# STATE OF NEVADA
# NUCLEAR WASTE PROJECT OFFICE

**PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT:** UNCERTAINTY IN MODELING AND PERFORMANCE ASSESSMENT

**DATE:** JUNE 26, 1989

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# UNCERTAINTY IN MODELING

I. Sources of Uncertainty

II. Data Limitations

III. Recommendations

# I. SOURCES OF UNCERTAINTY

**Cranwell and Helton 1981 (NUREG/CP-0022) identify:**

- **Process Modeling Uncertainty**
- **Input Data Uncertainty**
- **Scenario Uncertainty**

**as primary components of uncertainty**

# BROAD CLASSES OF UNCERTAINTY

Eisenburg, et al 1987 identify five (5)

- Systematic and Random Error in Measurement
- Spatial Variations in Geologic Parameters
- Conceptual Models
- Physicochemical Process Modeling
- Future States of Nature

Schalla and Leonhart, 1981
NUREG/CP-0022 identify:

- Data limitations as a source of uncertainty in formulating conceptual hydrologic models

Kocher, Sjoreen and Bard, 1983
NUREG/CR-2506 identify:

- Insufficient Site Characterization as a source of uncertainty in estimating ground water transport times

# WATER CONDUCTING ELEMENTS IN TUFF

- Fractures or other voids in rock
- Matrix pores

Large permeability heterogenities necessitate using average properties.

# TRANSPORT MECHANISMS

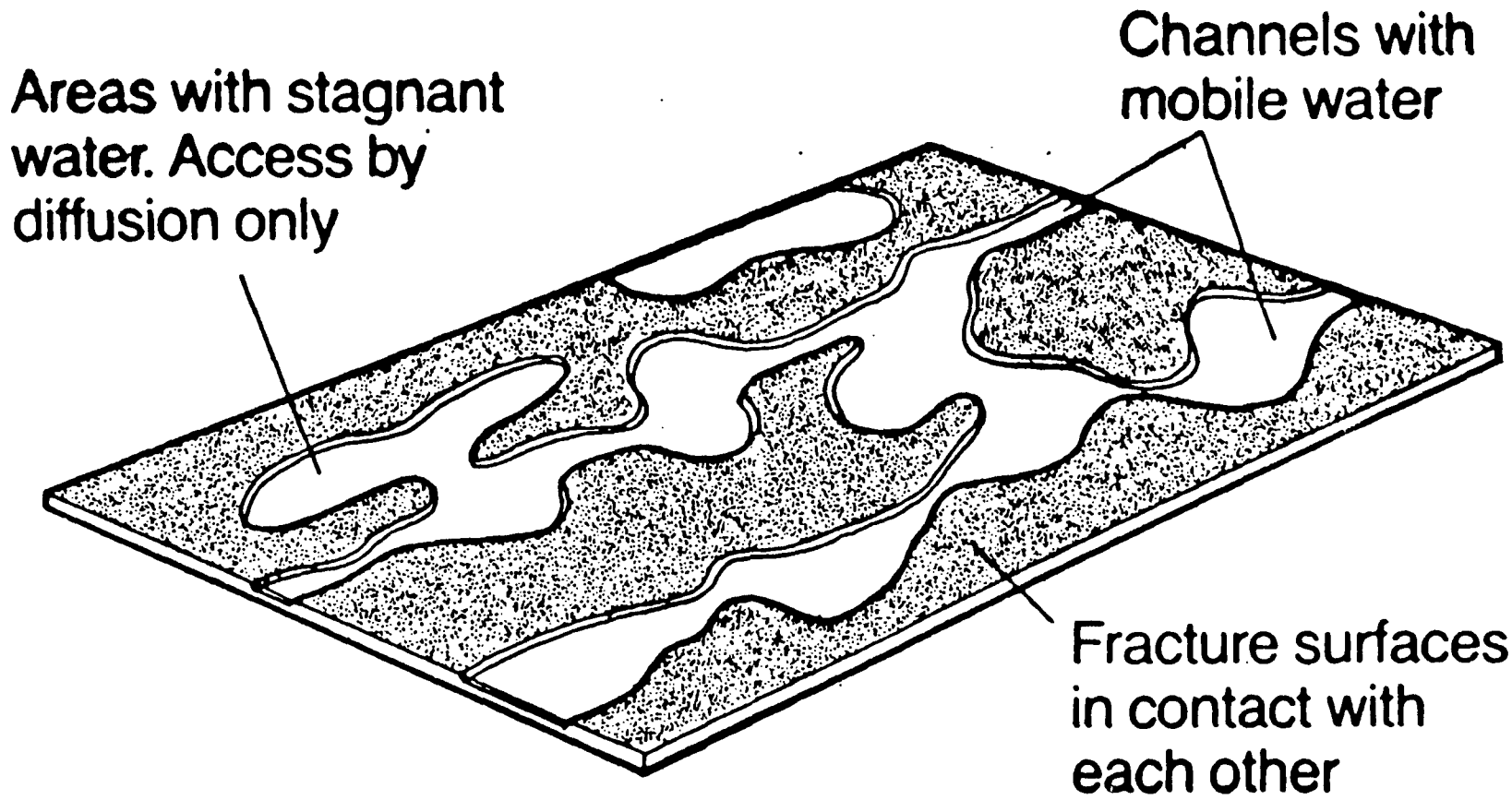
- o Advection
- o Dispersion
- o Sorption
- o Matrix diffusion
- o Chain decay
- o Colloids

