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NEIL F. HARTIGAN

ATTORNEY GENERAL
STATE OF ILLINOIS
CHICAGO

December 8, 1989

John H. Frye, III, Chairman
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. James H. Carpenter
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Jerry R. Kline
Administrative Judge
Atomic Safety and Licensing Board
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Washington, D.C. 20555

In the Matter of
KERR-McGEE CHEMICAL CORPORATION
(West Chicago Rare Earths Facility)
Docket NO. 40-2061 ML, ASLBP No. 83-495-01-ML

Dear Administrative Judges:

This forwards Illinois' testimony for the hearing to be held in Chicago on December 14-15, 1989. The testimony has been previously sent by facsimile to the Board and has been hand delivered to the parties. While I realize the Board has struck Dr. Thiers' testimony I am filing it for the purposes of the record.

Sincerely,

Douglas J. Rathe
Assistant Attorney General
Environmental Control Division
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Chicago, IL 60601 (312) 814-3094

DJR:bp

cc: Service List
dr132b

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CERTIFICATE OF SERVICE

I DOUGLAS J. RATHE, an attorney in this case do certify that on the 8th day of December, 1989, I caused to be served the foregoing Illinois' Testimony for the December 14 and 15, 1989 Hearing upon the parties listed below by Express Mail:

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and by first class mail, in envelopes bearing sufficient postage to the remaining parties listed on said Notice, by depositing same with the United States Postal Service located at 100 West Randolph Street, Chicago, Illinois, 60601

drl32b

DOUGLAS J. RATHE

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Comments of Don L. Warner
with respect to Contention 4(a)

1. I share the ASLB's concern with respect to the differing rates of cell infiltration used by Kerr-McGee and the NRC staff. As I understand it, Kerr-McGee obtained a value of 0.001 inches per year through use of the HELP model (Kerr-McGee, Vol. II, p. 2-74). A second value of 0.07 inches per year was also calculated with the HELP model. The minimum rate of cell infiltration used by Kerr-McGee was, apparently, 0.01 inches per year (Vol. II, p. 2-80). The reason for selection of that value was not explained. Values of cell infiltration up to 5 inches per year were used (Kerr-McGee, Vol. II, p. 2-80). The NRC staff used only one value, 3 cm or 1.2 inches per year (SFES, p. E-10). Thus, the values that have been speculated as being within the range of possibility are from 0.001-5 inches per year, a 5,000 fold difference. I believe that the natural rate of infiltration for the area of 3.6 inches per year (SFES, p. 4-91) should be assumed as a conservative or worst-case value. This is because the long-term integrity of covers such as that proposed for the West Chicago site have not been demonstrated and it is possible that such a cover will deteriorate from natural effects so that it will, eventually, allow infiltration at the same rate as other land in the vicinity.

2. I share the ASLB's concern with respect to the variability of the E stratum and would extend that concern to other geologic units underlying the West Chicago site. The E stratum ranges in thickness from about 1.3 feet to 25.5 feet over the site (Kerr-McGee, Vol. II, p. 2-42). According to Schubert (Docket No. 40-2061-ML; ASLB No. 83-495-01-ML) the E sand is apparently absent in drill hole B-9 and reaches 43 feet or possibly more on the north end of the disposal site. Hydraulic conductivity values for the E sand range from 22.3 to 568 feet per day (Kerr-McGee, Vol. II, Tables 2-15 & 2-16). The NRC used a single hydraulic conductivity value of about 192 feet per day in its modeling, about one-third of the maximum value. This points out the reason for concern about the range of geologic variability at the Kerr-McGee site. It is the principal reason why the type of modeling done by the NRC is inappropriate for meaningful characterization of that site.

As I have in my earlier affidavits, I will quote from the originators of vertical-flow cell infiltration model with respect to the limitations of their model when linked to the AT123D model for such a site. According to Gilbert et al (1983) "The aquifer structure at an actual site will, of course, be much more complicated than the simple structure assumed for the generic model described above. There will be different hydrological strata with three-dimensional, inhomogeneous structures, and there will be dispersion (even within homogeneous regions) of the ion-exchange rates, which leads to dispersion of the distribution coefficients. Mechanisms other than ion exchange between water and adsorbing surfaces may be important for both release and transport of radionuclides. The migrating regions of radioactive contamination in the unsaturated zone will, therefore, assume various shapes and will not have sharp boundaries, and the migration through the aquifer to the well will be more complicated than described. A more sophisticated model that took these complications into account would require site-specific data on the hydrological structure and properties. . . . The simple model described above provides generic estimates of the contamination of drinking water that can be expected to occur . . . ." I interpret these comments as supporting my position with respect to the NRC modeling work.

5. I agree with the estimate of the NRC staff that probably about 38% of groundwater recharge presently reaches the Silurian dolomite aquifer at the West Chicago site (SFES, p. 4-91). It disagrees with the Kerr-McGee statement that "only a very small percentage of water entering the glacial aquifer from the surface finds its way to the dolomite aquifer." The rate of recharge to the dolomite aquifer could be even greater, in the future, as will be discussed under my response to 6.

6. The ASLB is prudent in its concern for the Silurian dolomite aquifer, a major groundwater supply unit for northern Illinois. The permanent siting of a waste disposal facility over such an aquifer is questionable practice when other locations exist in the State that are more geologically suitable. Large scale withdrawal of water from the Silurian dolomite aquifer and consequent lowering of the piezometric surface in that aquifer has, undoubtedly, stimulated greater vertical recharge through the overlying glacial deposits at the West Chicago site and in the vicinity. Additional withdrawals that resulted in an even lower piezometric surface in the Silurian dolomite aquifer would be expected to cause an increased rate of vertical recharge to the Silurian dolomite aquifer.

