421164	5.49297E-06	6.00E-08	-4.4584E-07	3.11897692
58217	0	AQ	0.2	78	4.65929E-06	2.00E-08	7.30281E-07	395.2294149	4.13863E-06	6.00E-08	1.14989E-06	40.00579664
58215	0	AQ	0.25	47.5	2.51251E-06	2.00E-08	4.73398E-05	16.28619875	3.10541E-06	6.00E-08	0.000216829	39.50800811
58213	0	AQ	0.266666667	55.7	2.64769E-06	2.00E-08	2.96282E-05	20.85894019	2.96209E-06	6.00E-08	0.000107695	33.081824
58214	0	AQ	0.266666667	52.6	2.53353E-06	2.00E-08	5.17238E-05	16.14685138	2.94029E-06	6.00E-08	0.000234189	27.57558854
58210	0	AQ	0.333333333	69.8	2.58793E-06	2.00E-08	2.94911E-05	23.27255622	2.44432E-06	6.00E-08	0.000139029	13.04789044
62084	0	MOP	0.5	15.7	7.61427E-07	2.00E-08	2.68521E-05	10.97572237	1.96964E-06	6.00E-08	0.000125536	10.02433635
62085	0	MOP	0.5	14.8	7.51785E-07	2.00E-08	2.11967E-05	11.98365285	1.96514E-06	6.00E-08	8.3904E-05	40.31175065
62087	0	MOP	0.5	61.3	1.45981E-06	2.00E-08	6.91321E-07	150.2485043	2.18179E-06	6.00E-08	9.11734E-08	52.99489426
62089	0	MOP	0.5	35	1.00132E-06	2.00E-08	4.49752E-07	156.3057956	2.06176E-06	6.00E-08	-3.89767E-07	49.51746193
62090	0	MOP	0.5	40.2	1.07845E-06	2.00E-08	5.65254E-07	139.2654202	2.08505E-06	6.00E-08	3.43739E-07	2.99156272
62092	0	MOP	0.5	60.3	1.43912E-06	2.00E-08	7.92645E-07	129.1725757	2.17685E-06	6.00E-08	-8.50805E-07	42.15727651
57891		AQ	1	73.7	8.9633E-07	2.00E-08	5.47191E-07	115.0469779	8.21086E-07	6.00E-08	-1.22582E-07	13.46157289
57892		AQ	1	75.4	9.10653E-07	2.00E-08	-7.55983E-08	-672.6585487	8.2375E-07	6.00E-08	4.09957E-08	12.21468859
57911		AQ	1	73.8	8.97182E-07	2.00E-08	3.18658E-08	1661.076009	8.21244E-07	6.00E-08	1.43171E-07	19.08218807
65985	0	AQ	1	14.8	3.94915E-07	2.00E-08	1.57487E-07	174.6009744	7.20981E-07	6.00E-08	7.12908E-07	66.19298561
65996	0	AQ	1	29.4	4.85487E-07	2.00E-08	2.64059E-07	139.6779396	7.46877E-07	6.00E-08	1.83581E-06	74.30712698
60716	0	AQ	1	62.2	7.7436E-07	2.00E-08	4.56219E-08	1130.681559	8.01824E-07	6.00E-08	2.14606E-06	16.34475202
60717	0	AQ	1	46	6.14801E-07	2.00E-08	4.28803E-07	115.4899845	7.74031E-07	6.00E-08	2.63379E-06	33.94837015
60647	0	AQ	1	24.6	4.536E-07	2.00E-08	6.36913E-05	5.608212242	7.38557E-07	6.00E-08	8.4165E-05	2.233703766