To what extent do they occur?

* Heterogeneity - Uncertainty in describing spatial structure

## SPATIAL STRUCTURE

- Homogeneous porous medium
- Homogeneous porous medium with fracture zones
- Heterogeneous porous medium
- Discrete fracture network
- Channel network
- Fractal geometry


Areas with stagnant water. Access by diffusion only
Channels with mobile water
Fracture surfaces in contact with each other

# CRITICAL QUESTIONS WITH REGARD TO BARRIER FUNCTIONS - LARGE UNCERTAINTY

1) What is a proper description of the spatial variability of the rock; is it a system of poorly connected fast channels or not?

2) How much capacity for sorption and matrix diffusion are generally available?

3) Are colloids an important transport mechanism?

4) Will the coupling between ground water flow, rock stress and rock deformation seriously affect the long-term function of the repository?

# II. DATA LIMITATIONS

- General limitations
- Data limitations due to insufficient Site Characterization

# GENERAL DATA LIMITATIONS

- Many hydrogeologic parameters are obtained from inference
- Many parameters are assumed correlated to other parameters
- Representativeness of samples collected
- Number of samples
- Sample disturbance during sampling
- Measurement and interpretation error

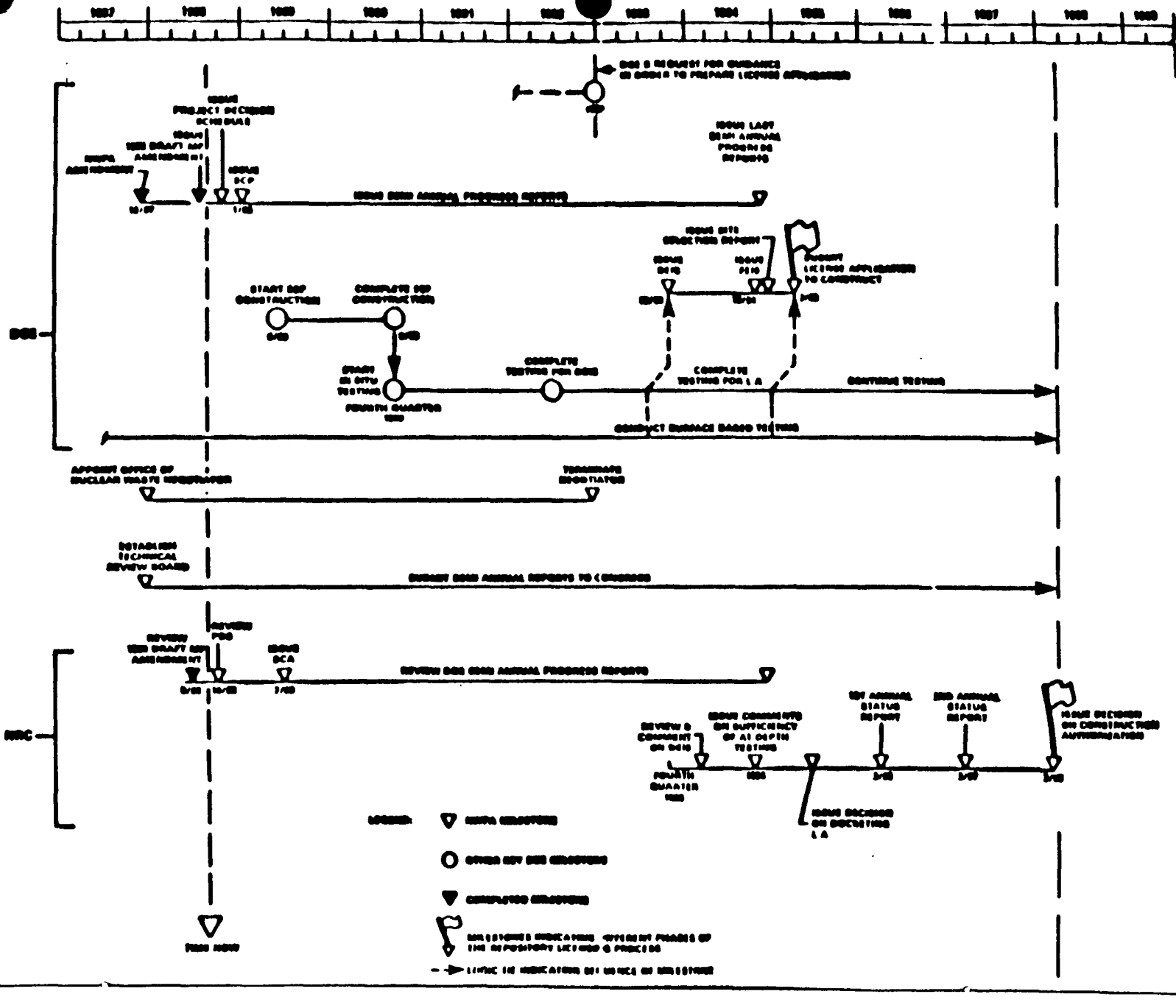
# TIME DEPENDENT LIMITATION

(i.e., time allocated for data acquisition)