Comments of Don L. Warner
with respect to Contention 3(g)(2)

Before further analyzing the issue of validation of the computer model used in the NRC staff's evaluation of the probable future impacts of onsite disposal at West Chicago on groundwater, it would be useful to discuss the reason for my concern with the model.

If one examines the input to the model and the resulting output, it immediately raises the question of what is happening in the modeling process that leads to the results that are presented in the SFES and of how realistic are those results. For example, the NRC staff has predicted an average concentration of lead in solution in the disposal cell leachate of 7.3 mg/l (Table E.1., SFES, p. E-9). In comparison with that value, which is about 150 times the IEPA drinking water standard, the peak concentration predicted at the midpoint of the downgradient waste pile edge is 0.011 mg/l (Table E.7., SFES, p. E-16), a dilution of 664:1. That same dilution ratio is predicted for all other chemical species and for peak concentrations at the site boundary 73m downgradient from the waste pile edge (Table E.7.). Having personally performed or directed considerable such modeling, I have great difficulty in accepting those modeling results, since they seem to be so physically implausible.

The fact that the modeling results presented in the SFES seem to be physically difficult to understand and to accept suggests a need for the comparison of such modeling results with those of other, previously validated, models or with the field data from a site such as West Chicago, where complex hydrogeological circumstances exist.

I do not dispute the fact that the vertical infiltration model and the lateral transport model used by the NRC can each be derived from first principals. That does not, inherently, make them legitimate for use in predicting the long-term performance of a proposed disposal site. For example, the vertical infiltration model requires that waste in the entire disposal cell be incorporated in a uniform rectangular block in which the leachate will have a uniform composition that will be maintained as the block of contaminated water moves uniformly toward the groundwater table. Such a model bears little resemblance to the real physical situation that I understand will exist where wastes with highly variable composition (Table 2.5, SFES, p. 2-15), are distributed nonuniformly, both vertically and horizontally, in the waste disposal cell and where vertical flow rates would be expected to be quite variable from place to place within the cell.

Perhaps the averaging processes used in the NRC model are satisfactory for comparison of alternate sites. I will not dispute that possibility, since that is not the issue that I am addressing. In fact, that is the sort of application that originators of both the vertical infiltration model (Gilbert, et al, 1983) and the lateral flow model (Yeh, 1981) state that their models are suitable for. What both authors also indicate that their models are unsuitable for and for which no evidence of suitability has been documented is the detailed modeling of a specific and hydrogeologically complex site, such as West Chicago.

It is argued by Kerr-McGee (ASLB Docket No. 40-2061-ML, ASLBP No. 83-495-01-ML) that, because Kerr-McGee carried out sophisticated numerical modeling for the West Chicago Site, it was not necessary for the NRC to do that. The SFES contains no discussion or analysis of Kerr-McGee's modeling results but, rather, relies upon the modeling done by the NRC staff for its conclusions.

With respect the Kerr-McGee modeling, I will agree that the two dimensional numerical flow and contaminant transport model used is an improvement over the AT123D model used by the NRC for analysis of lateral flow at the West Chicago site. However, the model used by Kerr-McGee does not consider vertical flow through the disposal cell at all and is not capable of incorporating the vertical components of flow into the saturated-zone modeling. In commenting on this latter model limitation, Kerr-McGee states that "Another limitation is the two-dimensional nature of the model. Because it is two-dimensional complete mixing in the vertical dimension is implicitly assumed to occur. The E Stratum at the disposal site is relatively thin, and so this assumption is not critical" (Kerr-McGee, Vol. II, p. 2-73). In fact, the E Stratum varies in thickness from near zero to 43 feet or possibly more (Schubert, ASLB Docket No. 40-2061-ML, ASLBP No. 83-495-01-ML). I do not know what the result would be of using a three dimensional model that would incorporate the vertical site properties; but I do not understand why that was not done, since three-dimensional models are readily available. Such three-dimensional modeling would have also allowed specific consideration of potential impacts upon the Silurian dolomite aquifer.

The results of the Kerr-McGee modeling should also be examined from the overall view of what they reveal or do not reveal. The dilution ratios predicted by the Kerr-McGee modeling to occur during flow through the saturated zone range from 21:1 to 5,882:1 (Kerr-McGee, Table 4, ASLB Docket No. 40-2061-ML, ASLBP No. 83-495-01-ML), a difference of about 300 times. Since a difference of 500 times would result from the range of assumed infiltration rates alone, (0.01-5 inches/year) it would seem that parameter was the most influential one in establishing the dilution ratios. Low infiltration rates resulted in relatively large dilutions, while high infiltration rates resulted in relatively smaller dilutions. The dilutions are for concentrations at the site boundary. Values are not given for concentrations (or dilutions) at the waste pile edge. In all cases, the predicted concentrations at the site boundary relate directly to the original concentrations assumed for the various chemicals in the disposal cell leachate. It is probable that dilution ratios would also relate directly to the rate of groundwater volumetric flow beneath the site as used in the model. In calibrating the Kerr-McGee model, a volumetric flow rate was established that would require infiltration of 9.5 inches/year (Kerr-McGee, Vol. II, p. 2-76) as compared with the most generally agreed up infiltration rate of about 3.6 inches/year (SFES, p. 4-91). This would, probably, result in a proportionally greater dilution ratio than would be predicted using a volumetric flow rate based upon infiltration of 3.6 inches/year.