60447	0	MOP	1	70.5	8.68481E-07	2.00E-08	7.48677E-07	93.01198278	8.15931E-07	6.00E-08	1.76349E-06	3.67176508
59805	A	AQ	1	0	2.14948E-07	2.00E-08	2.24985E-05	6.887245728	4.82218E-07	6.00E-08	0.000201767	4.369193135
59805	B	AQ	1	0	2.14948E-07	2.00E-08	2.9588E-05	6.173475551	4.82218E-07	6.00E-08	0.000228622	1341.475004
59805	C	AQ	1	0	2.14948E-07	2.00E-08	2.86583E-05	6.239587502	4.82218E-07	6.00E-08	0.000223167	-682.2442692
61588	A	AQ	1.0033	0.3	1.71443E 07	2.00E-08	8.93419E 06	7.471656302	3.89925E-07	6.00E-08	2.73948E-05	-289.5535615
61588	C	AQ	1.0048	1.2	1.73373E-07	2.00E-08	8.54338E-06	7.598809261	3.90319E-07	6.00E-08	2.64034E-05	344.0123802
61588	B	AQ	1.0085	0.3	1.70559E-07	2.00E-08	9.84869E-06	7.172250212	3.87915E-07	6.00E-08	2.99632E-05	-137.3145888
58878	0	AQ	1.25	21.5	3.47312E-07	2.00E-08	3.75923E-07	77.62258853	5.86464E-07	6.00E-08	1.14167E-06	3.60273086
57925	0	AQ	1.333333333	65.8	6.11242E-07	2.00E-08	1.63809E-07	236.9751418	6.06099E-07	6.00E-08	-4.92547E-08	3.462849183
58440	0	AQ	2	37.6	2.72646E-07	2.00E-08	-1.65987E-05	-10.28653477	3.80309E-07	6.00E-08	0.000304371	3.6165837
58440	0	AQ	2	37.6	2.72646E-07	2.00E-08	-1.32546E-05	-9.767220699	3.80309E-07	6.00E-08	0.000217959	380.6601721
60535	0	AQ	2	47.4	3.13615E-07	2.00E-08	5.47406E-07	53.52525457	3.88099E-07	6.00E-08	5.89173E-07	184.7498047
55938	0	AQ	2.5	82	3.85064E-07	2.00E-08	-5.27799E-08	-395.0065975	3.3344E-07	6.00E-08	-1.82252E-08	-534.5201903
55938	0	AQ	2.5	86.1	3.96666E-07	2.00E-08	-7.80359E-07	-24.07809519	3.35725E-07	6.00E-08	3.77748E-06	311.2580898
60576	0	AQ	3	53.8	2.29081E-07	2.00E-08	1.34111E-07	131.3626039	2.62092E-07	6.00E-08	7.16022E-07	67.53819681
55926	0	AQ	3.333333333	20.2	1.2787E-07	2.00E-08	1.58231E-07	73.13011522	2.19228E-07	6.00E-08	8.40827E-07	45.26108556
55926	0	AQ	3.333333333	20.6	1.28595E-07	2.00E-08	-2.11678E-07	-26.22822211	2.19443E-07	6.00E-08	1.70701E-06	7.851791131
AQ-DM Average:			1.1287	40.93947368	1.03927E-06				1.41105E-06			
Std. Dev:			0.86356202	0.86356202	0.86356202				0.86356202			
AQ-DM Average:					1039.266159 pCi/L				1411.049087 pCi/L			

