February 3, 2005

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
LOUISIANA ENERGY SERVICES, L.P.	)	Docket No. 70-3103
(National Enrichment Facility)	)	ASLBP No. 04-826-01-ML

NRC STAFF TESTIMONY OF ALAN TOBLIN CONCERNING NUCLEAR INFORMATION AND RESOURCE SERVICE AND PUBLIC CITIZEN ENVIRONMENTAL CONTENTION 1 ("NIRS/PC EC-1") (IMPACTS UPON GROUND AND SURFACE WATER)

Q1. Please state your name, occupation, and by whom you are employed.

A1. My name is Alan Toblin. I am employed as a consultant with Advanced Technologies and Laboratories International, Inc. ("ATL") in Germantown, Maryland. I am providing this testimony under a technical assistance contract between the staff of the Nuclear Regulatory Commission ("NRC Staff" or "Staff") and ATL. A statement of my professional qualifications is attached hereto.

Q2. Please describe your current responsibilities.

A2. I am currently performing work on the groundwater transport of contaminants and on the health consequence risk of chemical and radiological releases from potential accidents at nuclear facilities.

Q3. Please explain what your duties have been in connection with the NRC Staff's review of Louisiana Energy Services, L.P.'s ("LES") application to construct, operate and decommission a gas centrifuge uranium enrichment facility near Eunice, New Mexico.

A3. As part of my official responsibilities, I assisted the NRC Staff in its evaluation of the potential environmental impacts related to the construction, operation, and decommissioning of a gas centrifuge uranium enrichment facility near Eunice, New Mexico. My specific role was to conduct an evaluation of potential impacts to ground and surface water and water supplies due to construction, operation and decommissioning of that proposed facility. I assisted in preparation of the Staff's "Draft Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico," NUREG-1790, issued September 2004, ("DEIS" attached as Staff Exhibit 1a). I also assisted the NRC Staff in preparing portions of the "NRC Staff's Response to Interrogatories and Document Request by Petitioners Nuclear Information and Resource Service and Public Citizen to Commission Staff," dated November 10, 2004.

Q4. What is the purpose of this testimony?

A4. The purpose of this testimony is to provide the NRC Staff's views concerning NIRS/PC EC-1 specifically regarding: (1) potential leakage from the stormwater detention basin and septic leach fields; (2) potential leakage from lined basins; (3) the presence of moisture in two borings; (4) hydrologic transport of contaminants through fracture zones; and (5) discharge of stormwater runoff.

Q5. What documents did you review in preparing this testimony?

A5. In preparing this testimony, I reviewed the DEIS, all references pertaining to the relevant sections on ground and surface water as set forth in the DEIS, and all materials as cited in this testimony.

Q6. Are you familiar with NIRS/PC EC-1?

A6. Yes. I understand that NIRS/PC EC-1, as admitted by the Licensing Board in its Memorandum and Order (Initial Prehearing Order) of April 15, 2004, and modified by the Licensing Board's Memorandum and Order (Ruling on Late-Filed Contentions) of November 22, 2004, states as follows:

Petitioners contend that the Environmental Report contained in the application does not contain a complete or adequate assessment of the potential environmental impacts of the proposed project on ground and surface water, contrary to the requirements of 10 C.F.R. 51.45.

The Draft Environmental Impact Statement, NUREG-1790 (September 2004) ("DEIS") likewise does not contain a complete or adequate assessment of the potential environmental impacts of the proposed project on ground and surface water, contrary to the requirements of 10 C.F.R. Part 51 in that:

(A) The DEIS correctly notes that leakage from the stormwater detention basin and the septic leach fields will probably cause formation of perched bodies of groundwater at the alluvium/Chinle interface. (DEIS, 4-13, 4-14). The DEIS contains estimates of the dimensions of such water bodies, flow rates, and discharge areas. However, NRC provides no explanation of such calculations, and it is not possible to determine whether they are reasonable.

(B) The DEIS does not contain an estimate of the probability and frequency of leakage through the liners of the treated effluent basin or the stormwater detention basin. The basins are to be lined with geosynthetic materials (DEIS at 4-11, 4-12), such liners are known to leak (EPA, Hydrologic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3, EPA/600/R-94/168a, Sept. 1994), and such information is necessary to demonstrate the impact of such leakage. The DEIS should contain an estimate of the leakage rate and should show the fate of water and contaminants that leak from the basins.

(C) According to the DEIS, "… no precipitation recharge (i.e., rainfall seeping deeply into the ground) occurs in thick, desert vadose zones with desert vegetation (Walvoord et al., 2002)" (DEIS at 3-35). However, cuttings from one of the borings drilled in September 2003 were "slightly moist" (ER Rev. 2 at 3.4-2). In addition, the clay at the bottom of boring B-2 was "moist" (SAR at Fig. 3.2-11). The DEIS should explain the presence of this moisture, which conflicts with its statements about lack of recharge.

(D) The DEIS states: "Although the presence of fracture zones that can significantly increase vertical water transport through the Chinle Formation has not been precluded, the low measured permeabilities indicate the absence of such zones." (DEIS at 3-35). Two permeability measurements have been made on the Chinle Formation at or near the site: laboratory measurement of core samples (ER Rev. 2 Table 3.3-2) and a slug test performed in MW-2 (Cook-Joyce, Hydrogeologic Investigation, Sec. 32, T. 21 R. 38, Nov. 19, 2003). Such extremely limited measurements, where faults are present, cannot describe the permeability of the entire site, and NRC should explain its reliance on such restricted data.

(E) The stormwater basin will discharge runoff containing numerous contaminants, which are not adequately identified in the DEIS, nor is their monitoring explained. LES has stated that the runoff will contain small amounts of oil and grease typically found in runoff from paved roadways and parking areas (RAI Response, May 20, 2004, at 33). However, other contaminants may be present, such as PAHs (USGS, Concentrations of PAHs and Major and Trace Elements in Simulated Rainfall Runoff from parking lots, 2003, Open File Report 2004-1208), other organics such as aliphatic hydrocarbons and alcohols (Barrett, M.E, et al., Review and Evaluation of Literature Pertaining to the Quality and Control of Pollution from Highway Runoff and Construction, Tech. Report CRWR 239, April 1993), and other contaminants from spills and accidents. Their presence should be disclosed. Further, stormwater should be monitored for such contaminants.

Q7. On behalf of the NRC Staff, have you conducted an evaluation of the potential impacts on hydrologic resources (i.e. ground and surface water) resulting from the construction, operation and decommissioning of the proposed NEF?

A7. Yes. I conducted an evaluation of the potential impacts to these hydrologic resources, which is set forth in various sections of the DEIS issued in September 2004. In particular, the impacts of the proposed NEF on hydrological resources in and around the region of the proposed Lea County site are discussed in DEIS §§ 3.7, 3.8, 4.2.6, 4.3.6, 4.4.3, and

6.1.1.2.

Q8. Have you reached a conclusion on behalf of the NRC Staff as to the potential impacts that may result from construction, operation, and decommissioning of the proposed NEF on hydrologic resources?

A8. Yes. I have reached conclusions as set forth in sections 3.7, 3.8, 4.2.6, 4.3.6, and 4.4.3 of the DEIS, which discuss the evaluation of the potential impacts due to construction, operation and decommissioning of the proposed NEF on hydrological resources in Lea County, and have determined that any such impacts would be small.

Basis (A) – Leakage from Stormwater Detention Basin and Septic Leach Fields

Q9. Are you familiar with Basis (A) for NIRS/PC EC-1?

A9. Yes. I understand that Basis (A) of NIRS/PC EC-1states that:

> (A) The DEIS correctly notes that leakage from the stormwater detention basin and the septic leach fields will probably cause formation of perched bodies of groundwater at the alluvium/Chinle interface. (DEIS, 4-13, 4-14). The DEIS contains estimates of the dimensions of such water bodies, flow rates, and discharge areas. However, NRC provides no explanation of such calculations, and it is not possible to determine whether they are reasonable.