If one were to take the lowest dilution ratio reported by Kerr-McGee (21:1) to reduce that by the ratio of infiltration rates discussed above (3.6 in/yr vs 9.5 in/yr) then to multiply that dilution ratio by the concentration of lead in cell leachate proposed by the NRC staff (7.3 mg/ℓ) the following result would be obtained:

(1/21)(9.5 in/3.6 in)(7.3 mg/ℓ) = 0.92 mg/ℓ (of lead in groundwater at the site boundary)

This calculation is intended only to show the result of analyzing and combining selected facts relating to modeling obtained from the Kerr-McGee report (Vol. II) and the SFES, and extrapolating them to a seemingly logical conclusion quite different than any contained in either of those documents. This analysis would suggest the need to carefully examine the methodology and results of the two modeling efforts to determine the extent to which they each may be satisfactory or unsatisfactory and to then provide such additional documentation, including further modeling, as may be necessary to reconcile the differences and deficiencies that seem to exist.

Hanna

RESUME

1. NAME: Don L. Warner, Dean, School of Mines and Metallurgy and Professor of Geological Engineering, University of Missouri-Rolla

2. DATE AND PLACE OF BIRTH: January 4, 1934, Norfolk, Nebraska

3. EDUCATION:

University	Degree	Date	Major Field(s)
Colorado School of Mines Golden, Colorado	Geological Engineer	1956	Geology-Engineering
Colorado School of Mines Golden, Colorado	M.Sc.-Geological Engineering	1961	Geology-Engineering
University of California Berkeley, California	Ph.D. Engineering Science	1964	Geological Engineering with minors in Geology and Civil Engineering

4. EMPLOYMENT HISTORY:

A. Staff Positions:

Dean, School of Mines and Metallurgy, University of Missouri-Rolla, Rolla, Missouri	June 1981 -
Acting Chairman, Department of Geological Engineering, University of Missouri-Rolla, Rolla, Missouri	Sept. 1980 - June 1981
Professor, Department of Geological Engineering, University of Missouri-Rolla, Rolla, Missouri	Sept. 1969 -
Federal Water Pollution Control Administration, U.S. Dept. of Interior, Cincinnati, Ohio; Chief of Earth Sciences - Ohio Basin Region	May 1967 - Sept. 1969
Basic and Applied Sciences Branch, Division of Water Supply and Pollution Control, U.S. Public Health Service, Cincinnati, Ohio; Research Geologist and Engineer	February 1964 - May 1967
Engineering Research Institute, University of California, Berkeley, California; Research Assistant	1962 - 1964
Department of Mineral Technology, University of California, Berkeley, California; Special Instructor	1962

Shell Oil Company, Casper, Wyoming; Geological Engr.	Summer 1961
Department of Basic Engineering, Colorado School of Mines, Golden, Colorado; Teaching Assistant	1959 - 1961
U.S. Department of Agriculture, Gunnison, Colorado; Civil Engineer	1958 - 1959
California Exploration Co., Guatemala, Central America; Geological Engineer	1956 - 1958
Gulf Oil Corporation, Casper, Wyoming; Geological Engineer	1956

B. Consultant to:

Governmental Organizations:

Federal Water Quality Administration, 1969-1971
U.S. Atomic Energy Commission Division of Materials Licensing, 1969-1974
U.S. Nuclear Regulatory Commission, 1974-1986
Ohio River Valley Water Sanitation Commission, 1969-1976
Illinois Institute of Environmental Quality, 1971-1972
Argonne Universities Association and Argonne National Laboratories, 1971-1975
Instituto do Desenvolvimento Economico Social do Para, and Universidade Federal do Para, Brazil, 1970-1971
U.S. Army Corps of Engineers, 1977-1980
Ozark Gateway Regional Planning Commission, 1976-1977
Ozark Regional Council of Governments, Joplin, Missouri, 1976-1977
New Castle County, Delaware, Areawide Waste Treatment Management Program, 1977
Ontario Ministry of the Environment, 1977
Attorney General, State of Illinois, 1977-present
County Commissioners, Wilkinson County, Georgia, 1978-1980
Forest Preserve District, DuPage Co., Illinois, 1978-1980
West Virginia University, 1984
United Nations Department of Technical Cooperation and Development, 1985
Kern Co., California, 1985
Madison Co., Illinois, 1987-1988
American Petroleum Institute, 1988-present
Louisiana Chemical Association, 1988-1989

Other Organizations:

Dames and Moore, 1968, 1986 - 1988
Raphael-Katzen and Associates, 1969
Law Engineering Testing Company., 1970, 1979
ARMCO Steel Corporation, 1971
General Electric Company, 1971
Singer Information Services Corporation, 1971
Black and Veatch, 1972, 1978
E. I. DuPont, Inc., 1972-1973
WAPORA, Inc., 1972-1975, 1978
General Electric-TEMPO, 1973-1981
Weston Geophysical Research, 1974

Woodward Moorehouse and Associates, 1974
Geraghty and Miller, Inc., 1975-1981, 1988-1989
National Water Well Association, 1975-1977, 1986
Stauffer Chemical Company, 1976, 1986
Freeman United Coal Company, 1977
France Stone Company, 1976-1979
Keplinger and Associates, Inc., 1979
Mobil Chemical Company, 1979-1980
Chem-Nuclear Services, Inc., 1980
Keck Consulting Services, Inc., 1979-1980
Cloverleaf Properties, Inc., 1980-81
Northside Sanitary Landfill, Inc., 1981
International Coal Refining Company, 1981
International Exploration Company, 1981
American Fly Ash Company, 1981-1982, 1986
O'Connor, Karaganis and Gail, 1981-82, 1988-1989
Engineering Enterprises, Inc., 1982-present
Nacelle Land and Management Corporation, 1984
CH^2M-Hill, 1985 - 1986
AMAX Lead Company, 1985 - 1986
American Cyanamid, 1985 -
Monsanto, 1986 - 1987
Shell Oil Co., 1987-88
ARCO - 1989