Total 38 Samples	Sample Size (ml)	
	<1	13
	1 to 5	25
	5 to 10	0
	10 to 20	0

Notes:
- Data Provided by Reggie Gaylord 9/21/06.
- Samples sizes for AQ-DM are <5 ml.

Appendix C - Oil

Oil (OI)

Oil

CES Sample Number	Rep	Sample Phase	Counting Sample Size (gm)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/ml)	Corrected Alpha result (uCi/ml)	Alpha Error (Percent)	Beta MDA (uCi/ml)	Corrected Beta result (uCi/ml)	Beta Error (Percent)
58528	0	OI	0.066666667	10.6	5.58258E-06	1.45689E-06	262.0146564	1.06983E-05	1.62133E-05	49.06519817
56241	0	OI	0.24	41.8	2.41233E-06	1.04786E-06	153.3296248	3.19754E-06	-1.00535E-06	-200.9270747
55536	0	OI	1.5	13.2	2.57393E-07	8.4938E-08	198.3658599	4.78694E-07	-8.88442E-09	-3505.119768
		OI	0.04	0.9	8.32E-06			1.28E-05		
		OI	0.02	1.3	1.44E-05			2.29E-05		
		OI	0.09	0.9	3.74E-06			5.97E-06		
		OI	0.24	0.9	1.35E-06			2.88E-06		
		OI	0.13	1.8	2.45E-06			5.27E-06		
		OI	0.077	3.4	4.34E-06			9.00E-06		
		OI	0.054	4.9	6.41E-06			1.31E-05		
		OI	0.043	8.4	8.34E-06			1.64E-05		
		OI	0.0421	3.4	8.10E-06			1.67E-05		
		OI	0.044	6.7	8.05E-06			1.61E-05		
		OI	0.045	2.5	7.30E-06			1.54E-05		
		OI	0.089	1.7	3.68E-06			7.80E-06		
66673	0	OI	0.1091	41.1	5.25381E-06	1.6713E-05	36.51515235	7.02375E-06	2.41134E-05	24.86543377
65825	0	OI	0.2412	0.9	1.34568E-06	1.45066E-06	75.94997821	2.88068E-06	2.76384E-06	74.17574026
65834	0	OI	0.1321	1.8	2.48843E-06	8.84314E-07	228.3228571	5.27294E-06	3.09038E-05	16.45294313
59362	0	OI	0.12	29.6	4.06E-06	3.43243E-06	93.91513331	6.23E-06	1.05715E-05	44.49836295
59133	0	OI	0.4	4.9	8.59E-07	7.56509E-07	91.67049502	1.76E-06	3.38567E-06	39.79682884
Average:			0.186158333	9.035	4.9368E-06			9.09275E-06		
Std. Dev:			0.323616489	12.92432529	3.46056E-06			6.13989E-06		
Average:					4936.797268 pCi/L			9092.747902 pCi/L		

Total 21 Samples

Notes:
- Data Provided by Reggie Gaylord 9/21/06.
- Oil specific gravity assumed to be 0.85 g/ml

Appendix D – Solids/Sludges

Solids, Sludges (SO, SL)

