

State of Nevada Briefing to the Nuclear Waste Technical Review Board (NWTRB)

Subject: Climate Change Concerns of the Proposed
Nuclear Waste Repository, Yucca
Mountain, Nevada

Date: 26 June 1989

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Climate Change

GENERAL CONCERNS

- A vadose-zone repository at Yucca Mountain will experience major hydrologic impacts from a climate change similar to the last pluvial climate which occurred about 16,000 to 10,000 years before the present.
- Anticipated hydrologic changes from a pluvial climate acting on Yucca Mountain is about 10 x more effective moisture--more recharge, more fracture flow, more perched water, and a rise in the water table to a level below the repository horizon.



REGIONAL EVIDENCE

- **Former extent of pluvial lakes in the Great Basin.**
- **Change in effective moisture (runoff and recharge) was about a one order of magnitude increase (10x modern).**
- **Extensive areas of ground-water discharge deposits in the Yucca Mountain region indicate greater discharge flux and rise in water tables up to several hundred feet.**



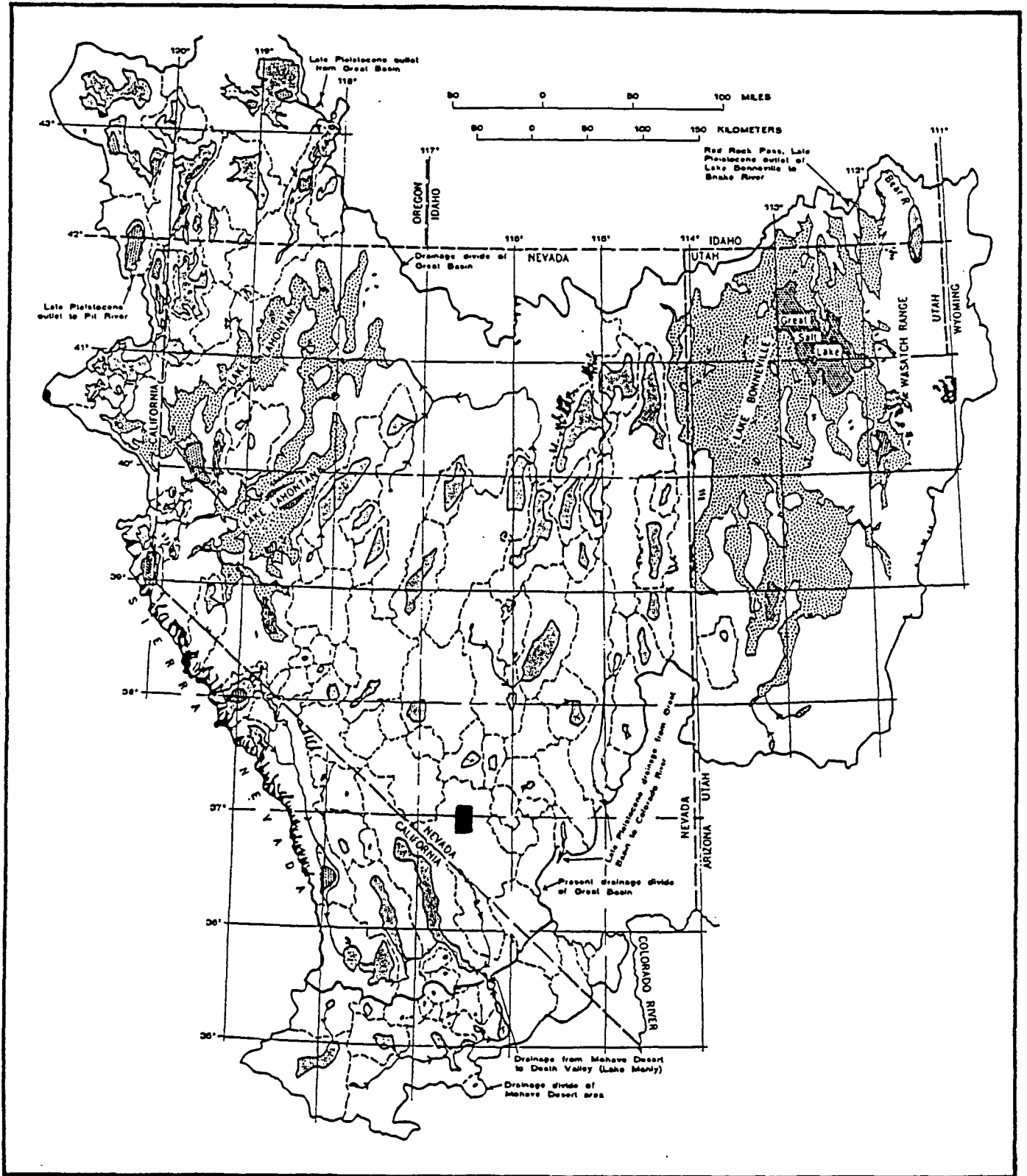


Figure 3. Plenipluvial Pleistocene lakes in the Great Basin (after Morrison, 1965; modifications from Mifflin and Wheat, 1979).

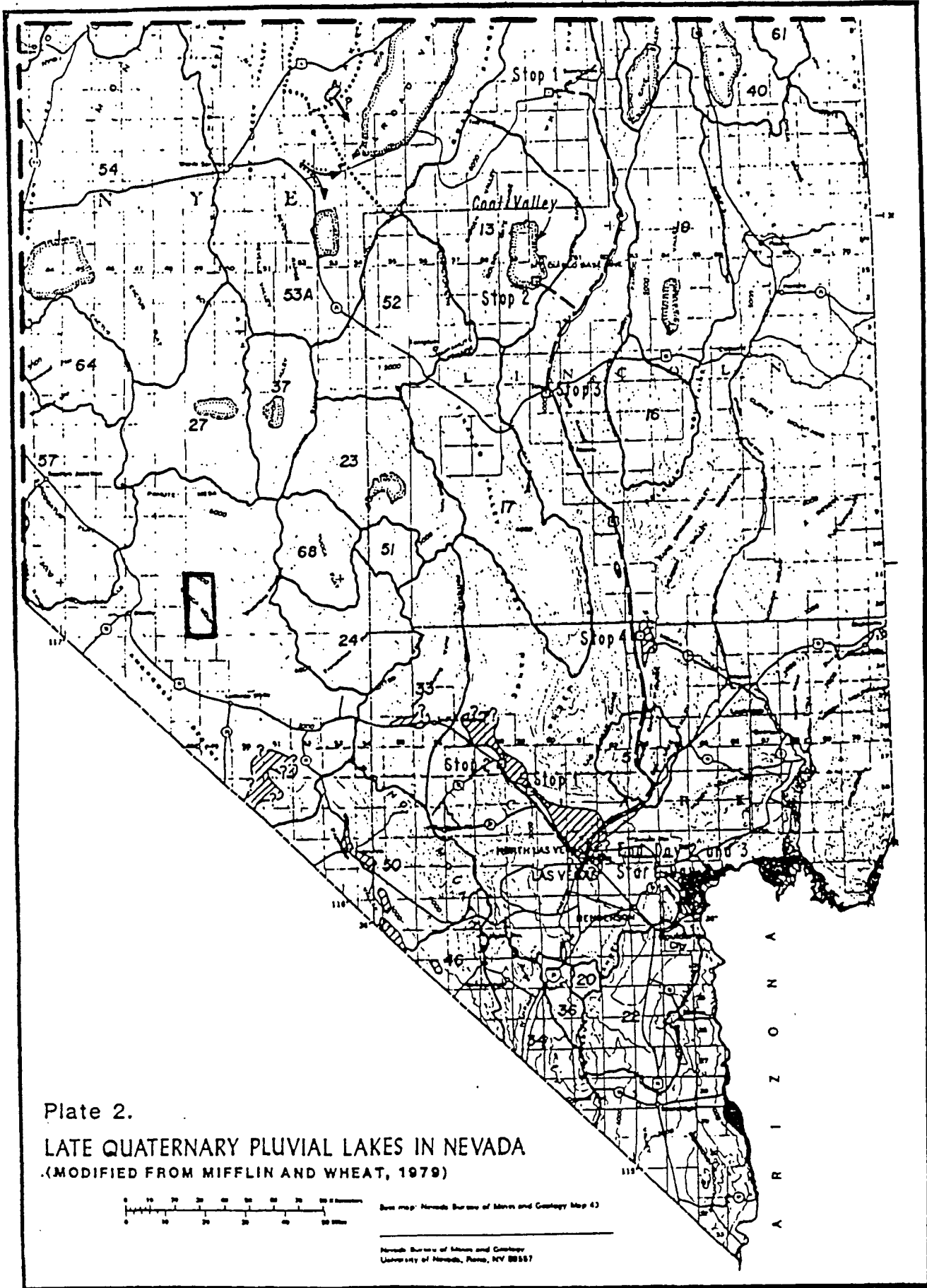


Plate 2.
 LATE QUATERNARY PLUVIAL LAKES IN NEVADA
 (MODIFIED FROM MIFFLIN AND WHEAT, 1979)