5. **HONORS AND AWARDS:**

Special Award Scholarship, Colorado School of Mines, 1951-1956
Blue Key Honorary Service Fraternity, 1955
Theta Tau Honorary Engineering Fraternity, 1954
Scabbard and Blade Honorary Military Fraternity, 1954
Colorado School of Mines, Graduate Fellowship, 1959-1961
University of California, Research Fellowship, 1962-1964
American Men of Science, 1967
Dictionary of International Biography, 1969
American Water Works Association - Best Paper Award, 1971
International Scholars Directory, 1972
Community Leaders and Noteworthy Americans, 1975
Who's Who in the Midwest, 1975, 1978, 1981, 1984, 1988
Tau Beta Pi, 1982
National Water Well Association Science Award, 1984
Distinguished Lecturer, National Water Well Assoc, 1986

6. **PROFESSIONAL SOCIETIES:**

American Association of Petroleum Geologists
American Institute of Mining, Petroleum, and Metallurgical Engineers
American Institute of Professional Geologists
Association of Engineering Geologists
Geological Society of America
National Water Well Association
National Society of Professional Engineers
Missouri Society of Professional Engineers

7. PROFESSIONAL REGISTRATION AND CERTIFICATION:

Registered Professional Engineer, Missouri E-21232
Certified Professional Geological Scientist No. 3682

8. COMMITTEES AND BOARDS

Member, Interior Department Ad Hoc Committee on Subsurface Waste Disposal, 1966
Interior Department Representative to State-Federal Coordination Committee, Applachia Mine Pollution Study, 1968-1969
Chairman, Ohio River Valley Water Sanitation Commission Committee on Subsurface Waste Disposal, 1970-1974
Technical Chairman, American Water Resources Association 1972 Annual Meeting
Chairman, American Society of Civil Engineers Committee on Underground Waste Disposal, 1972-1975
Member, Argonne Laboratories Regional Studies Advisory Board, 197-
Editor, Ground Water and Ground Water Monitoring Review, 1980-1985
Member, Ground Water Policy Committee, American Institute of Professional Geologists, 1982
Member, Mineral Resources Committee, National Association of Universities and Land-Grant Colleges, 1982-present; Chairman, 1989-
Member, U.S. Department of Interior Advisory Committee on Mining and Mineral Resources Research, 1985-present
Member, Science Advisory Committee, Underground Injection Practices Council, 1985-1986
Member, ASCE Task Committee on Guidelines for Artificial Recharge of Ground Water, 1985-present
Member, National Science Foundation, Land Treatment Panel, Hazardous Wastes Treatment and Disposal Workshop - 1986
Member, Research Committee, Underground Injection Practices Council, 1985-1988
Member, Board of Directors, Underground Injection Practices Council, 1986-present

9. INTEREST AND ACTIVITIES

A. General Interests:
Water resources, ground water hydrology, water pollution and environmental studies, subsurface exploration and exploitation, engineering properties of soil and rocks.

B. Funded Research and Training Grants:
U.S. Atomic Energy Commission Grant for Study of the Feasibility of Underground Waste Disposal in New York, 1970-1971
U.S. Geological Survey Grant for Study of Industrial Waste Injection Wells in the United States, 1970-1972
U.S. Environmental Protection Agency Grant for Training of Mineral Engineers in Environmental Protection, 1971-1976
U.S. Office of Water Resources Research Study of Ground Water Levels in New Lead Belt Area of Missouri, 1972-1974
Ohio River Valley Water Sanitation Commission Grant for Study of Industrial Wastewater Injection in the Ohio River Valley Region, 1974-1976

U.S. Nuclear Regulatory Commission Grant for Study of the Geology of the New Madrid Seismic Area, 1976-1977
U.S. Environmental Protection Agency Grant for Study of the Radius of Influence of Injection Wells, 1977-1980
Environmental Protection Agency Grant for Computer Simulation to Assess Environmental Impact of Residential Ground Water Heat Pump Utilization, 1979-1981
U.S. Environmental Protection Agency Grant for Transfer of Injection Well Technology Program, 1980-1981
Missouri Department of Natural Resources Grant for Evaluation of the Cabool, Missouri, wastewater spreading site. A. W. Hatheway and Ju-Chang Huang co-investigators, 1983
Williams Pipeline Company Contract for Study of the Impact of Pipeline Leakage in Missouri, Charles Morris and P.R. Munger, coinvestigators, 1985
American Cyanamid Contract for study of Pressure Buildup and Travel of Injected Liquids in the 2,400 Foot Sand and Chemical Reactions of Injected Liquids with Confining Strata; Leonard Koederitz, Ernst Bolter and Samir Hanna, coinvestigators, 1986-87
Underground Injection Practices Council, U.S. EPA Contract, for study of Hydrogeological and Hydrochemical Assessment of the Basal Sandstone and Overlying Paleozoic Age Units for Wastewater Injection and Confinement in the North Central Region; Cary McConnell, coinvestigator, 1986-88
American Petroleum Institute, Contract for Modeling of the Environmental Effects of Abandoned Oil and Gas Wells; Cary McConnell, coinvestigator, 1988

C. Curricula Developed

Training program for environmental protection in mineral engineering
Technology transfer program in injection well technology
Short course in "Ground Water Analysis and Design of Dewatering Systems" offered annually 1975-1984
Geological Engineering 331 - Subsurface Hydrology
Geological Engineering 431 - Advanced Subsurface Fluids Engineering
Geological Engineering 343 - Subsurface Exploration
Geological Engineering 335 - Environmental Geological Engineering

10. **PUBLICATIONS:**

1. **Warner, D. L.**, 1961, Stratigraphy of Mancos-Mesaverde Intertonguing Southeast Piceance Basin, Colorado, and Geology of a Portion of the Grand Hogback, Garfield County, Colorado: M. Sc. Thesis, Colorado School of Mines, 169 p.