Solids, Sludges

CES Sample Number	Rep	Sample Phase	Counting Sample Size (g)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/g)	Corrected Alpha result (uCi/g)	Alpha Error (Percent)	Beta MDA (uCi/g)	Corrected Beta result (uCi/g)	Beta Error (Percent)
58637	B	XX	0.253	36.5	2.12196E-06	0.000982748	5.275802496	2.99925E-06	0.001786695	3.078308139
58638	0	XX	0.08866667	13.6	4.37906E-06	2.39722E-06	141.2335165	8.10651E-06	2.36656E-05	28.10844607
58639	0	XX	0.1508	21.3	2.87078E-06	2.99794E-06	81.55506866	4.85892E-06	1.334E-05	29.59895944
58641	0	XX	0.148	1.5	2.21172E-06	2.77215E-06	69.74969379	4.70255E-06	1.02291E-05	35.91746536
58642	0	XX	0.09866667	22.9	4.48806E-06	6.86955E-06	61.71153289	7.45504E-06	2.73139E-05	23.50134668
58695	0	XX	0.508	3.7	6.64659E-07	4.76988E-08	915.7625575	1.37834E-06	2.64172E-06	39.96980114
58701	0	XX	0.08666667	19.5	4.86964E-06	1.0162E-05	48.42152368	8.41738E-06	2.54752E-05	27.35534095
58747	0	XX	0.09833333	5.6	3.52695E-06	1.81449E-06	143.0417946	7.15746E-06	1.1726E-05	45.82201425
58748	0	XX	0.256	10.3	4.44879E-06	0.005785413	3.462628826	7.35942E-06	0.001146983	4.097919438
58793	0	XX	0.10985	98.7	9.6641E-06	6.98927E-06	102.0921306	7.78188E-06	4.39173E-06	122.3621524
58794	0	XX	0.11505	94.7	9.06397E-06	2.09562E-05	45.31573545	7.39026E-06	2.5623E-05	25.68193316
58473	0	XX	0.231	5.29	2.02852E-06	7.76598E-06	34.5399888	3.99279E-06	1.89429E-05	19.21964763
58474	0	XX	0.25	10.6	2.02018E-06	0.001441071	3.619006768	3.74175E-06	0.002484153	1.999440639
58502	0	XX	0.25	33.5	2.79263E-06	1.9672E-06	114.6475831	3.95469E-06	1.55489E-05	21.97539991
58503	0	XX	0.283	17.2	1.95895E-06	2.30646E-05	17.92080767	3.36165E-06	1.41706E-05	21.04207625
58504	0	XX	0.254	15	2.11582E-06	3.25687E-05	15.94669095	3.72477E-06	4.06838E-05	11.35587171
58505	0	XX	0.253	24.5	2.42946E-06	1.27251E-06	132.6792552	3.82777E-06	5.45002E-06	47.99180148
58101	0	XX	0.106	37.8	5.15888E-06	2.13112E-06	161.3992837	7.17873E-06	-1.0476E-06	-440.4430019
58102	0	XX	0.112	46.3	5.51289E-06	3.07335E-06	126.6273991	6.91515E-06	2.02949E-06	228.7291679
58103	0	XX	0.1332	55	5.24821E-06	3.34549E-06	112.6057815	5.92016E-06	1.10841E-06	355.0884195
58104	0	XX	0.115	49.3	5.60431E-06	1.59741E-06	223.4059561	6.77487E-06	-1.40561E-06	-307.8942962
58105	0	XX	0.09	46.2	6.85068E-06	2.43503E-06	187.3112291	8.6038E-06	2.54792E-06	226.6764909
58106	0	XX	0.106	44.5	5.67694E-06	1.20833E-07	2789.058726	7.28006E-06	2.03474E-06	239.6840472
58107	0	XX	0.11	46.8	5.65339E-06	1.44575E-06	249.2397182	7.04793E-06	1.70383E-07	2704.545047
58108	0	XX	0.0888	35.4	5.95216E-06	6.56476E-07	552.9512411	8.52468E-06	9.39177E-07	598.1833624
58109	0	XX	0.1155	63.8	6.85855E-06	3.05844E-06	151.9046756	6.96671E-06	7.35732E-07	624.5482049
58110	0	XX	0.0964	50.8	6.83048E-06	1.98611E-06	223.9295501	8.10561E-06	2.23687E-06	242.7939505
58111	0	XX	0.11	51.5	6.04615E-06	5.95376E-06	79.22598207	7.11303E-06	7.01081E-07	668.9548751
58112	0	XX	0.111	37.7	4.91952E-06	3.8304E-06	97.32193034	6.85389E-06	4.5851E-06	103.846947
58113	0	XX	0.112	52.1	5.98929E-06	3.06147E-06	135.3433495	6.99403E-06	8.8032E-07	524.9034441
58114	0	XX	0.115	55.5	6.12214E-06	2.3212E-06	175.2221253	6.86533E-06	7.31665E-07	618.7326039
58115	0	XX	0.092	37.5	5.9187E-06	3.14663E-06	130.5104553	8.2658E-06	-1.76568E-07	-3047.353575
58116	0	XX	0.118	53.1	5.76644E-06	7.22747E-06	65.97744458	6.65194E-06	6.31585E-07	694.4814964
58117	0	XX	0.115	50.7	5.71755E-06	1.70828E-06	217.9178673	6.79331E-06	1.44554E-06	312.9945827
58118	0	XX	0.092	32.3	5.49826E-06	3.59173E-06	110.2568003	8.1718E-06	6.71896E-07	799.8462037