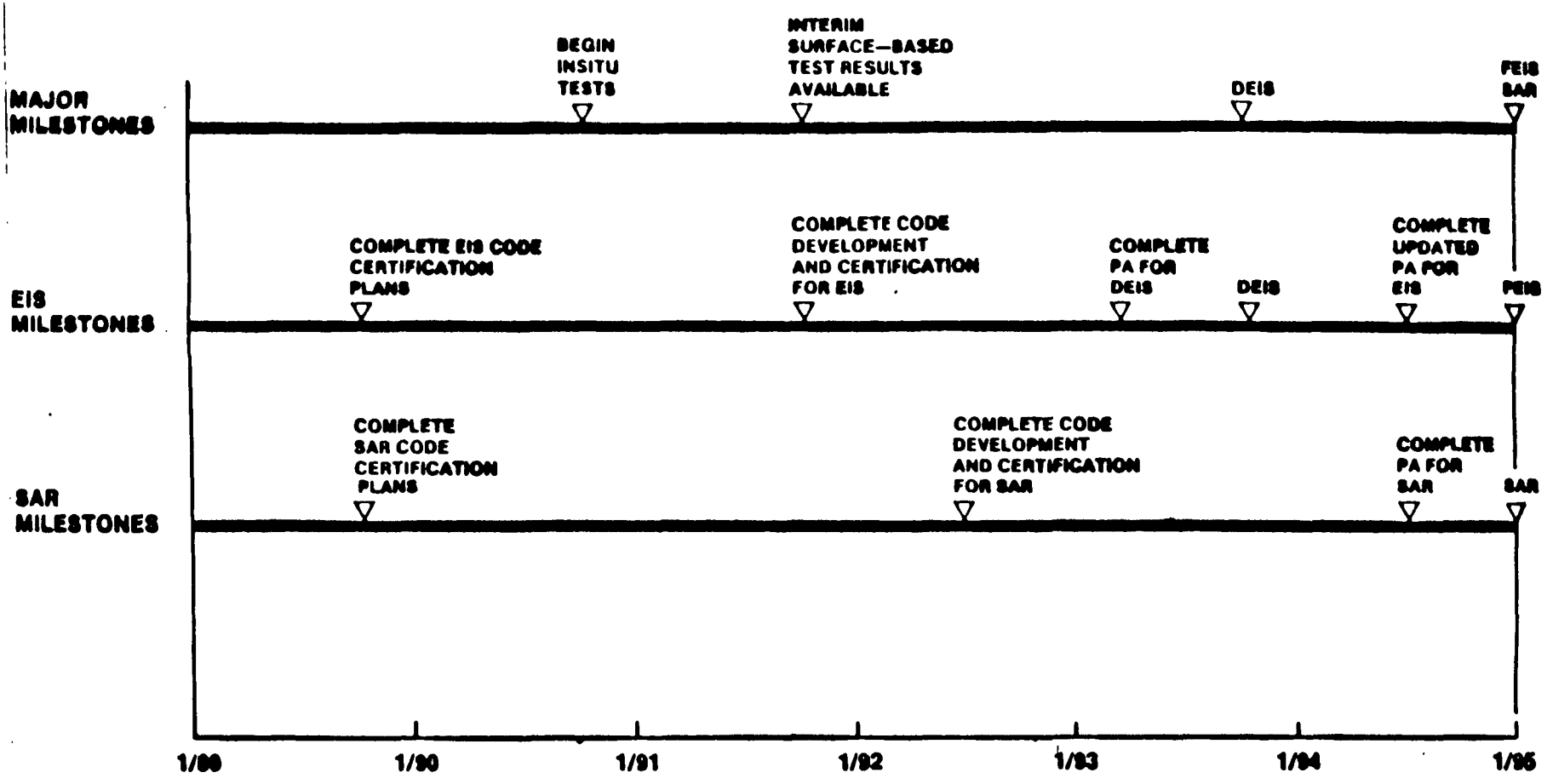
This limitation is correctable.

ENCLOSURE 3

TIMELINE OF LEVEL I NRC & DOE MAJOR REPOSITORY MILESTONES



# PERFORMANCE ASSESSMENT (PA) MILESTONES FOR LICENSING



**At what point does the schedule go from "ambitious" to "unrealistic"?**

# QUESTIONS

(1) What data will actually be used in the License Application?

(2) What will be its quality?

(3) How long does it take to generate data?

# HYDROLOGY DATA - SATURATED ZONE

| Type of Data | Period of Record | | Date Released | Quality |
|---|---|---|---|---|
| Water Level - Pressure Transducer (15 wells) | (1983 - Feb. 1987) | Non QA'd<br>QA'd | Mar. 1987<br>? | poor |
| Water Level - other (28 wells) | (1981 - 1987) | | Jan. 1989 | fair |
| Drawdown and recovery (10 wells) | (Oct. 1980 - 1984) | Non QA'd | Apr. 1987 | ? |