2. ________, 1961, Stratigraphy of the Lower Portion of the Mesaverde Formation, Southeast Piceance Basin, Colorado (abstract):

3. ________, 1964, Mancos-Mesaverde (Upper Cretaceous) Intertonguing Relations Southeast Piceance Basin, Colorado: American Assoc. Petroleum Geologists Bulletin, V. 49, No. 7, p. 1091-1107.

4. ________, 19[illegible], An Analysis of the Influence of Physical Chemical

Factors Upon the Consolidation of Fine-Grained Clastic Sediments: Ph.D. Dissertation, University of California, Berkeley, 136 p.

5. ________, 1964, Theoretical and Experimental Analysis of the Influence of Physical-Chemical Factors on the Compaction of Clayey Sediments (abstract): Geological Society of America.

6. ________, 1965, Deep-Well Disposal of Industrial Wastes: Chemical Engineering, V. 72, No. 1, January 4, p. 73-78.

7. ________, 1965, Deep-Well Injection of Liquid Waste: U.S. Public Health Service Publication No. 999-Wp-21, 55 p.

8. ________, 1966, Deep-Well Injection-Interaction of Injected and Interstitial Water: American Society of Civil Engineers Proc., V. 92, No. SA4, p. 45-69.

9. ________, 1966, Subsurface Injection of Liquid Wastes: in Proc. of 1966 Western Resources Conference, p. 107-125.

10. Warner, D. L. and Doty, L.F., 1966, Chemical Reaction Between Recharge Water and Aquifer Water: in Proc. International Assoc. Scientific Hydrolbgists "Symposium on Artificial Recharge and Management of Aquifers" March 19-26, 1967, Haifa, Isreal, p. 278-288.

11. Warner, D. L., 1966, Ground Water Quality Studies, in Water Quality Studies, a Training Course Manual: U.S. Department of the Interior, Federal Water Pollution Control Administration, p. 15-1 to 15-11.

12. ________, 1967, Discussion of the article "Estimating Distance to Hydrologic Boundaries from Discharging Well Data." by S. I. Strausberg: Ground Water, V. 5, No. 4, p. 47.

13. U. S. Department of the Interior, Federal Water Pollution Control Administration, 1967, Stream Pollution by Coal Mine Drainage in Appalachia: 271 p., 62 figs., compiled and edited by D. L. Warner.

14. Warner, D. L., 1967, Deep Wells for Industrial Waste Injection in the United States-Summary of Data: U.S. Department of the Interior, Federal Water Pollution Control Administration, WP-20-10, 45 p.

15. ______, 1968, Deep Well Disposal, in Industrial Waste Disposal, R.D. Ross ed.: New York, Reinhold Book Corporation, p. 245-260.

16. ______, 1968, Subsurface Disposal of Liquid Industrial Waste by Deep-Well Injection, in Subsurface Disposal in Geological Basins - A Study of Reservoir Strata: Am. Association of Petroleum Geologists Memoir 10, p. 11-19.

17. ______, 1968, Discussion of the article "Two Dimensional Dispersion," by J.C. Bruch and R.L. Street: Am. Soc. of Civil Engineers Proc., V. 94, No. SA4, p. 739-740.

18. ______, 1968, Preliminary Field Studies Using Earth Resistivity Measurements for Delineating Zones of Contaminated Ground Water: Ground Water, V. 7, No. 1.

19. ______, 1969, Extent Sources and Control of Pollution from Mining Activities: in Proceedings Mining Environmental Conference University of Missouri, Rolla, Missouri, April, 1969.

20. ______, 1969, Summary Report Monongahela River Mine Drainage Remedial Project: U.S. Department of the Interior Federal Water Pollution Control Administration, Cincinnati, Ohio, compiled and edited by D. L. Warner.

21. Ohio River Valley Water Sanitation Commission, 1969, Perspective on the Regulation of Underground Injection of Wastewaters;

Part I - Public Policy, Legislative and Legal Aspects by Edward J. Cleary.

Part II - Administrative Guidelines and Evaluation Criteria by Don L. Warner.

22. Cleary, E. J., and Warner, D. L., 1970, Some Considerations in Underground Wastewater Disposal: Jour. Amer. Water Works Assoc., V. 62, No. 8, August, p. 489-498.

23. Warner, D. L., 1970, Regulatory Aspects of Liquid Waste Injection into Saline Aquifers: Water Resources Research, V. 6, No. 5, October, p. 1458-1463.

24. ______, 1972, Survey of Industrial Waste Injection Wells, Vols. 1-3: University of Missouri, Rolla, Missouri, June, final report to the U.S. Geological Survey under Contract No. 14-08-001-12280.

25. Warner, D. L. and Orcutt, D. H., 1973, Industrial Wastewater-Injection Wells in The United States - Status of Use and Regulation, in Preprints of papers presented at the Second International Symposium on Underground Waste Management and Artificial Recharge, Vol. 2, p. 687-697 Am. Assoc. Petr. Geologists, Tulsa, Oklahoma.