Solids, Sludges

CES Sample Number	Rep	Sample Phase	Counting Sample Size (g)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/g)	Corrected Alpha result (uCi/g)	Alpha Error (Percent)	Beta MDA (uCi/g)	Corrected Beta result (uCi/g)	Beta Error (Percent)
58119	0	XX	0.0928	44.6	6.49371E-06	3.32652E-07	1126.825695	8.31728E-06	-3.97242E-06	-129.9263432
58120	0	XX	0.12	47.4	5.22691E-06	1.9647E-07	1577.660794	6.46832E-06	9.90763E-07	432.1483854
58121	0	XX	0.0896	29	5.38778E-06	2.8821E-06	129.8089268	8.32802E-06	-3.52286E-07	-1535.28618
58122	0	XX	0.115	40.2	4.9205E-06	9.82014E-07	312.6440338	6.65081E-06	-3.93235E-07	-1096.405541
58123	0	XX	0.116	43	5.07744E-06	2.03911E-06	165.843479	6.63207E-06	-4.09735E-07	-1049.377399
58124	0	XX	0.0888	38.1	6.18436E-06	1.58448E-06	249.3355283	8.57473E-06	2.07692E-07	2698.726455
58125	0	XX	0.119	46.7	5.21835E-06	3.50862E-07	905.1340559	6.51359E-06	2.91205E-06	152.2206342
58126	0	XX	0.113	40.9	5.05799E-06	3.24534E-06	112.153759	6.77849E-06	1.12741E-06	398.7299145
58127	0	XX	0.1008	48.3	6.30308E-06	5.92064E-07	630.6468663	7.71411E-06	-2.2296E-06	-219.089378
58128	0	XX	0.1024	48.2	6.19573E-06	2.38487E-06	172.8354385	7.59208E-06	4.89737E-07	1017.821748
58129	0	XX	0.0968	38.5	5.70552E-06	2.88225E-06	134.6392798	7.87281E-06	-2.64747E-06	-187.4295762
58130	0	XX	0.204	16.8	1.99134E-06	3.91833E-07	310.1902372	3.55211E-06	-1.92551E-06	-113.5829074
58131	0	XX	0.095	15.2	4.18055E-06	1.61282E-06	169.5301027	7.59698E-06	-3.33784E-06	-141.7519863
58163	0	XX	0.1	38	5.48394E-06	3.045E-06	127.3643365	7.61272E-06	2.39486E-06	213.7589494
58164	0	XX	0.1	36.4	5.36096E-06	8.56055E-07	381.6042863	7.58645E-06	-2.0388E-06	-236.0690351
58165	0	XX	0.1	37.8	5.46841E-06	1.91084E-05	32.98348843	7.60945E-06	3.86422E-06	135.2855753
58166	0	XX	0.1	34.3	5.20377E-06	3.83585E-06	99.3991715	7.55161E-06	-3.39581E-07	-1444.458165
58167	0	XX	0.1	46.3	6.17443E-06	7.97394E-07	470.8897755	7.74497E-06	-2.8828E-07	-1745.565293
58168	0	XX	0.096	43.3	6.16163E-06	2.20935E-06	181.8126416	8.0187E-06	-2.00784E-06	-253.9723839
56010	0	XX	0.4	47.6	1.57256E-06	1.90544E-05	18.13150161	1.94127E-06	3.53693E-05	8.314617529
56011	0	XX	0.09666667	48.1	6.55382E-06	0.002155424	7.158656612	8.04078E-06	0.005857626	3.285247906
56012	0	XX	0.52	47.6	1.20966E-06	2.55133E-05	14.06921014	1.49328E-06	4.41074E-05	6.58146584
56013	0	XX	0.16	75.2	5.68116E-06	0.000243109	12.1408492	5.1465E-06	0.00059183	7.630399604
56014	0	XX	0.2	50.9	3.297E-06	0.000228432	9.597098136	3.90766E-06	0.000377539	4.360232102
56024	0	XX	0.08266667	75.6	1.10361E-05	0.000771535	9.933957494	9.96847E-06	0.000893598	7.806418122
56127	0	XX	0.13	80.6	7.32419E-06	0.000692358	10.414057	6.39675E-06	0.001812915	7.587949912
66654	0	XX	0.031975	34.7	1.6367E-05	0.000990309	8.040520134	2.36381E-05	0.000159134	15.57924891
66656	0	XX	0.03355	37.8	1.62993E-05	0.002729646	6.419863346	2.26809E-05	0.004190565	3.611389284
66719	0	XX	0.036075	64.5	2.21782E-05	3.02294E-05	66.39966972	2.2339E-05	6.64435E-05	28.39864331
66721	0	XX	0.053225	58.6	1.38234E-05	6.57273E-05	29.48377918	1.49422E-05	8.77448E-05	17.37737851
66759	0	XX	0.026825	10.8	1.39133E-05	5.37587E-05	32.56046398	2.66018E-05	0.000130209	18.79957743
66761	0	XX	0.02785	17.7	1.47732E-05	0.000285803	13.22890224	2.60776E-05	0.000481979	7.874875638
66118	0	XX	0.036275	98.3	2.92178E-05	3.61444E-05	70.9133489	2.35533E-05	7.01336E-05	28.71902089
66129	0	XX	0.0315	40.6	1.80668E-05	1.93702E-05	76.15249049	2.43012E-05	2.43362E-05	71.42289328
66144	0	XX	0.031275	24.8	1.45447E-05	6.23543E-05	30.37040245	2.36261E-05	0.000112548	19.26994136