Q10. Basis (A) refers to the alluvium/Chinle interface. Please describe the alluvium and Chinle and their relationship to each other and to other geologic formations beneath the proposed NEF site.

A10. Three significant geologic formations are found beneath the proposed NEF site: the Antlers Formation, the Chinle Formation and the Santa Rosa Formation. DEIS Table 3-8 includes descriptions of these formations at the proposed NEF site from the surface down, and sets forth their depths and thicknesses. At the proposed NEF site, the Antlers Formation (referred to as “Alluvial Deposits” in DEIS Figure 3-16) on average extends from a depth of 1.4 feet to 39 feet below the ground. The Antlers Formation is made up chiefly of sand and silty sand. Below the Antlers Formation lies the Chinle Formation, which on average extends from a depth of 39 feet to 1,115 feet below the proposed NEF site. The Chinle Formation (also known as the Triassic Red Beds) is a highly impermeable claystone and silty clay layer with interbedded siltstone and sandstone, and this thick layer of rock beneath the proposed NEF site isolates the deep and shallow hydrologic systems located there. Below the Chinle Formation lies the Santa Rosa Formation, which ranges in depth from 1,115 feet to 1,425 feet below the ground at the proposed NEF site. The Santa Rosa Formation includes sandy beds containing a ground water aquifer. The low permeability of the overlying Chinle Formation inhibits potential ground water migration to the Santa Rosa aquifer, and there is no indication of a hydraulic connection between the Chinle and Santa Rosa Formations. (DEIS, at pp. 3-35 to 3-36).

Q11. Can you please explain what is meant by "perched bodies of groundwater at the alluvium/Chinle interface?"

A11. Perched groundwater is saturated groundwater that sits on top of an impermeable layer and flows downgradient. The impermeable layer (here, the Chinle Formation) creates a barrier to downward water movement. Perched groundwater is therefore higher than and apart from underlying aquifers. In this case, perched groundwater could form at the interface between the alluvial deposits in the Antlers Formation and the underlying Chinle Formation.

Q12. What would be the source of any potential perched bodies of water that could result from activities at the proposed NEF site?

A12. Discharge from the stormwater detention basin and septic fields would be the source of any such perched bodies of water.

Q13. Assuming that perched water bodies form beneath the site, did you consider the dimensions of these perched water bodies, their flow rates, and potential discharge locations in assessing the environmental impacts of the proposed NEF site?

A13. Yes.

Q14. In determining the potential environmental impacts to ground and surface water from the proposed NEF, what is the signficance of determining the flow rates of perched bodies of groundwater at the alluvium/Chinle interface?

A14. In this question and those that follow, I am interpreting the term “flow rate” to mean groundwater velocity or pore velocity, unless indicated otherwise. The flow rate indicates how rapidly the perched water would progress downgradient and where it might become available for use. The importance of determining the flow rate is related to water use and water quality. In this case, it is unlikely that the perched water under the proposed site would be used for human consumption because there are no nearby wells or springs, and the closest possible discharge location (Monument Draw) is not used due to its intermittent flow. There are no present users of groundwater downgradient, i.e., in the direction of flow, and any use of this perched water from the proposed site for human consumption in the future would be unlikely because of its limited extent and uncertain availability. The potential contaminants in any perched water bodies would be from normal site runoff and sanitary uses.

Q15. Did you perform a calculation to determine what the flow rates of perched bodies of groundwater at the alluvium/Chinle interface would be?

A15. Yes, pages 4-13 and 4-14 of the DEIS discuss these calculations, which were elaborated upon in “NRC Staff’s Response To Interrogatories and Document Requests by Petitioners Nuclear Information and Resource Service and Public Citizen to Commission Staff,” dated November 10, 2004. The estimated groundwater velocity of the basin and septic discharge at the alluvium/Chinle interface is based on an application of Darcy’s Law. Darcy’s Law relates the properties of the formation through which the water is being transported, in this case the Antlers alluvium, to the groundwater velocity. The Darcy Velocity (Vd) is equal to the hydraulic conductivity (kh) of the formation multiplied by the gradient (slope) of the groundwater surface (dh/dl). (DeWiest, R.J.M., *Flow Through Porous Media*, Academic Press, New York, New York, 1969, at p. 3 ("DeWiest"), attached as Staff Exhibit 2). The chosen kh = 0.01 cm/sec, is on the conservative side (i.e., results in greater Darcy Velocity) of the range of site surface soils hydraulic conductivity provided in the LES ER, at pp. 3.4-14 and 3.4-15. This kh value is also on the conservative end of the range provided in Table 5.1 of *Data Collection Handbook To Support Modeling Impacts of Radioactive Material In Soil*, Yu, C., et al, Argonne National Laboratory, April 1993, at Table 3-1, p. 23, ("Yu") attached as Staff Exhibit 6. The gradient of the groundwater surface is assumed to follow the slope of the Chinle Formation surface, 0.02 cm/cm towards the south-southwest, as set forth on DEIS page 3-35.

Based on information at pages 3.4-6 and 3.6-3 of the LES Environmental Report, Revision 2 ("LES ER," LES Exhibit 1), the flow rate (taken here to mean the volumetric rate of water movement) from the basin is estimated as the precipitation, at a rate of 46.1 cm/yr, falling on the basin's drainage area of 39 hectares. In the calculation, runoff infiltration, evaporation of runoff water and basin water, and evapotranspiration have been ignored, resulting in a conservative estimate of flow rate. For example, because evapotranspiration is the combination of water that is evaporated and transpired from soil and plant surfaces as a part of their metabolic processes, not accounting for evapotranspiration leads to a conservative estimate of basin discharge flow rate since it assumes a greater volume of available water.

The resulting conservative estimate of flow from the stormwater detention basin, which is the product of precipitation rate and the drainage area, is 180,000 m^3/yr, accounting for units conversion. This value is in line with the estimate of annual stormwater flow released to the onsite retention/detention basins of 174,000 m^3/yr. (DEIS, at p. 4-12).

Q16. Please explain the results of your calculation of the flow rates of potential perched bodies of groundwater at the alluvium/Chinle interface.

A16. The resulting Darcy Velocity is 0.0002 cm/sec, or 63.1 m/yr. The actual velocity through the soil pores (i.e., the pore velocity or "Vp") is equal to the Darcy Velocity divided by site surface soil porosity (p). The chosen p = 0.25 (25 percent) is a conservative value. (Yu, at Table 3-1, p. 23; DEIS at pp. 3-34, 3-35). The resulting pore velocity of 252 m/yr is a conservative estimate for the reasons described in A15, above.

Q17. In determining the potential environmental impacts to ground and surface water from the proposed NEF, did you determine the dimensions of potential perched bodies of groundwater at the alluvium/Chinle interface that may develop?

A17. Yes. I conducted this evaluation in order to assess the potential availability for use by humans or livestock. The significance of any impact resulting from availability for use is dependent on water use and water quality. In this case, any potential perched water that may collect under the proposed site would not be used for human consumption because there are no nearby wells or springs, and the closest possible discharge location (Monument Draw) is not used due to its intermittent flow. There are no present users of groundwater downgradient, i.e., in the direction of flow, and the use of this perched water from the proposed site for human consumption in the future would be unlikely because of its limited extent and uncertain availability. The potential contaminants in any perched water bodies would be from normal site runoff and sanitary uses.

Q18. Did you perform a calculation to determine what the dimensions of potential perched bodies of groundwater would be at the alluvium/Chinle interface?