# HYDROLOGY DATA - UNSATURATED ZONE

| Types of Data | Period of Record | Date Released | Quality |
|---|---|---|---|
| Matric Potential vs. depth (UZ-1) instrumented | (Nov. 1983 - 1989) | not released | Suspect as per USGS |
| Saturation vs. depth Laboratory analysis of cores, cuttings, neutron probes (8 wells) | (1983, 1984, 1985) | (Preliminary results presented Nov. 1985) raw data not released | ? |

**Historically, reliable, good quality data are not available for at least two (2) years after a test is finished.**

**This means that for in-situ tests requiring more than two (2) years, the data will not be available for the License Application.**

- **prototypes**
- **USGS internal reviews**

**License Application will be based largely on sparse, surface-based testing**

# III. RECOMMENDATIONS

**To ensure a high quality and complete LA, DOE/NRC should move immediately to correct this time-limited data deficiency.**

- **Determine immediately how much in-situ data will be required in the LA and its quality.**
- **Extend deadlines to allow these data to be reliably collected, and interpreted.**
- **Stop compressing the data collection phase (deadlines must be moved commensurate with delays).**

# RECOMMENDATIONS - continued

Expand research into basic processes needed to address critical questions

- Unsaturated flow in fractured/porous media
- Analog studies
- Tectonic coupling to flow field

# IN SUMMARY

- Performance Assessment and Modeling Uncertainties are extremely large
- Data limitations are severe - some are correctable
- Even with good data, we will not be able to reliably model and predict the unsaturated zone (processes)
- Schedule compression must stop (Quality of License Application is at risk)
- Deadlines moved commensurate with delays
- License Application will be based on sparse, low-quality surface-based test data

**RESUME**

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**EDUCATIONAL BACKGROUND:**

University of South Florida, M.S., 1978, Hydrogeology
Florida Atlantic University, B.S., 1975, Geology
University of Minnesota, Ph.D. candidate/Hydrogeology, 1989

**WORK HISTORY:**

President/Principal Hydrogeologist
L. Lehman & Associates, Inc.; 1985 - Present

Private Consultant
Hydrogeology; 1983 - 1985

Hydraulic Engineer
U.S. Nuclear Regulatory Commission; 1979 - 1982

Hydrogeologist
Parsons, Brinkerhoff, Quade & Douglas, Inc.; 1977 - 1979

**EXPERIENCE:**

Ground Water Modeling

- Currently developing modeling efforts as the representative of the State of Nevada at the international flow and transport model validation effort for nuclear waste repository performance codes (INTRAVAL).
- Directed the development of conceptual flow models at solid and hazardous waste sites contaminated with volatile organic contaminants and other pollutants.
- Performed ground water flow and contaminant transport modeling of high-level nuclear waste sites (the Hanford Site Washington).
- Performed time series analyses using computerized data bases to establish baseline ground water conditions at high-level nuclear waste sites.

Expert Witness Testimony

- Served as primary technical expert regarding the ground water contamination at the Flying Cloud Landfill under litigation procedures, public hearings, and formal governmental agency meetings at various levels.

- Hydrogeologic expert for a class-action suit in Fernald, Ohio regarding ground water contaminants from defense-related nuclear operations.

- Provided the primary expert testimony regarding potential ground water contamination and site suitability for a solid waste landfill in McHenry County, Illinois.

- Provided expert testimony concerning potential ground water contamination from sewage sludge land application and agricultural runoff.

Hydrogeologic Investigations

- Directed the development of site characterization studies, environmental sampling and analytical program as part of the Remedial Investigation/Feasibility Study (RI/FS) for the Union Scrap Superfund Site.

- Technical review and analysis of the RI/FS at the Flying Cloud Landfill regarding ground water contamination and design of the ground water pump-out system.

- Directed staff in hydrogeological studies of potential solid waste disposal sites in Minnesota and Illinois.

- Directed the evaluation of the RI/FS for the Fernald nuclear defense facility in Ohio with regard to ground water contamination at that site.