Solids, Sludges

CES Sample Number	Rep	Sample Phase	Counting Sample Size (g)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/g)	Corrected Alpha result (uCi/g)	Alpha Error (Percent)	Beta MDA (uCi/g)	Corrected Beta result (uCi/g)	Beta Error (Percent)
66146	0	XX	0.040225	33.5	1.27909E-05	4.3395E-06	204.9942331	1.87402E-05	2.72132E-05	51.03672669
66148	0	XX	0.039475	45.8	1.553E-05	2.79851E-06	370.1918543	1.96002E-05	3.26299E-05	45.2871544
66380	0	XX	0.023175	25.7	1.98799E-05	2.80836E-05	65.45499213	3.19517E-05	0.000113089	24.16271408
66382	0	XX	0.048225	93.7	2.15157E-05	8.40291E-05	33.21391418	1.76061E-05	0.000111406	17.32075737
66387	0	XX	0.029075	3.9	1.16458E-05	1.31492E-05	74.5020911	2.40956E-05	3.82831E-05	47.10100145
60705	0	XX	0.0625	53.7	1.09803E-05	1.42378E-05	69.69270567	1.25773E-05	4.37611E-05	24.96385369
60706	0	XX	0.125	57.3	5.77829E-06	6.12804E-06	83.25037332	6.34313E-06	2.72931E-05	21.41006232
60707	0	XX	0.125	52.5	5.39716E-06	3.28281E-06	138.013316	6.27142E-06	3.59857E-05	16.91692015
60361	0	XX	0.5	11	7.4856E-07	2.21225E-07	240.5316696	1.42793E-06	3.24311E-06	34.59480021
60362	0	XX	0.3	4.3	1.13505E-06	1.34248E-06	72.04909973	2.33781E-06	3.95827E-06	44.54925668
60363	0	XX	0.25	25.3	1.83246E-06	1.34141E-06	132.376195	2.95913E-06	3.18234E-05	10.97380567
60364	0	XX	0.25	10.3	1.4824E-06	2.83713E-07	364.7905806	2.85065E-06	7.25625E-06	31.44367245
60484	0	XX	0.2472	12.5	1.54649E-06	5.90202E-06	32.95882112	2.89946E-06	1.52293E-05	17.84143266
60485	0	XX	0.2472	12.9	1.55525E-06	8.99405E-06	25.66533367	2.90245E-06	2.09662E-05	14.20477291
59603	A	XX	0.23733333	22	1.84222E-06	3.04146E-06	55.94332854	3.09257E-06	5.34861E-06	43.78868121
59603	B	XX	0.23666667	29	2.03977E-06	2.64246E-06	66.47304527	3.15292E-06	4.2748E-06	54.28348795
59797	0	XX	0.125	5.1	2.75504E-06	9.64573E-07	191.1469726	5.62293E-06	1.90202E-06	199.007252
59798	0	XX	0.15	13	2.56667E-06	6.38872E-07	263.2559935	4.78448E-06	2.83027E-06	116.4621941
59659	0	XX	0.706	62.9	1.10779E-06	2.53296E-06	46.98265317	1.13749E-06	5.3544E-06	20.26340538
59660	0	XX	0.7	62	1.10309E-06	2.35174E-06	49.04018667	1.14495E-06	4.95846E-06	21.45085253
59661	0	XX	0.568	47.7	1.10902E-06	3.22973E-06	38.80952448	1.36736E-06	4.69922E-06	24.85874259
59662	0	XX	0.4224	34.8	1.24071E-06	2.53633E-06	49.46922872	1.78976E-06	6.02007E-06	25.21884974
59663	0	XX	0.531	54.7	1.3109E-06	2.78935E-06	49.42506904	1.48398E-06	7.23741E-06	19.54450647
59664	0	XX	0.528	72.5	1.67806E-06	4.66019E-06	40.96539347	1.55147E-06	7.91403E-06	19.45860789
59665	0	XX	0.534	68.2	1.57913E-06	3.25159E-06	50.44656313	1.52093E-06	6.68492E-06	21.38992518
59666	0	XX	0.534	59.1	1.38763E-06	2.96068E-06	48.94205704	1.49105E-06	6.42566E-06	21.44894611
59667	0	XX	0.5325	56.4	1.33917E-06	3.39606E-06	43.32801064	1.48584E-06	6.39498E-06	21.40525063
59668	0	XX	0.5295	56.2	1.34294E-06	3.01403E-06	47.70929712	1.49355E-06	7.5017E-06	19.19156636
59669	0	XX	0.4248	37.2	1.27639E-06	2.77366E-06	47.8242283	1.78899E-06	7.02976E-06	22.35249803
59670	0	XX	0.4224	32.3	1.19754E-06	1.96574E-06	58.12571417	1.77984E-06	5.95833E-06	25.29260301
59671	0	XX	0.4296	37.8	1.27291E-06	3.05535E-06	44.4216232	1.77129E-06	6.62003E-06	23.24136449
59672	0	XX	0.537	49.1	1.19675E-06	2.98338E-06	43.57462513	1.45029E-06	5.93742E-06	21.70706022
59673	0	XX	0.4272	40.2	1.32457E-06	3.87063E-06	38.58952622	1.79036E-06	6.00203E-06	25.32771565
59674	0	XX	0.4284	49.8	1.51521E-06	4.04166E-06	41.08592136	1.82042E-06	5.91778E-06	25.97293006
59675	0	XX	0.528	42.8	1.11231E-06	3.63667E-06	36.29890651	1.45644E-06	6.28423E-06	20.85596884