26. Warner, D. L., 1973, Disposal Wells, in Groundwater Pollution: Water Resources Engineering Educational Series, Program X: University of California, Berkeley, January 23-25, and New York City, New York, November 6-8.

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Professional Activities of Don L. Warner

Related to Land Disposal of Wastes

1964-1967	Staff scientist and engineer for Basic and Applied Sciences Branch of U. S. Department of H. E. W., Public Health Service - performed research and provided consultation concerning waste disposal to the land and groundwater contamination investigation and analysis.
1967-1969	Chief of Earth Sciences Ohio Basin Region U. S. Federal Water Pollution Control Administration - Coordinated regional activities concerning water pollution from mining activities, including mining waste disposal, and acted as national resource person in land waste disposal and groundwater contamination analysis.
1969-1986	Consultant to U. S. AEC and NRC concerning land waste disposal and groundwater contamination analysis.

Specific Recent (1976-present) Activities Concerning

Hazardous and Special Waste Disposal

1976-1977	Studied occurrence of water pollution and recommended remedial measures concerning pollution from mining activities in Tri-State lead-zinc mining district in Southwest Missouri for Ozark Gateway Regional Planning Commission and Ozark Regional Council of Governments.
1977	Retained as an expert by New Castle County, Delaware, for study of Army Creek landfill groundwater contamination problem.
1977-Present	Consultant to Illinois Attorney General for evaluation of:

1. Wilsonville, Illinois, waste disposal site
2. Paxton landfill, Chicago, Illinois
3. Sheffield, Illinois, low level nuclear waste disposal site
4. Sheffield, Illinois, Chemical waste disposal site
5. Princeville, Illinois, waste disposal site
6. CID, Chicago, Illnois, waste disposal site

7. ESL, Joliet, Illinois, waste disposal site

8. Brighton Landfill, Brighton, Illinois

9. Brockman Landfill, Ottawa, Illinois

1978-1980	Retained as an expert by the Forest Preserve District DuPage, County, Illinois, for evaluation of Mallard Lake landfill site
1978-1980	Consultant to County Commissioners, Wilkinson, Co., Georgia concerning Gordon Service Co. hazardous waste facility
1980	Consultant to Chem-Nuclear Services, Inc. concerning suitability of sites in Illinois and Indiana for acquisition for hazardous waste disposal
1981	Consultant to Northside Sanitary Landfill, Inc., concerning evaluation and expansion of site at Zionsville, Indiana
1980-1981	Consultant to Cloverleaf Properties, Inc., concerning proposed Rickano hazardous waste disposal site, Warren Co., Missouri
1981-1982	Consultant to American Flyash Company for design of 1986 exploration program and evaluation of site for disposal of flyash and slag from Powerton Station, Pekin, Illinois
1981-1982	Consultant to O'Connor, Karaganis and Gail for evalution of Pioneer Development proposed hazardous waste landfill, LaSalle Co., Illinois.
1982-1983	Consultant to Karaganis, Gail and White, Ltd. concerning mitigation of pollution from Lemon Lane landfill site, Bloomington, Indiana
1985-1986	Consultant to AMAX Lead Company concerning effects on groundwater of smelter wastes and effluents
1986-1988	Consultant to Gulf & Western concerning groundwater and surface water contamination from abandoned mines in Gilman District, Colorado
1987-1988	Consultant to Madison Co., Illinois concerning landfill expansion
1987-1988	Consultant to citizens group concerning proposed landfill Champaign Co., Illinois.

STATEMENT REGARDING INFILTRATION RATE ISSUE RAISED BY CONTENTION 4(a) AS SET FORTH IN THE NOVEMBER 14, 1989 MEMORANDUM AND ORDER OF THE ATOMIC SAFETY AND LICENSING BOARD OF THE US NRC

by

Gerald R. Thiers

The Memorandum and Order cited above states the need to resolve the difference between two infiltration rates published for the cell: The Kerr-McGee Engineering Report estimate of 0.025 cm/year (Vol. II, p. 2-80) and the SFES value of 3 cm/year (SFES, p. E10).

Subsequent testimony by expert witnesses results in the following estimates:

1. Charley Yu, in answer to the question on Page 2 of his testimony, "What is the most probable value of infiltration rate and what is its uncertainty?", states:

   "The actual value of infiltration rate depends on the construction of the disposal cell and <u>the integrity of the cell in the long-term</u> (Emphasis added). For the analysis of the long-term impacts, a reasonably conservative infiltration rate was estimated by the staff. This conservatism is consistent for all alternatives. Cell infiltration rate may vary from time to time. The value of <u>3 cm per year</u> (Emphasis added) represents the "time-averaged" annual infiltrate rate; it was estimated based on site-specific annual precipitation, evaportranspiration and runoff."

2. On page 7 of testimony submitted by a panel composed of Charles W. Fetter, Jr., James L. Grant and John C. Stauter, the testimony reads:

   "Kerr-McGee allowed for increased infiltration through the root zone into the cell by increasing the assumed hydraulic conductivity of the surface soil layer by a factor of 10 - a very conservative adjustment that serves to over-estimate predicted infiltration. Under these conditions, cell infiltration was calculated to be about 0.1 inches (**0.254 cm**) **per year** (Emphasis added)."

These two testimony statements reduce the range of infiltration rates presented by Kerr-McGee to approximately 0.3 to 3.0 cm/year.