Technical Program Management

- Provided overall project direction to the Yakima Indian Nation regarding the disposal of high-level nuclear waste and defense wastes at the Hanford reservation, including scientific and engineering efforts related to waste disposal design and siting issues.

- Served as prime contractor to the Minnesota Governor's Nuclear Waste Council for high-level nuclear waste Crystalline Repository Project and provided technical assistance in the areas of hydrology, geology, ground water modeling and regulatory/program analysis.

- Provided technical management assistance to the Nevada Governor's office in regards to scientific and engineering contractor support regarding the high-level nuclear waste repository at the Nevada Test Site.

Regulatory Development and Analysis

- Directed the development of rules to regulate the siting, design, construction, operation and closure of a low-level radioactive waste storage or disposal facility in the State of Maine.

- Participated in the development of siting criteria for the Federal Regulation (10 CFR 60) for high-level nuclear waste repositories.

- Provided formal review and comment efforts for various clients in regards to ground water and waste management regulations related to solid waste, hazardous waste, high-level and low-level nuclear waste, U.S. defense wastes, agricultural impacts on ground water, and ground water quality standards.

- Developed site suitability and selection criteria for radioactive waste disposal facilities keyed to various federal and state statutes.

**PROFESSIONAL ACTIVITIES:**

President, Minnesota Ground Water Association (1988)
Chairwoman, Subcommittee on Ground Water Protection Strategies; Environmental Quality Board Advisory Committee on Ground Water Protection (1988)
Member, Minnesota Pollution Control Agency Joint Hydrology Task Force

Certifications

Registered Geologist, State of Indiana
Professional Hydrogeologist, American Institute of Hydrology

Associations

International Association of Hydrogeologists
National Water Well Association
American Geophysical Union
Engineers Club of Minneapolis
American Institute of Hydrology

**SELECTED PUBLICATIONS:**

Nguyen, V.V., G.V. Abi-Ghanem and L.L. Lehman; Fractal Mixing in a Class of Composite Media; Preprints of Proceedings of the Stochastic Approach to Subsurface Flow, Montvillargenne, France; 6/85.

Lehman, L.L.; Factor Analysis of Groundwater Flow Paths in the Central Columbia Plateau; Comments of the Yakima Indian Nation on the Draft Environmental Assessment for the Hanford Site, Washington under the Nuclear Waste Policy Act, Volume 2; 3/85.

Lehman, L.L., GeoTrans, Inc.; Preliminary Sensitivity Analysis of Rockwell Flow Path Using SWIFT; Comments of the Yakima Indian Nation on the Draft Environmental Assessment for the Hanford Site, Washington under the Nuclear Waste Policy Act, Volume 2; 3/85.

Lehman, L.L.; Model Comparison; Comments of the Yakima Indian Nation on the Draft Environmental Assessment for the Hanford Site, Washington under the Nuclear Waste Policy Act, Volume 2; 3/85.

Lehman, L.L., V.V. Nguyen; Regional Correlation Between Precipitation and Piezometric Potential in Basalts: Analysis and Application; 3/88.

Lehman, L.L., Eric Hansen; Secondary Concentration of Air-Released Uranium through Watershed Runoff at the Feed Materials Production Center, Fernald, Ohio; 3/88.

Nguyen, V.V., L.L. Lehman; Interscale Transfer of Information in Nuclear Waste Repository Multibarrier Systems; Proceedings of Western Regional Conference Society of Groundwater Scientists and Engineers; 1/85.

Bennett, R.H., L.L. Lehman, et.al.; Interrelationships of Organic Carbon and Submarine Sediment Geotechnical Properties; Marine Geotechnology, Volume 6, Number 1; 3/84.

Upchurch, S.B., M. Dalton and L.L. Lehman; Groundwater Mixing in the Lower Floridan Aquifer in the Southern Peace River Basin; Florida Scientist, Volume 41, Supplement 1; 1978.