A18. Yes, pages 4-13 and 4-14 of the DEIS discuss the calculations, and A15, above, explains the basis of the calculations. In determining the dimensions of any potential perched water which may flow from the storm water detention basin and the septic field, I performed separate calculations for each. By adding the results of those calculations, one can determine the total overall area of potential perched water. However, in reality, the perched water from these sources may be in separate streams or commingled. The first step in my calculation was to determine the cross sectional area of the water body. The perched water cross-sectional area that I calculated for the discharge from the stormwater detention basin, 2850 m^2, is equal to the flow rate from that basin (180,000 m^3/yr) divided by the Darcy velocity (Vd) (63 m/yr). For the septic system, I calculated the area to be 116 m^2 by dividing the actual system disharge, 7.3 million liters/yr (LES ER, at p.3.12-8, LES Exhibit 1), by Vd. For both calculations, the effect of evapotranspiration has been conservatively ignored.

Q19. How did you use this information to determine the dimensions of the potential perched bodies of groundwater at the alluvium/Chinle interface?

A19. For the stormwater detention basin, I assumed that the average width of the underlying perched water body was 1000 meters, approximately twice the width of the basin perpendicular to the direction of flow (DEIS, at p. 4-12); the perched water body depth, 2.85 meters, is its cross-sectional area as described in A18 above, divided by the assumed width.

The combined area of the leach fields is approximately 892 square meters (9,600 square feet) (LES ER, at p.3.12-8, LES Exhibit 1). For the septic system, I assumed that the average width of the underlying perched water body would be 100 meters, approximately three times its characteristic length of the square root of the combined area. The perched water body depth, 1.16 meters, is its cross-sectional area, as described in A18 above, divided by its width. As these releases travel downgradient, I would expect these releases to dissipate as a result of evapotranspiration.

Q20. In evaluating the environmental impacts to ground and surface water from the proposed NEF, did you determine the discharge areas of perched bodies of groundwater at the alluvium/Chinle interface?

A20. Yes. I determined the discharge areas in order to identify potential downgradient water users because determining such areas is part of the evaluation of potential environmental impacts to ground and surface water. In performing this evaluation, I first considered whether wells or springs were identified near the site and downgradient from it. I then identified the nearest downgradient water body into which perched water might discharge.

Q21. Please explain the results of your determination of the discharge areas of potential perched bodies of groundwater at the alluvium/Chinle interface.

A21. No wells or springs were identified near the site in the direction that perched water would flow. Monument Draw, approximately 3 miles south-southwest of the site, is an intermittent stream and the nearest downgradient water body to the proposed site. (DEIS, at p. 3-32). Therefore, it is likely that if any perched water does not evapotranspire before it reaches Monument Draw, it will discharge there. Nonetheless, the intermittent nature of flow in Monument Draw makes it an unpredictable, and therefore, unreliable source of water.

<u>Basis (B) – Leakage from Lined Basins</u>

Q22. Are you familiar with Basis (B) for NIRS/PC EC-1?

A22. Yes. I understand that Basis (B) of NIRS/PC EC-1states that:

> (B) The DEIS does not contain an estimate of the probability and frequency of leakage through the liners of the treated effluent basin or the stormwater detention basin. The basins are to be lined with geosynthetic materials (DEIS at 4-11, 4-12), such liners are known to leak (EPA, Hydrologic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3, EPA/600/R-94/168a, Sept. 1994), and such information is necessary to demonstrate the impact of such leakage. The DEIS should contain an estimate of the leakage rate and should show the fate of water and contaminants that leak from the basins.

Q23. Basis B notes that the DEIS does not contain estimates of the probability, frequency or rate of leakage through basin liners. Can you provide such estimates?

A23. No, I cannot predict the probability, frequency or rate of leakage that will occur with any degree of certainty. The probability and frequency of leakage would depend on the performance of the specific liner material used in these types of basins over time. In order to calculate probability and frequency of leakage, I would have to assign numerical values to the number of tears that would occur per square foot of liner, as well as the number of tears that would be expected to occur over time. I am aware of no reliable estimates of these factors that could be applied to the particular basins which would be constructed at the proposed NEF, although some limited evaluations of leakage have been conducted. For example, one such study was conducted by the Southwest Research Institute in San Antonio, Texas, in which an electrical survey technique developed there found an average of 0.3 to 5 leaks per 10,000ft^2 of liner surveyed. However, the liners surveyed included a variety of materials and thicknesses and included a wide ranges of sizes and types of basins. Therefore, these results may not represent conditions at the basins to be constructed at the proposed NEF. More significantly, the findings varied widely, with some liners having no leaks, while others had as many as 70 leaks per 10,000 ft^2. In itself, this variability indicates that the average found in the 62 liners surveyed is subject to a large degree of uncertainty.

With respect to leak rate, I would have to take into account the additional factor of whether, and for how long, water is present in the basin. This introduces yet another uncertainty into the calculation. As a consequence of these uncertainties, it is my judgement that any quantitative assessments of these values would have little or no meaning, and in fact could be very misleading.

Q24. Please explain the structure and contents of the lined basins referred to in Basis B of EC-1.

A24. The Treated Effluent Evaporative Basin ("TEEB") would contain uranium-bearing effluent from the Liquid Effluent Collection and Treatment System. From the bottom up, this lined basin will consist of (1) a minimum of 2 feet of compacted clay soils; (2) lower geosynthetic liner; (3) leak collection piping, sump, and pumping system; (4) geomembrane drainage mat with imbedded leak collection piping; (5) upper geosynthetic liner; and (6) a minimum of 1 foot of compacted clay. Essentially, the TEEB is a double-lined basin with a leak-detection system between the liners.

The lined "stormwater detention basin" referred to in Basis B is the Uranium Byproduct Cylinder ("UBC") Storage Pad Storm Water Retention Basin ("USPSRB"). From the bottom up, this lined basin will consist of (1) a minimum of 2 feet of compacted clay; (2) geosynthetic liner; and (3) a minimum of 1 foot of compacted clay. This basin would contain stormwater runoff from the UBC Storage Pad and blowdown from the Cooling Tower and the Heating Boiler. Blowdown water is released from these systems as a part of routine operations. Blowdown in the USPSRB contains a buildup of total dissolved solids ("TDS") caused by the evaporation of water that leaves the solids behind, and additives to the system. The solids are normal components of drinking water, such as, calcium, chloride, magnesium, sodium and sulfate. (DEIS, at p. 3-41). Blowdown TDS would range from three to five times the potable water supply obtained from the City of Hobbs. (LES Groundwater Discharge Permit Application, September 2003, at p.8, LES Exhibit 4). Based on the water supply TDS concentration as given on page 3-41 of the DEIS, the blowdown water would have a TDS concentration in the range of approximately 1200-2100 milligrams per liter. TDS is not a health regulated drinking water pollutant and only affects taste, odor and color (rather than health). The additives, oxidizing biocide, corrosion inhibitor and dispersant chemical constituents, are used to assure efficient cooling tower operation, and would be released in the USPSRB in concentrations of approximately 5-10 ppm. (LES Groundwater Discharge Permit Application, September 2003, at p. 5).

Q25. What is the primary cause of leakage of lined basins?

A25. The primary cause of leaks in geomembrane-lined impoundments is improper installation due to inadequate field seaming. Field seaming is the process by which adjacent portions of liner material are joined in order to form a continuous barrier. Seaming is chiefly done by permanent welding of overlapping pieces of liner using heat and pressure. Seaming around patches and small details, such as pipes and sumps, is typically performed with extrusion welding which forms a welded bead at the seam. Leaks in the parent material generally can be attributed to accidental damage from equipment or tools, e.g., equipment being dropped and gouges. (Laine, D. & Miklas Jr., M., *Detection and Location of Leaks in Geomembrane Liners Using an Electrical Method: Case Histories*, Southwest Research Institute, San Antonio, Texas, November 1989, ("Laine and Miklas"), LES Exhibit 72).

Q26. Is it possible to minimize leakage of lined basins?

A26. Yes. Proper installation and adherence to industry standards can minimize the possibility of lined basins leaking.

Q27. Has LES committed to assuring proper installation of liners for the Treated Effluent Evaporative Basin or the UBC Storage Pad Storm Water Retention Basin?