Scale map: Nevada Bureau of Mines and Geology Map 43

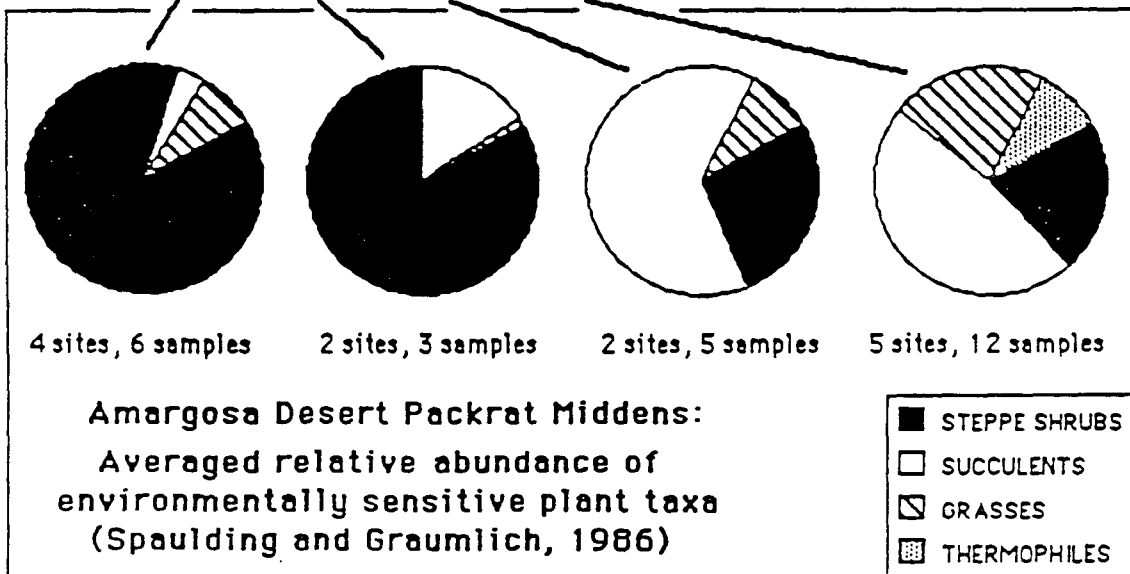
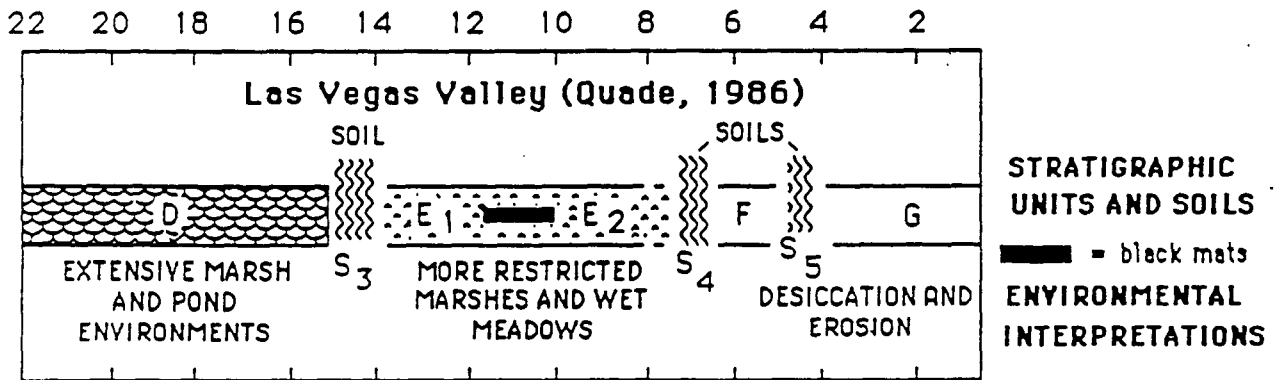
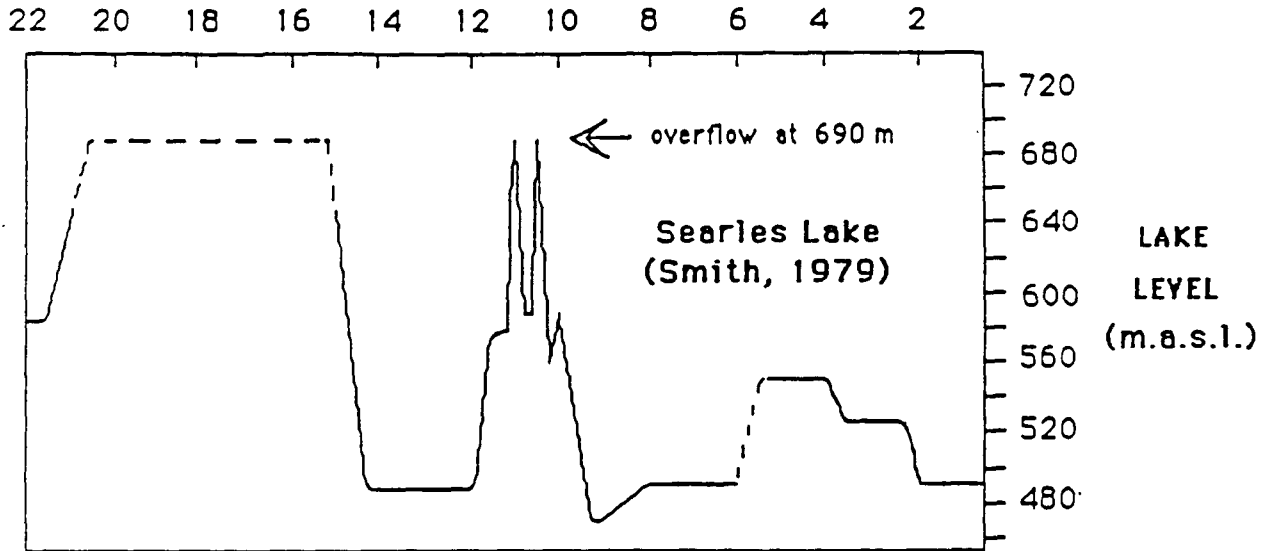
Nevada Bureau of Mines and Geology
 University of Nevada, Reno, NV 89557