Solids, Sludges

CES Sample Number	Rep	Sample Phase	Counting Sample Size (g)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/g)	Corrected Alpha result (uCi/g)	Alpha Error (Percent)	Beta MDA (uCi/g)	Corrected Beta result (uCi/g)	Beta Error (Percent)
59676	0	XX	0.5325	42.3	1.09505E-06	2.15367E-06	51.93249797	1.44264E-06	6.49173E-06	20.18772831
59677	0	XX	0.426	33.8	1.21292E-06	3.19811E-06	41.7292284	1.77072E-06	7.05882E-06	22.09569218
59678	0	XX	0.472	40.3	1.20057E-06	3.01259E-06	42.86252104	1.62077E-06	5.54437E-06	24.91944748
59679	0	XX	0.4284	34.7	1.2216E-06	3.71262E-06	37.87042864	1.7643E-06	7.06127E-06	22.04001195
59680	0	XX	0.4224	45.2	1.43894E-06	3.98825E-06	40.42178019	1.82951E-06	7.32911E-06	22.06534287
59681	0	XX	0.4248	39.2	1.31313E-06	2.72363E-06	49.23391636	1.79667E-06	6.57153E-06	23.63500986
59682	0	XX	0.528	42.4	1.10597E-06	3.26706E-06	38.76323884	1.45524E-06	6.0403E-06	21.47063527
58218	0	SL	0.25	69.7	3.44568E-06	2.16216E-05	25.91939942	3.25845E-06	2.32486E-05	15.77592453
58219	0	SL	0.25	66.7	3.3019E-06	9.67326E-06	39.07151551	3.2387E-06	1.07218E-05	26.24459489
58220	0	SL	0.25	58.2	2.92633E-06	8.86144E-05	12.85139861	3.17825E-06	8.4068E-05	8.446478756
55966	0	SL	0.04	56.6	1.78784E-05	4.82826E-05	41.68598114	1.97896E-05	9.09554E-05	20.4342611
55967	0	SL	0.0625	52.3	1.07635E-05	1.50629E-05	71.66324732	1.25381E-05	0.000100017	13.51338996
55968	0	SL	0.0825	66.7	1.00058E-05	2.22315E-05	52.01455824	9.81425E-06	9.92569E-05	12.94348421
55996	0	SL	0.0625	77.2	1.48068E-05	2.41045E-05	63.93671947	1.32242E-05	0.000112472	14.51239963
59259	0	ZZ	0.05	23.2	8.8941E-06	0.000117734	15.60361631	1.47219E-05	7.28058E-05	18.83592743
59260	0	ZZ	0.05	15.6	7.98807E-06	0.000111957	15.12358558	1.44489E-05	8.28706E-05	16.84089463
Average:			0.21049167	41.04454545	5.75495E-06			7.48793E-06		
Std. Dev:			0.17464808							
Average:					5.754950838 pCi/g			7.487932011 pCi/g		

Total 121 Samples

CES Matrix Codes
XX - Other Solid (debris, lab trash, etc.)
SL - Sludge
ZZ - Other "liquid" (Viscous, multiphase, very high solids, etc.)