A27. Yes. LES has committed to selecting and installing the liners for the TEEB and the USPSRB in accordance with New Mexico Environment Department ("NMED") Guidelines for Liner Material and Site Preparation for Synthetically-Lined Lagoons. Liner installation would be performed by manufacturer-certified installers, who would install and test the liners according to project specifications. (LES Groundwater Discharge Permit Application, September 2003, at pp. 11-12, LES Exhibit 4).

Q28. Despite proper selection and installation of the liners for the TEEB and USPSRB, is there still a possibility of leakage?

A28. Yes. Despite all due care, there is a possibility of leakage. The possibility of leakage is the reason that leak collection and detection systems are installed when there is a potential exposure from hazardous basin contents.

Q29. In the event of a failure in the leak detection system and bottom synthetic liner of the TEEB or the synthetic liner of the USPSRB, what is the fate of the water and contaminants in these basins?

A29. Depending on the size of the leak, the water in the basin could eventually saturate the clay underlying the basin. The permeability of the clay, however, would be very low since compacted clay would be used. This water could eventually make its way down to the alluvium/Chinle interface where it would either mix with the water from the stormwater detention basin and septic systems, or would evapotranspire.

Q30. Should the contents of the water in the TEEB and USPSRB be considered in assessing the overall environmental impacts in the event of a leak in the liners and failure in the leak detection systems?

A30. Yes. The contents of the water in the TEEB and USPSRB should be considered in assessing the overall environmental impacts.

Q31. In your professional judgment, would the contaminants in the TEEB and USPSRB water, if such water leaked through the liners, be of significant environmental concern?

A31. No. In my professional judgment, the contaminants of any TEEB or USPSRB water which may leak from the liners are not of significant environmental concern.

The TEEB is a double-lined basin with a leak detection system which minimizes the possibility of leaks. A water balance of the TEEB, including consideration of effluent and precipitation inflows and evaporation outflows, indicates that this basin would be mostly dry for 1 to 8 months of the year depending on annual precipitation rates. (DEIS, at p. 4-12). Furthermore, the clay layer underlying the lower synthetic liner in the TEEB would adsorb and hold any small amount of uranium that might be released, thereby preventing the escape of uranium beyond this layer. (Yu, at p. 110). A water balance of the USPSRB indicates that this basin would be mostly dry for 2 to 12 months of the year depending on precipitation rates. (LES Response to Request for Additional Information Regarding the National Enrichment Facility Environmental Report, May 20, 2004, Table ER RAI 4-2A.2a, LES Exhibit 3; LES Revision to Applications for a Material License Under 10 CFR 70 "Domestic licensing of special nuclear material," 10 CFR 40 "Domestic licensing of source material," & 10 CFR 30 "Rules of general applicability to domestic licensing of byproduct material," NEF#04-029, July 30, 2004, at p. 3, attached as Staff Exhibit 13). Similarly to the TEEB, the nature of the clay underlying the USPSRB liner would tend to adsorb and hold any contaminants that may leak. Moreover, as indicated in A27, LES has committed to take measures to ensure proper installation of the basin liners.

Basis (C) – Moisture in Boring

Q32. Are you familiar with Basis (C) for NIRS/PC EC-1?

A32. Yes. I understand that Basis (C) of NIRS/PC EC-1states that:

> (C) According to the DEIS, "… no precipitation recharge (i.e., rainfall seeping deeply into the ground) occurs in thick, desert vadose zones with desert vegetation (Walvoord et al., 2002)" (DEIS at 3-35). However, cuttings from one of the borings drilled in September 2003 were "slightly moist" (ER Rev. 2 at 3.4-2). In addition, the clay at the bottom of boring B-2 was "moist" (SAR at Fig. 3.2-11). The DEIS should explain the presence of this moisture, which conflicts with its statements about lack of recharge.

Q33. Please explain what the term "precipitation recharge" means and its use in assessing environmental impacts on ground and surface water resulting from the construction, operation, and decommissioning of the proposed NEF site.

A33. Precipitation recharge occurs when rainwater seeps into the ground and replenishes or recharges the groundwater, especially an aquifer. Precipitation recharge is a factor used to assess movement of water and any potential contaminants in that water.

Q34. What measurements would indicate precipitation recharge at the proposed NEF site?

A34 Precipitation recharge would be indicated by drilling multiple borings across the proposed site and examining cuttings from the borings to determine the presence of moisture. Precipitation recharge is a phenomenon that would be noted over a wide area at multiple borings. Given the relatively small size of the proposed site and the general consistency of the alluvial soil, one would expect evidence of precipitation recharge to be present consistently throughout the proposed site. Therefore, if precipitation recharge existed at the proposed site, one would expect multiple borings across the proposed site to produce cuttings that were moist.

Q35. How many borings were drilled at the proposed NEF site?

A35. As documented in a Cook-Joyce Hydrogeologic Report and the Mactec Preliminary Subsurface Exploration Report, 14 borings were drilled to the top of the Chinle Formation. (*Hydrogeological Investigation, Section 32; Township 21 Range 38, Eunice, New Mexico*, Cook-Joyce, Inc., November 19, 2004, at p.4 ("Cook-Joyce Hydrogeological Investigation") LES Exhibit 3; *Report of Preliminary Subsurface Exploration, Proposed National Enrichment Facility, Lea County, New Mexico*, Mactec Engineering and Consulting, Inc., October 2003, at p. 7 ("Mactec") attached as Staff Exhibit 8).

Q36. In your professional judgment, are these 14 borings adequate to assess the presence of precipitation recharge at the proposed NEF site?

A36. Yes. The breadth and spacing of these borings (set forth in DEIS Figure 3-21) are such that precipitation recharge would be detected through the presence of moisture at multiple borings.

Q37. How many borings from the proposed site produced cuttings that were "slightly moist" or "moist"?

A37. Multiple (approximately 5) soil layers were logged at each of the 14 borings. Only one layer of one boring was logged as "slightly moist" and only one layer in another boring was logged as "moist."

Q38. Are the two separate occurrences of moisture in the two borings consistent with the remainder of the borings drilled at the proposed site?

A38. No.

Q39. Do you believe that the finding of moisture in the two borings indicates that the statement in the DEIS regarding lack of precipitation recharge is incorrect?

A39. No. I do not agree that these notations of moisture conflict with the statement in the DEIS. The Cook-Joyce log of Boring No. B-9 indicates slight moisture from a depth of 6 to 14 feet below ground. (Cook-Joyce Hydrogeologic Investigation, at Appendix A, LES Exhibit 3). Both above and below this layer in the Antlers Formation, the soils are noted as very dry. The lack of any indication that this moisture is seeping further downward is consistent with the conclusion that precipitation does not seep deeply into the ground beneath the proposed NEF site. Instead, precipitation can infiltrate into shallow portions of the subsurface where it is subject to upward hydraulic gradients caused by vaporization and evaoptranspiration, drawing water upwards. (DEIS, at p. 3-35).

The indication of moist clay in the top of the Chinle Formation (Mactec Boring Number B-2) is an isolated observation. Except as noted above, all other soil layer notations from the nine Cook-Joyce and five Mactec borings, including those in the Chinle clay, are noted as being dry. Notwithstanding these two indications of moisture, the totality of the evidence demonstrates a lack of precipitation recharge at the proposed NEF site. This evidence includes: (1) the multiple layers at the 12 totally dry borings and the associated dry layers at the two borings discussed above, (2) computer modeling and confirming measurements taken in the high plains of Texas presented on page 3-35 of the DEIS, and (3) the lack of groundwater in any of the nine Cook-Joyce boreholes after they were allowed to remain open for a minimum of 24 hours. This evidence supports the statement in the DEIS regarding the lack of precipitation recharge.

Basis (D) – Fracture Zones

Q40. Are you familiar with Basis (D) for NIRS/PC EC-1?