SITE-SPECIFIC EVIDENCE

- **Glass alteration occurs well above the present water table. Some appears to be related to a paleowater table and some, well above the zone of complete alteration, to perched water.**
- **Fractures have secondary mineral coatings and fillings precipitated from aqueous solutions.**
- **The macro-fossil evidence (packrat middens) reflects the timing of vegetation community changes, the approximate climate related, and, locally, phreatophytic plant fossils which require perennial saturation at root level.**



14
C yr B.P. (x 1000)



SUMMARY

- **It is important to confidently predict future climate changes when characterizing a repository in fractured rock within the vadose zone because of hydrologic sensitivity to increases in effective moisture.**
- **A change to the full pluvial climate would markedly increase fracture flow and perched-water conditions.**



REFERENCES

- MIFFLIN, M. D. and M. M. Wheat, 1979, Pluvial lakes and estimated pluvial climates of Nevada; Nevada Bureau of Mines and Geology Bulletin 94.
- MIFFLIN, M. D. and J. Quade, 1988, Paleohydrology and hydrology of the carbonate rock province of the Great Basin (East-Central to Southern Nevada); *in* Holden, G. S., ed., Geological Society of America Field Trip Guidebook, 1988.
- MORRISON, R. B., 1965, Quaternary geology of the Great Basin; *in* The Quaternary of the United States, Princeton University Press, p. 265-285.
- QUADE, J., 1986, Late Quaternary environmental changes in the Upper Las Vegas Valley, Nevada; Quaternary Research, 26, p. 340-357.
- SMITH, G. I., 1979, Subsurface stratigraphy and geochemistry of Late Quaternary evaporites, Searles Lake, California; U. S. Geological Survey Professional Paper 1043.
- SPAULDING, W. G. and L. J. Graumlich, 1986, The last pluvial climatic episodes in the deserts of southwestern North America; Nature, 320, p. 441-444.