Notes:
- Data Provided by Reggie Gaylord 9/21/06.

Appendix E - Solvents

Solvents (SV)

Solvent

CES Sample Number	Rep	Sample Phase	Counting Sample Size (ml)	Residual Mass Net Wt. (mg)	Alpha MDA (uCi/ml)	Corrected Alpha result (uCi/ml)	Alpha Error (Percent)	Beta MDA (uCi/ml)	Corrected Beta result (uCi/ml)	Beta Error (Percent)
		SV	1	36.2	5.84E-07			5.41E-07		
		SV	1	35.3	5.77E-07			5.41E-07		
		SV	2	92.5	3.68E-07			2.65E-07		
		SV	2	20.3	2.21E-07			2.50E-07		
		SV	2	17.6	2.12E-07			2.49E-07		
		SV	2	19	2.17E-07			2.50E-07		
		SV	2	25.5	2.52E-07			2.69E-07		
		SV	2	71.3	3.83E-07			2.77E-07		
		SV	1	49.3	6.40E-07			7.79E-07		
		SV	2	32.1	2.50E-07			3.76E-07		
		SV	2	0.9	1.62E-07			3.47E-07		
		SV	2	1.2	1.63E-07			3.48E-07		
		SV	1	1.6	3.28E-07			6.96E-07		
		SV	1	2.3	1.32E-08			2.79E-08		
		SV	1.67	51	3.96E-07			4.69E-07		
65705	0	SV	1	49.3	6.44495E-07	3.87301E-06	29.19275733	7.791E-07	2.0761E-05	6.88679966
65706	0	SV	2	32.1	2.52205E-07	1.23122E-06	32.34804847	3.757E-07	8.0165E-06	7.48283722
65707	0	SV	2	0.9	1.62288E-07	6.0932E-07	41.95699326	3.474E-07	1.0061E-05	6.14976034
65708	0	SV	2	1.2	1.62976E-07	4.47134E-07	41.09055763	3.477E-07	1.6262E-06	19.465765
60385	0	SV	0.5	40.7	1.13984E-06	3.25453E-06	41.2366412	1.531E-06	1.0703E-05	14.7366489
60393	0	SV	0.5	45.6	1.22259E-06	2.22565E-06	56.11594749	1.547E-06	8.7521E-06	17.0875596
60394	0	SV	0.5	31.2	9.96041E-07	3.33819E-06	36.46112649	1.5E-06	9.3692E-06	15.8628786
60396	0	SV	0.25	33.2	2.04932E-06	4.39255E-06	48.88939252	3.013E-06	1.4057E-05	19.6058019
60397	0	SV	0.0975	33.2	5.25467E-06	6.54865E-06	72.57424539	7.726E-06	2.9314E-05	22.9279162
60399	0	SV	0.1	22.3	4.3908E-06	5.83379E-06	69.63595381	7.345E-06	3.0632E-05	21.2502886
60400	0	SV	0.1	35.2	5.27056E-06	1.01765E-06	381.3792787	7.567E-06	3.1197E-05	21.5035899
60401	0	SV	0.1	16	4.01667E-06	6.19059E-06	61.95792903	7.232E-06	2.953E-05	21.5646566
60403	0	SV	0.333333333	46.7	1.86295E-06	1.88723E-06	83.91247155	2.325E-06	7.072E-06	27.3472431
60404	0	SV	0.5	23.1	8.88153E-07	1.84956E-06	48.97166407	1.472E-06	5.2587E-06	23.9808668
59704	0	SV	1.25	33.7	4.27908E-07	0.00100354	4.369808498	6.231E-07	0.00200419	2.77045403
Average:			1.196694444	30.01666667	1.12E-06			1.65E-06		
Std. Dev:			0.756630224	21.32749696	1.53452E-06			2.418E-06		
Average:					1116.922532 pCi/L			1647.2047 pCi/L		

Total 30 Samples

Notes:
- Data Provided by Reggie Gaylord 9/21/06.