A40. Yes. I understand that Basis (D) of NIRS/PC EC-1states that:

> (D) The DEIS states: "Although the presence of fracture zones that can significantly increase vertical water transport through the Chinle Formation has not been precluded, the low measured permeabilities indicate the absence of such zones." (DEIS at 3-35). Two permeability measurements have been made on the Chinle Formation at or near the site: laboratory measurement of core samples (ER Rev. 2 Table 3.3-2) and a slug test performed in MW-2 (Cook-Joyce, Hydrogeologic Investigation, Sec. 32, T. 21 R. 38, Nov. 19, 2003). Such extremely limited measurements, where faults are present, cannot describe the permeability of the entire site, and NRC should explain its reliance on such restricted data.

Q41. The DEIS statement quoted above is from Section 3.8 of the DEIS. Are you the author of that Section?

A41. Yes.

Q42. You use the term "fracture zones" in the DEIS. Please explain what these zones are, and how they relate to water transport through rock.

A42. Fracture zones within a rock formation are caused by mechanical forces on the rock, such as shear stress and thermal compaction. Fractures can also result from human activities such as drilling and core handling. Open fractures are ones which have not been filled with cementing materials. When open, such fractures may provide conduits (i.e., fast flow paths) for the comparatively rapid movement of ground water through an otherwise relatively impermeable rock mass. (Schmelling, S. & Ross, R*., Contaminant Transport in Fractured Media: Models for Decision Makers*, EPA/540/4-89/004, U.S. Environmental Protection Agency, April 1989 ("Schmelling and Ross"), attached as Staff Exhibit 9).

Q43. Do the presence of fracture zones in rock necessarily indicate the presence of fast flow paths?

A43. No. As explained in Schmelling and Ross, the presence of fracture zones does not necessarily indicate that fast flow paths are present. In order to transmit water, fractures have to form an interconnected system which can transmit water through the formation thickness. Fracture orientation is an important characteristic; fractures have to be aligned parallel to the direction in which water would flow in order to provide effective pathways for water flow. The fractures have to remain open and not be filled with cementing materials, such as clay or carbonate minerals. The lack of interconnectivity, the lack of proper orientation, or the filling of fracture apertures with minerals can result in the absence of fast flow paths.

Q44. In which direction would water flow within the Chinle and the overlying Antlers Formations?

A44. In the Chinle, water generally flows vertically downwards, albeit very slowly. In the Antlers Formation, which overlies the Chinle, flow is vertically downward until contact with the relatively impermeable Chinle is made. At the alluvium/Chinle interface, the water would then flow horizontally to the south-southwest, along the direction of the slope of the contact.

Q45. Basis D references the concept of "permeability." Please discuss permeability and explain how permeability measurements are taken.

A45. Permeability pertains to the ability of a soil or rock mass to transmit fluids. When discussing hydrogeology, the terms permeability and hydraulic conductivity are often used interchangeably. Permeability can be measured in the laboratory or in the field. In the laboratory, permeability is typically determined by measuring the flow transmitted by field samples of the geologic medium being investigated under conditions of known hydraulic head (i.e., the pressure from a column of water). Slug tests are a common method of in-situ field testing used for measuring permeability; the test consists of suddenly changing the static water level in a well by, for example, adding or removing water. As the water level returns back to its static level, it is tracked and the water level over time is compared with theoretical models.

Q46. Were such measurements taken at or near the proposed NEF site?

A46. Yes. LES performed a slug test at a well in the siltstone bed, located approximately 220 feet beneath the proposed NEF site, within the Chinle Formation. (DEIS, at p. 3-35; Cook-Joyce Hydrogeologic Investigation, at p. 8, LES Exhibit 3). In addition, a total of 36 tests of vertical permeabilities and 6 horizontal permeabilities were performed in the laboratory on samples taken from the Chinle Formation under the Waste Control Specialists ("WCS") facility, located in Andrews, Texas. (*Geotechnical Investigation and Engineering Analysis for Waste Control Specialists Inc*, Jack H. Holt Ph.D. and Associates Inc., File No. 10-25792, March 12, 1993, LES Exhibit 3).

Q47. Are the permeability findings in this WCS study applicable to the proposed NEF site?

A47. Yes. The WCS site is located only one mile to the east of the proposed NEF site. Both sites lie within the Central Basin Platform of the Permian Basin (as shown in DEIS Figure 3-15), and would thus have similar underlying geologic structures, including the Chinle Formation.

Q48. What are the units by which permeability is measured?

A48. Permeability is related to groundwater velocity through Darcy's Law (discussed in A15). Permeability is measured in units of length per unit time, e.g., cm/sec. The value of permeability is related to the ability of the geologic unit to transmit water.

Q49. What did the permeability measurements you described in A49 show?

A49. Laboratory tests of Chinle Formation clay and imbedded siltstones and sandstones taken near the proposed NEF site showed that all of these materials are of low permeability. A permeability of 3.7 x 10^{-6} cm/sec was measured with the slug test performed for the 220-foot elevation siltstone bed within the Chinle Formation in Monitoring Well 2 at the proposed NEF site. Permeabilities determined by the lab tests at WCS ranged from less than 10^{-9} to 1.76 x 10^{-8} cm/sec for the clay taken from the Chinle Formation. Lab tests on the sandstone and siltstone beds determined a range of permeabilities from 2.58 x 10^{-8} to 1.93 x 10^{-6} cm/sec.

Q50. In your opinion, does the sampling which has been conducted at the proposed NEF site and other nearby locations within the Chinle formation provide an adequate assessment of the permeability of the entire NEF site?

A50. Yes. The large number of samples taken within the Chinle formation in close proximity to and at the proposed NEF site (as discussed in A46) represent a reliable indicator of the permeability of this geologic unit.

Q51. Are you aware of recent data relevant to the presence of potential fracture zones and fast flow paths that exist below the proposed NEF site?

A51. Yes. As indicated in A46, the Chinle Formation has been studied in detail at the nearby WCS site. A recent example of such a study is a geology report which contains an evaluation of the relationship between faulting in the Triassic Red Beds and the overlying Antlers Formation. The analysis was performed to evaluate the fault recently discovered beneath the WCS site (referenced in DEIS, at p. 3-26). This report notes that there are no indications that the overlying Antlers Formation was affected by the faulting in the Triassic Red Beds. Therefore, the faults would have been inactive for at least the past 135 million years, the age of the Antlers Formation. This evaluation found no evidence of a fast flow path resulting from the faulting at the WCS site. This was attributed to the presence of swelling clays in the fractures and closure or healing of the fracture joints. (*Section VI Geology Report Prepared For: Waste Control Specialists, LLC, Andrews, Texas,* Cook-Joyce, Inc. & Intera, Inc., August 2004, at pp. 4-9 to 4-11, LES Exhibit 73).

Q52. Given your knowledge of the geology of the site, and the history of faults in the site vicinity, what is your conclusion regarding the likelihood that fracture zones exist that can significantly increase the vertical transport of water through the Chinle formation beneath and surrounding the proposed NEF site.

A52. The results of investigations near the proposed NEF site indicate that it is unlikely that there are fracture zones which lead to increased vertical water transport. This is based on the fact that any active faulting in the immediate area occurred over 135 million years ago, and any resulting fractures would have had time to close, as demonstrated in the study at the WCS site. These conclusions are confirmed by the low permeability findings in the Chinle formation beneath and in close proximity to the proposed NEF site, as evidenced by over 40 permeability measurements taken within the last 13 years.

Basis (E) – Stormwater Runoff

Q53. Are you familiar with Basis (E) for NIRS/PC EC-1?

A53. Yes. I understand that Basis (E) of NIRS/PC EC-1states that:

> (E) The stormwater basin will discharge runoff containing numerous contaminants, which are not adequately identified in the DEIS, nor is their monitoring explained. LES has stated that the runoff will contain small amounts of oil and grease typically found in runoff from paved roadways and parking areas (RAI Response, May 20, 2004, at 33). However, other contaminants may be present, such as PAHs (USGS, Concentrations of PAHs and Major and Trace Elements in Simulated Rainfall Runoff from parking lots, 2003, Open File Report 2004-1208), other organics such as aliphatic hydrocarbons and alcohols (Barrett, M.E, et al., Review and Evaluation of Literature Pertaining to the Quality and Control of Pollution from Highway Runoff and Construction, Tech. Report CRWR 239, April 1993), and other contaminants from spills and accidents. Their presence should be disclosed. Further, stormwater should be

monitored for such contaminants.