Limiting the infiltration rate to the range cited above depends on the clay layer remaining intact and unaffected by weather, including erosive forces due to storm water runoff. The acceptable design storm for uranium tailings disposal cells is given by the U.S. Nuclear Regulatory Commission in their document, "Standard Review Plan of UMTRCA Title I Mill Tailings Remedial Action Plans," October, 1985, as the probable maximum precipitation (PMP). Kerr-McGee has agreed (IX-Eng. Rep. 9-13) that the PMP storm event is "generally accepted by the NRC." This is in fact the state-of-the-art for design of covers for uranium tailings disposal cells, as indicated by the US NCR staff in "Uranium Mill Tailings Management Position," 1989.

Unfortunately the cell cover proposed by Kerr-McGee is designed using only "storm-specific forms of the USLE [Universal Soil Loss Equation] and the MUSLE [Modified USLE]" (VI Eng. Rep 6-9 to 6-18). These equations, which do not include snow-melt or storms as large as the PMP, and do not consider gully erosion*, are not the equations approved by NRC for the design of covers for uranium tailings repositories (See US NRC staff Technical Position, "Design of Erosion Protection Covers for Stablization of Uranium Mill Tailings Sites," August, 1989, p. A-2). The approved method is the Horton method described on pages A-2 through A-6 in this reference. This method should be used for design of the cover. NRC specifically states that the cover should be designed for gully erosion (above ref., p. 6)

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*Ref. "Erosion Control During Highway Construction," National Cooperative Highway Research Program Report 221, April 1980, pp. 5 and 6.

using the PMP storm (same ref., p. 4-6). (See also US NRC, Overland Erosion of Uranium Mill Tailings Impoundments: Physical Processes and Computational Method, NUREG/CR-3027, March 1982, and US NRC, Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments, NUREG/CR-3397, October 1983).

Because the cover is not designed to resist large storms and is not designed to prevent the formation of gullies, which concentrate runoff, deep and extensive erosion will develop. This will constitute major damage, and could lead to total removal of the cover. Unless the cover is designed to resist these phenomena it cannot be relied on to protect the clay layer. This means the clay layer can be eroded or subjected to other forms of deterioration, causing the infiltration rate to increase beyond the range estimated for an intact, undisturbed clay layer. As a minimum the infiltration rate would then revert to the natural value for the West Chicago area, of approximately 3 to 4 inches/year.

Even if portions of the clay remained intact, gullies which extend through the clay to the tailings would allow direct inflow of runoff. In this case the infiltration rate would be greater than the natural value and would be bounded only by the annual precipitation of 30 + inches per year. Unless the cover is designed using state-of-the-art criteria for uranium tailings cells, as required by the NRC, an infiltration rate that is significantly higher than that used in the SFES should be used in computing potential impacts on groundwater quality.

GERALD R. THIERS
Principal Engineer

EXPERIENCE SUMMARY

Jerry Thiers has more than 33 years of experience in geotechnical engineering, specializing in environmentally sensitive design of foundations, dams and hazardous waste containment. He has taught, performed, and managed the various aspects of field investigations, feasibility studies, seepage and geochemical analyses and design of earth related construction.

Thiers has supervised research and design in slope stability, seismic loading, consolidation, and behavior of piles and subsurface and above grade waste repositories. He was responsible for design, testing, and performance monitoring of a 400-foot high earth dam; foundation design and construction analysis for a major fossil-fuel power plant; and preparation of criteria, drawings and specifications for uranium tailings isolation systems.

His work has included pile testing for a 1,000-pile foundation for a turbine-generator manufacturing plant, geotechnical investigations and design for the Trans-Panama pipeline, seepage cut off structures for mine waste leach facilities, shallow and deep foundations for a coal gasification plant, and seismic analyses of dams for tailings disposal, hydropower, and water supply. As consultant on the uranium tailings reclamation system for Union Carbide at Uravan, Colorado, Thiers worked on seismic, seepage and consolidation analyses for the uranium tailings pile. As Site Design Engineer for the Uranium Mill Tailings Remedial Action Project, Thiers is responsible for design procedure and final design for isolation of radioactive uranium tailings at sites ranging from 8 to over 90 acres, with tailings volumes ranging from 40,000 to 4,000,000 cubic yards. This work includes preparation of construction drawings and specifications and hydrogeologic and contaminant migration analyses for permanent repositories for the tailings. Thiers' work has led to publication of more than a dozen articles.

EDUCATION: BS (1956), MS (1959), PhD (1965), Civil Engineering; University of California, Berkeley

SOCIETY: American Society of Civil Engineers

REGISTRATIONS: Civil Engineer - California, Pennsylvania, Washington

University of Washington
Seattle, Washington
1959 - 1962

As a faculty member, Thiers conducted applied hydraulic experiments and was a consultant on a major landslide at the Portland Zoo.

U.S. Army Corps of Engineers
Seattle, Washington
1957 - 1959

Thiers participated in foundation investigations, the analysis of the stability of a major earth and rockfill embankment, and stability analyses for numerous dikes and levees.

PUBLICATIONS:

"Radon and Leachate Control in Uranium Tailings Disposal" with J. Kam and J. S. Long, Proceedings, AIChE Summer National Meeting, Philadelphia, PA, August, 1989.

"Selection of Durable Rock for UMTRA Project Sites" with G. Lindsey and R. Rager, DOE Annual Contractors Meeting, Gaithersburg, MD, October, 1988.

"Recent Developments in Disposal and Isolation of Uranium Mill Tailings Under the UMTRA Program," with T.R. Wathen, Proceedings, Waste Management '87, Tucson, Arizona, March, 1987.

"Burying the Nuclear Past," with J.R. D'Antonio and J.A. Caldwell, Civil Engineering, February, 1987.