Q54. Describe the stormwater basin referenced in Basis E, and state the purpose of this basin.

A54. The unlined Site Stormwater Detention Basin ("SSDB") will collect and contain stormwater from the developed areas of the site (other than the UBC Storage Pad), thereby reducing the potential for flooding caused by storms. The drainage area of the SSDB is 39 hectares (96 acres). (LES ER, at p. 3.4-6, LES Exhibit 1). The SSDB would have approximately 23,350 cubic meters (100 acre-ft) of storage capacity. The SSDB would have two feet of clearance between the water surface and the top of the basin. The surface area of the SSDB at high water elevation would be 19 acres, and the SSDB would be sized to contain the volume equal to that for the 24-hour, 100-year return period storm. (LES Groundwater Discharge Permit Application September 2003, at p. 11, LES Exhibit 4). The main purpose of a detention basin is to minimize increases in stormwater runoff from developed areas, so that pre-development runoff volumes to the surrounding land will not be exceeded. A detention basin also can have positive impacts on local surface water quality resulting from settling of suspended solids within the basin.

Q55. Would you expect some contamination of stormwater runoff at the proposed NEF site?

A55. Yes. I would expect the stormwater runoff to contain contaminants typical of industrial facilities that one would expect to find from activities such as vehicle maintenance and fueling, filling storage tanks, and painting operations during construction and operation. (DEIS, at pp. 4-10 & 4-11). While all of these potential contaminants are not specifically listed in the DEIS, the general chemical categories that would encompass them are listed as the parameters that will be evaluated as part of the stormwater monitoring program. (DEIS Table 6-9).

Q56. Is it possible that stormwater runoff could be contaminated by spills and accidents?

A56. Yes. However, the DEIS at page 4-10 discusses LES's planned implementation of the Spill Prevention Control and Countermeasures Plan during construction and operation. These mitigation measures are designed to minimize releases from spills and accidents to site soils. By doing so, the impact of spills and releases into stormwater runoff, which transports contamination in soil by dissolution of contaminants or suspension of contaminated soil particles, would also be reduced. The potential contaminants one would expect to be involved in an industrial accident are included in the list of all process chemicals and gases which would be used at the proposed NEF at Table 4-21 of the DEIS. Additionally, DEIS page 4-15 describes how under its Stormwater Pollution Prevention Plan, LES would establish staging areas to manage waste materials. Such materials would be segregated, and generation of such materials would be minimized. As shown in DEIS Tables 5-1 and 5-2, the Stormwater Pollution Prevention Plan is part of the mitigation measures that LES has committed to implement during both construction and any later operation of its proposed facility.

Q57. Please describe the polycyclic aromatic hydrocarbons ("PAHs") and the other "organics such as aliphatic hydrocarbons and alcohols" referenced in Basis E.

A57. As indicated in Basis E, PAHs, aliphatic hydrocarbons and alcohols may all generally be described as organics. On a molecular level, PAHs consist of rings of carbon and hydrogen. One type of sealer applied to asphalt parking lots and driveways is based on coal tar emulsions; coal tar consists of at least 50 percent PAHs by weight. Aliphatic hydrocarbons, on the other hand, are straight chain hydrocarbons. Examples of aliphatic hydrocarbons are methane, propane and kerosene. Alcohols are chain hydrocarbons, the most common examples of which are methanol and ethanol.

Q58. How are these types of contaminants typically introduced into the environment at an industrial facility such as the proposed NEF?

A58. PAHs are found in most petroleum products. PAHs can enter the environment, for example, from emissions from generators or motor vehicles. PAHs also can result from runoff from surface sealed parking lots. Aliphatic hydrocarbons are also a petroleum product, and are a component of motor oil and gasoline. Alcohol is a component of gasoline as it is presently formulated to reduce ozone and toxic air pollutants from auto exhausts. All of these contaminants would be expected near highways, major roadways, and parking lots in the vicinity of industrial facilities.

Q59. Will PAHs, aliphatic hydrocarbons and alcohols likely be present in any stormwater runoff from the proposed NEF site?

A59. As stated above in A58, these organics can be present in normal highway and parking lot runoff. However, there is no reason to expect that their presence at the proposed NEF would be any greater than at any other facility that is located near highways and has parking lots.

Q60. Basis E references the need to monitor stormwater for contaminants. Will contaminants in stormwater be monitored ?

A60. Yes. As discussed in DEIS Section 6.2.2, monitoring will be governed through the National Pollutant Discharge Elimination System ("NPDES") process and State regulations. Implementation of a Stormwater Monitoring Program would begin during construction of the proposed LES facility. Data collected from this program would show whether contamination of stormwater is being effectively prevented. Monitoring would continue during any operation of the proposed NEF. (DEIS, at p. 6-17). LES has proposed that its Stormwater Monitoring Program, regulated by NMED through the Groundwater Discharge Permit, would include quarterly monitoring of stormwater in the SSDB. (DEIS, at p. 6-18). The parameters to be monitored there are oil and grease, total suspended solids, Biological Oxygen Demand ("BOD"), Chemical Oxygen Demand ("COD"), phosphorus, nitrogen, pH, nitrates, and metals. (DEIS Table 6-9, at p. 6-18).

Q61. This list of parameters to be monitored does not specifically include PAHs, aliphatic hydrocarbons and alcohols. Why not?

A61. As stated above, these organics are typically found in stormwater releases where there are highways and parking lots. Monitoring of two of the parameters listed in the DEIS, BOD and COD, would detect the presence of these contaminants.

Q62. Does this conclude your testimony on NIRS/PC EC-1?

A62. Yes.

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EDUCATION: M.S., Chemical Engineering, University of Maryland, 1970
B.E., Chemical Engineering, Cooper Union, 1968
Course work and qualifying exam completed for PhD in Chemical Engineering, University of Maryland, 1970-72

EXPERIENCE SUMMARY:

Mr. Toblin has 32+ years of professional experience as a Principal Investigator and Technical Manager for analyses of contaminant (chemical, radionuclide, thermal) transport in groundwater, surface water and air environments. He has performed such analyses for numerous major industrial sites and government agencies, including all major DOE sites, in support of construction, operations, and clean-up activities. He has defended such analyses as an expert witness in state and federal hearing processes. Mr. Toblin also performs probabilistic risk assessments in support of licensing and operations of power plants and other facilities.

PROJECT EXPERIENCE:

Analyst; Determine Water Resources Impacts for the Proposed National Enrichment Facility; NRC (ATL Inc.); Lea County, New Mexico; Evaluated potential impacts to ground and surface water and water supplies due to construction, operation and decommissioning of that proposed facility. Prepared corresponding sections of the Draft Environmental Impact Statement.

Analyst; Determine Water Quality Impacts and Human Health Risks for Decontamination and Decommissioning of Sequoyah Fuels Corp; NRC (ATL Inc.); Gore, Ok.; Reviewed site analyses of water quality (chiefly groundwater) and human health impacts (ingestion, inhalation, external radiation) for site decommissioning. Performed independent analyses of future groundwater impacts on the site, at the site boundary and offsite. (Draft) Environmental impact statement written.

Analyst; Hazardous Waste Cap Performance for Operating Unit 3; Portsmouth Naval Yard; Portsmouth, N.H.; Evaluated water budget for the hazardous waste site for no action, and with various cap options. Determined flow through the cap to the groundwater using HELP3 model.

Analyst; Hydrologic Transport from Saltstone Disposition; DOE; Savannah River; Evaluated groundwater and subsequent surface water transport of contaminants from the proposed saltstone vaults. Transport included unsaturated flow, saturated flow, and impacts on local creeks.

Analyst; High Level Waste Tank Closure in F and H Areas; U.S. DOE; Savannah River Site; Performed groundwater modeling in support of closure of high level waste tanks in F and H areas at Savannah River Site. Performed for tank farm and specific tank closure plans and EIS.

Analysis includes concentration profiles at hypothetical 1-meter and 100-meter wells plus groundwater discharge points.

Analyst; River Water System EIS; U.S. DOE; Savannah River Site;. Performed groundwater quality and quantity modeling of the impacts of changing flows through Savannah River Site, including draining of L-Lake.

Task Leader; Sandia Sitewide EIS; U.S. DOE; Albuquerque, NM; Performed groundwater and surface water modeling of the water quality and quantity impacts of Sandia (Albuquerque) Sitewide operations.

Analyst; Yucca Mountain EIS; U.S. DOE; Las Vegas, NV; Performed radiological dose analyses for the no action alternative to the proposed disposal of material at Yucca Mountain. Atmospheric, surface water, and groundwater modeling analyses of the effects of leaving high level waste and spent fuel in place at each of the U.S. nuclear power plants and at DOE sites.

Analyst; Interim Management of Nuclear Materials EIS; F-Canyon Plutonium Solutions EIS; U.S. DOE; Savannah River; Performed analyses of radiological and chemical releases to hydrosphere for various source materials and processing options. Calculated doses to public from releases. Authored water resources sections of EIS.

Task Leader; Waste Management EIS; U.S. DOE; Savannah River; Determined radiological and chemical concentrations and drinking water doses as a result of releases from below grade vaults and slit trenches. Applied and modified the results from the Radiological Performance Assessment so that they were appropriate for the specific EIS options.

Task Leader; Critical Review of RESRAD Computer Code; Argonne National Laboratory; Argonne, Ill; Performed in-depth review of regulations, theory, coding, and results of code to implement DOE policy for reducing Residual Radioactive (RESRAD) material to levels as low as reasonably achievable (ALARA) on a site-specific basis. Emphasized environmental transport (air, groundwater, surface run-off). Suggestions to improve code's applications and fix errors found were implemented by code's authors.

Technical Manager; Waste Management Activities For Groundwater Protection at the Savannah River Plant EIS; U.S. DOE; Savannah River; Technical Manager for analyzing the contaminant transport and human health effects from the burial of low-level waste at DOE sites. Determined allowable disposal concentrations such that all DOE/NRC/EPA/State regulations regarding radiation exposure would be met at the time of emplacement and in the future. Authored EIS sections.

Technical Manager; Groundwater Contamination Remediation; Sherwin Williams; Directed three dimensional finite element groundwater modeling analysis which simulated the past release to and subsequent movement of material in a multi-aquifer system. A conceptual model was formulated and the flow (3D-FEMWATER) and transport (3D-LEWASTE) models used to deduce the release scenario from the present state of the plumes. Predictions of the temporal and spatial fate of the plumes, assuming no interdiction, lead to use of the model to develop a strategy for remediating the groundwater contamination.

Technical Manager; Resource Conservation and Recovery Act, Subpart X permitting at U.S. Army Open Burning and Open Detonation units; Martin Marietta; Directed technical group which performed multimedia hazardous material environmental transport modeling in air, groundwater, and surface water in support of RCRA Subpart X.

Analyst; Accelerator Production of Tritium EIS; U.S. DOE; Performed surface and groundwater impact analyses for Accelerator Production of Tritium.

Analyst; Remedial Investigation and Feasibility Study of Dahlgren Naval Base; U.S Department of Defense; Portsmouth, Virginia; Computer modeling of the impacts of remediation alternatives on groundwater and surface water quality and quantity for sites 9, 10, 17, 19, 25 and 29.

Analyst: Accident Environment for Proposed Pluto Space Shot: Determined accident environments (fragment velocity, position, pressure from explosions, etc.) for space shot from 2 proposed rocket systems.

Analyst: Modern Pit Facility Environmental Impact Statement: Performed accident analyses of proposed facility at 5 sites. Determined dose to non-involved worker, MEI and population. Produced isodose maps for each site.

Analyst; Site-wide Environmental Impact Statement for Lawrence Livermore National Laboratory; Performed accident analyses for non-involved and involved workers, MEI and population for all site facilities existing and proposed. Performed dose and health impact analyses from normal radioactive releases (ground water, atmospheric) to MEI and population from existing and proposed facilities.

Analyst; Level 3 Probabilistic Risk Assessment of Joseph M. Farley Nuclear Plant, Southern Nuclear Company; Performed PRA including source term derivation, analysis of meteorology/climatology data, local economic and agricultural production, evacuation simulation. Radiological dose, economic costs and risk calculated for hypothetical risk-important accidents.

Analyst; Level 3 Probabilistic Risk Assessment of V.C. Summer Nuclear Station, South Carolina Electric & Gas; H.B. Robinson Nuclear Station, Carolina Power & Light; Performed PRA including source term derivation, analysis of meteorology/climatology data, local economic and agricultural production, evacuation simulation. Radiological dose, economic costs and risk calculated for hypothetical risk-important accidents.

Analyst; Temperature Distribution in Atlantic Ocean from Uprated Brunswick Steam Electric Plant; Carolina Power and Light Company; Southport, NC; Statistical analysis of muti-year thermal monitoring data to determine isotherm areas and extents. Operations data scaled to account for increased heat load of proposed uprate. Scaling included heat load and buoyancy effects.

Task Leader; Develop Radiological Accident Response Code; Mallinckrodt; St.Louis, Mo.; Developed atmospheric transport and dose calculation computational model, based on Rascal kernel, directly applicable to client's site. Model is simple to use, contains all of the site-specific parameters, and calculates doses in the event of various accident scenarios at specific special receptors.

Task Leader; Review of Ultimate Heat Sink Technical Specification Change; NRC (Scientech Corp.); Hartsville, S.C.; Evaluated utility's application with regard to changing their method of operating their ultimate heat sink (cooling pond). Reviewed supporting material and suggested revisions to the application.

Task Leader; Level 3 Probabilistic Risk Assessment of Hatch NPP; Southern Nuclear Operating Company; Baxley, Georgia; Performed PRA including source term derivation, analysis of meteorology/climatology data, local economic and agricultural production, evacuation simulation. Radiological dose, economic costs and risk calculated for hypothetical risk-important accidents.

Task Leader; Review of Hazard and Operability Study of Ross Incineration Services; U.S. Environmental Protection Agency; Cleveland, Ohio; Reviewed Failure Mode and Effects Analysis. Comments regarding hazards analyzed and actions taken supplied to EPA.

Task Leader; Modeling of the thermal response of the service water pond at V.C. Summer Station NPP to upgrades in station operation; South Carolina Electric and Gas Corp; Columbia, S.C.; Modeled 30 years of sequential 3D pond temperatures for comparison with technical specification limits on temperature rise through the pond. The transient response of the pond to varying pond elevation, plant operation and meteorology was performed. A 30 day period of measured pond temperatures were simulated with the model and found to be an excellent match.

Task Leader; Accident Consequence Analysis (Level 3 PRA); Scientech Corp (U.S. NRC); Rockville, MD; Co-instructor of course presented to USNRC personnel. Course covered source terms, dispersion, health effects and health models, protective measures, and economic consequences.

Analyst; Reconfiguration (Stockpile Stewardship and Management, Highly Enriched Uranium, Fissile Material Development, Storage and Disposition, Tritium Supply and

Recycling EISs); U.S. DOE; Washington, D.C.; Performed accident risk analyses (radiological and chemical) in support of DOE reconfiguration.

Task Manager; Programmatic Spent Nuclear Fuel Management EIS; U.S. DOE; Idaho Falls, Id; Technical direction of group performing Occupational and Public Health and Safety sections dealing with use of the Oak Ridge Reservation and Nevada Test Site as alternative Spent Nuclear Fuel Management sites. Responded to comments of public and governmental agencies.