"Uranium Tailings Reclamation - Regulation, Design and Construction," with T.R. Wathen, Proceedings, Waste Management '86, Tucson, Arizona, March, 1986.

"Tailings Stabilization Experience at the Canonsburg UMTRA Site," with T.R. Wathen and L.L. Farnes, Proceedings, Geotechnical and Geohydrological Aspects of Waste Management, Fort Collins, Colorado, February, 1986.

"Isolation of Abandoned Uranium Mill Tailings," with E.S. Smith, Proceedings, XI International Conference on Soil Mechanics and Foundation Engineering," San Francisco, California, August, 1985

"Construction Experience at the Canonsburg UMTRA Site," Proceedings, 7th Symposium on Management of Uranium Mill Tailings, Low-Level Waste, and Hazardous Waste, Fort Collins, Colorado, February, 1985

"Seismic Design of Concrete-Faced Rockfill Dams," with F. B. Guros, T. R. Wathen, and C. E. Buckles, Proceedings, Eighth World Conference on Earthquake Engineering San Francisco, California, July, 1984.

PUBLICATIONS: (continued)

"UMTRA Project: Canonsburg Final Design," with F. B. Guros and E. S. Smith, Proceedings, Sixth Symposium on Management of Uranium Mill Tailings, Low-Level Waste, and Hazardous Waste, Fort Collins, Colorado, February, 1984.

"Trans-Panama Pipeline System, Geotechnical Studies," with R. W. Heneks, Proceedings, ASCE Specialty Conference on Pipelines in Adverse Conditions - II, San Diego, California, April, 1983.

"Offshore Geotechnical Studies for Trans-Panama Pipeline System," with H. Al-Ausi, Proceedings, ASCE Specialty Conference on Pipelines in Adverse Conditions - II, San Diego, California, April, 1983

"Some Engineering Properties of Chirique Grande Silt," with H.R. Al-Alusi, Proceedings, ASCE Speciality Conference on Engineering and Construction in Tropical and Residual Soils, Honolulu, Hawaii, January, 1982.

"Dynamic Analysis of Two Tailings Dams," with C. E. Buckles and R. G. Edwards, Proceedings, ASCE National Convention, New Orleans, Louisiana, October, 1982.

"Dynamic Behavior of Tailings Materials," with A. Phukunhaphan and C. F. Tsai, Proceedings, ASCE National Convention, New Orleans, Louisiana, October, 1982.

"Field Density, Gradation and Triaxial Testing of Large-Size Rockfill for Little Blue Run Dam, with T. D. Donovan, ASTM STP 740, pp. 315-325, 1981.

"Foundation Treatment for Little Blue Run Dam," with L. W. Lobdell and B. M. Milhalcin, Proceedings, ASCE Speciality Conference on Rock Engineering for Foundations and Slopes, Vol. I, pp. 283-308, Boulder, Colorado, August 1976.

"Design of Large Slabs on Granular Material," with H. A. Salver and R.E. Gray, Proceedings of the Eighth International Conference on Soil Mechanics and Foundation Engineering, Moscow, U.S.S.R., 1973.

"Load-Deformation Mechanism for Bored Piles," with R. D. Ellison and E. D'Appolonia, Proceedings of the American Society of Civil Engineers, Vol. 97, SM4, April 1971.

Developing Priorities for Street Improvement Programs in Urban Areas, with L. Hoel and J. Dettore, Highway Research Record Number 348, Planning and Evaluation of Transportation Systems, Highway Research Board, National Academy of Sciences, Washington, D.C., 1971.

Strength and Stress-Strain Characteristics of Clays Subjected to Seismic Loading Conditions, with H. B. Seed, ASTM STP 450, 1969.

"Guideway Substructure," Transportation Research Institute Report No. 1, Chap. 3, Urban Rapid Transit Concepts and Evaluation, Carnegie Mellon University, Pittsburgh, Pennsylvania, 1968.

"Cyclic Stress-Strain Characteristics of Clay," with H. B. Seed, Proceedings of the American Society of Civil Engineers, Vol. 94, SM2, March 1968.

Seismic Effects of Structures Supported on Piles Extending Through Deep Sensitive Clays, with R. A. Parmelee, J. Penzien, C. F. Scheffey, and H. B. Seed, Report to California State Division of Highways, August 1964.

Experience Details

UMTRA Project, Various States, Headquarters in Albuquerque, N.M., Site Design Engineer; ~~Criteria and Analysis Consultant:~~ As Criteria and ~~Analysis Consultant~~ reviewed design documents and developed major portions of design manual for design of uranium tailings repositories at 24 locations in 10 states, repository volumes ranging from 40,000 to ~~3.3~~ million cubic yards, over 8 to 90 acres. Supervised preparation of preliminary and final design construction drawings and specifications for Canonsburg Site, and conceptual, preliminary and final design for Burrell site, preliminary design for Slickrock site, and final design for Shiprock site. Managed engineering during construction for Canonsburgh, Shiprock, and Lakeview.

Panama Pipeline, Charco Azul to Chirique Grande, Panama, Task Leader: Determination of foundation design parameters and construction quality for 130-km long, 36-\and 40-inch diameter pipeline, with pumping sta- tions, oil storage tanks, and offshore tanker loading and unloading facilities. Directed geotechnical investigations, foundation studies, and construction monitoring. Prepared reports presenting results of studies and field monitoring.

Forest Lake Dam, Monterey, California, Project Manager: Managed geotechnical investigation, including drilling and laboratory testing, and seismic stability analysis of a seismic stability evaluation of 60-foot high, 70-year old earthfill dam. Directed preparation of reports on results of evaluation and conceptual designs for remedial action for the California-American Water Company.