Analyst; Programmatic Tritium Supply and Recovery EIS; U.S. DOE; Washington, D.C.; Performed 10 CFR 100 dose limit analysis to determine the suitability of locating various tritium supply source designs and sizes at Oak Ridge Reservation, Pantex, and Nevada Test Site. Determined site capacity in accordance with regulation.

Analyst; Nonnuclear Consolidation EA, Nuclear Weapons Complex Reconfiguration Program; U.S. DOE; Kansas City, MO; Gathered data for chemical accident exposure analysis via site visit, interview with site personnel, personal inspection of facilities. Performed chemical accident analyses of existing and proposed chemical storage and operations facilities using CHEMS-PLUS (Chemical Hazard Evaluation Methodologies software package). Wrote environmental background sections.

Analyst; Estimated Frequency of Loss of Off-Site Power Due to Extremely Severe Weather and Severe Weather for Salem and Hope Creek Generating Stations; Public Service Electric & Gas; Salem, NJ; Determined frequency of occurrence of severe and extremely severe weather (snowfall, tornadoes, storms, hurricanes) and resulting frequency of off-site power loss to generating stations. A report which reported the results was produced and used by power company to successfully demonstrate to NRC, in accordance with Regulatory Guide 1.155, that special design and operating conditions limitations previously required by the commission were not necessary.

Analyst; Control Room x/Q Values for the Beaver Valley Power Station; Duquesne Light Co.; Pittsburgh, Pa; Performed theoretically advanced simulation of atmospheric dispersion in the presence of building wake turbulence for a 5 year sequential meteorological record. The results were included in a report which was used to successfully demonstrate to the Nuclear Regulatory Commission that special design implementations (filter systems) for station control room occupants, the necessity of which were indicated by previous analyses, were not required.

Analyst; Cooling Water Discharge Modeling; U.S. DOE; Savannah River; Developed thermal model of site streams between reactors (L, K, C, and power plant) and Savannah River (including swamp). Model used to predict downstream temperatures from cooling water discharges from various (combinations of) reactors, reactor operating levels, and discharge options. Model results were compared with subsequent operating data and demonstrated to be accurate. Developed associated models of cooling tower and cooling pond thermal performance (as a function of reactor operating condition and meteorology). Analyses used in various projects including design of alternative reactor cooling water systems, 316a demonstrations, L-Reactor restart, K-Reactor restart, and New Production Reactor cooling system design. Cooling pond model (L-Lake) used to study response of thermal discharge from lake to changing meteorological and reactor operating conditions; also to study vertical thermal structure of lake and possible destratification in response to major changes in reactor operating levels. Various reports and EIS sections (and technical appendices) produced.

Analyst; Evaluation of Proposed 40 CFR 193, Subpart C; U.S. DOE, Office of Environmental Guidance; Washington, D.C.; Reviewed performance assessments and other supporting technical documents to proposed EPA rule on groundwater dose limits from low level radioactive waste disposal. Presented technical arguments showing that generic studies which formed the basis of the proposed rules were not appropriate for DOE sites. Report generated.

Analyst; V.C. Summer Station - Cooling Lake Thermal Performance; South Carolina Electric & Gas; Columbia, SC; Performed computer mathematical study of horizontal and vertical temperature distribution in a cooling lake to determine the likelihood of exceeding regulatory discharge limitations. The model simulated the cooling lake response to 30 years of historical meteorology, power plant (at various power levels) and pumped storage operation. The pumped storage reservoir's thermal response was also modeled. The results of the model were accepted by the state and an NPDES permit granted. An associated study to quantify the incremental (from power plant operation) evaporation from the cooling lake was used by the pumped storage operator to assess the power plant owners for the cost of makeup water and lost pumped storage energy caused by the plant's thermal discharge.,

Analyst; Internal Dose Reconstruction Model; Defense Nuclear Agency, Washington, DC; Developed a calculational model and associated computer code reconstructs internal doses resulting from inhalation and ingestion of radioactivity in a space and time varying contaminant field. The model was applied to participants at atmospheric tests of nuclear devices. These participants were moved through the radioactive field in accordance with the historical record; contamination from previous detonations were included.

Technical Manager; Environmental Survey Prioritization; U.S. DOE - Office of Environmental Audit; Washington, DC; Responsible for direction of multidisciplinary group which prioritized environmental problems at all U.S. DOE sites. Rankings used a health-based assessment of environmental transport of contaminants, including evaluation of source terms, environmental transport mechanisms, and human health effects and consideration of all environmental media (air, surface water and groundwater, soil, direct radiation). "Debugged," revised, and refined associated computer program, MEPAS. Developed technical guidance for developing conceptual models of environmental problems, applying the computer model, and interpreting results. Developed Risk Information System (RIS) which integrated various quantitative measures of environmental impact. Presented results to 5-Year Planning group for their use; critiqued their use of information. Presented results and responded to questions from congressional staff.

Analyst; Hazard Ranking System; U.S. EPA - Superfund Office; Washington, DC; Evaluated risk assessment methodologies in support of congressionally mandated revision to Hazard

Ranking System. Performed theoretical study and practical applications of models for use in comparative studies of mathematical models. Results of study used in selecting a more mechanistic methodology (modified HRS) for ranking the risk of hazardous waste sites.

Hydrologist; Various Projects; Industrial/Governmental Clients. Is responsible for analysis of physical effects due to transport of effluents into surface and groundwater environments. Responsibilities have included evaluation of effects from existing and proposed discharges at Milliken, Bell, Cayuga, and Somerset (New York State Electric and Gas Co.); Perry (Cleveland Electric and Illuminating Co.); Belvedere, Carrols Pond, Douglas Point, and Chalk Point (Potomac Electric Power Co.); Greenwood and Fermi (Detroit Edison Co.); Tyrone and Sherburne (Northern States Power Co.); Davis-Besse (Toledo Edison Co.); South Texas Project (Houston Lighting and Power Co.); Dresden, Powerton, La Salle, Braidwood, Byron, and Collins (Commonwealth Edison Co.); San Onofre (Southern California Edison Co.); Ginna, Russell, Beebee, and Sterling (Rochester Gas and Electric Co.); Palo Verde (Arizona Public Service Co.); Schuylkill Refinery (Gulf Oil Co.); Great Bend (Columbus and Southern Ohio Co.); Big Bend (Tampa Electric Co.); Rio Haina (Dominican Republic); Skagit-Hanford (Northwest Environmental Services Co.); Savannah River Plant (U.S. Department of Energy); Limerick (Philadelphia Electric Co.); V.C. Summer (South Carolina Electric and Gas Co.); uranium mill tailings sites (U.S. Department of Energy); deep geologic nuclear waste repositories (Office of Nuclear Waste Isolation); hazardous waste sites (U.S. Environmental Protection Agency); all of the defense production and support facilities of U.S. Department of Energy; Mallinkcrodt.

CHRONOLOGICAL WORK HISTORY:

Consultant; April 2004 to Present.

Engineer; Tetra Tech NUS, Inc.; Gaithersburg, Maryland; October 1971 to March 2004.

Teaching Assistant; University of Maryland; College Park, Maryland; September 1968 to June 1971. Taught both graduate and undergraduate courses, concerned with computer applications to chemical engineering. Conducted mathematical research on dynamics of nonlinear control systems.

Analyst; Kennedy Van Saun Corp.; New York, New York; June 1968 to September 1968. Conducted engineering analysis of solids separation systems.

PUBLICATIONS:

"An Example of the Public Risk Arising from the Accidental Contamination of Drinking Water by the Deposition of Airborne Radionuclides" (coauthor), Proceedings of International ANS/ENS Topical Meeting on Probabilistic Safety Methods and Applications, 1985.

"Higher Order Approximations to Unit Impulse Response," Master's Research Paper, University of Maryland, College Park, MD., January 1970.