VITAE

MARTIN D. MIFFLIN

EDUCATION:

- Ph.D., 1968, University of Nevada, in Hydrogeology.
- M.S., 1963, Montana State University, in Applied Science.
- B.S., 1960, University of Washington, in Geology.
Washington State University, Eastern Washington.

PROFESSIONAL EXPERIENCE:

- President and Senior Hydrogeologist of Mifflin & Associates, Inc., a consulting firm which conducts hydrogeologic and geologic investigations, July, 1986 to Present.
- Research Professor, Water Resources Center, Desert Research Institute, University of Nevada System. Research in ground-water problems in arid-zone hydrology. Specific areas of activity: carbonate-rock hydrology, ground-water exploration and development, exploratory-drilling techniques, vadose-zone moisture conditions, and recharge in arid terrane. During this period of time, major ground-water exploration and development programs were established for the State of Nevada (Jean Prison water supply, Valley of Fire State Park), the U.S. Air Force (Tonopah Test Range, Tolicha Peak), and Nevada Power Company (Meadow Valley Well Field development, monitoring, and modeling; carbonate-rock ground-water exploration program near Moapa). Program Director of the Yucca Mountain Candidate High-Level Nuclear Waste Repository technical support program for the State of Nevada (1983-1986), Sept., 1977 to July, 1986.
- Senior Hydrogeologist, UNDP, Chile. Leave of absence from the Desert Research Institute for service in Region 4, Chile United Nations Development Program (UNDP) project. Water-resource assessment project in semi-arid region of Chile, chief resident administrative responsibility for the UNDP of the project, March, 1978 to March, 1979.
- Water Resources Center Associate Director and Research Professor, Desert Research Institute, Las Vegas, Nevada. Head administrator for the Water Resources Center of the Desert Research Institute in the Las Vegas branch office. General responsibilities included research funding, direction, and execution of program of the Water Resource Center in Southern Nevada. Areas of research interest during this period included land subsidence caused by fluid withdrawals and associated earth fissures and faults in Las Vegas Valley and Mexico, deep carbonate-rock aquifers in Nevada as a potential water-supply alternative for Eastern and Southern Nevada, and waste-water treatment by natural marsh systems in Las Vegas Valley. Expert testimony on the Cross Florida Barge Canal ground-water hydrology was given to the State of Florida Bureau of Planning and Florida Cabinet in July, 1976; as well as serving on the board of review for the Water Element of the State Plan of Florida from 1976 to 1977. Periodic consulting 1975, 1976, 1977 for the Comision del Plan Nacional Hidraulico, in the area of ground-water policy and executed programs of resource evaluation and advanced training of personnel, July, 1975 to Sept., 1977.
- Resident Consultor, International Bank for Reconstruction and Development (World Bank). Leave of Absence from the University of Florida in order to accept an 18-month position as World Bank Resident Consultor in ground water to the Plan Nacional Hidraulico (PNH), a newly-created planning organization within the Mexican government. Held additional position of Jefe de Aguas Subterraneas (chief in charge of ground-water planning and associated investigations within PNH). Responsibilities involved training and development of professional staff, development of procedures and policy, and direction of ground-water studies designed for both short and long-term planning of ground-water exploitation and management. PNH was a joint effort by the United Nations Development Programs (UNDP) and the Mexican Government. The effort of the UNDP was executed by the World Bank (International Bank for Reconstruction and

Development) and the procedure was to supply five resident consultants who were expert in various disciplines in water-resource planning and development. I was also appointed to a Mexican government management role, and maintained the Bank title. Subsequently, the experimental program was judged successful by the UNDP, World Bank, and the Mexican Government formalized the organization into the continuing national planning agency for water-resource development in Mexico (Comision del Plan Nacional Hidraulico, ASRH), Sept., 1973 to July, 1975.

Associate Professor Geology, University of Florida. Teaching responsibilities in the following courses: Physical Geology, Introductory Geosciences, Geomorphology, Structural Geology, Ground-Water Geology and Hydrogeology. Research was more or less limited to local problems of ground-water pollution and continued work (summers of 1970, 1972) on isostatic rebound in the Lahontan Basin of the Great Basin. Member of the University of Florida Graduate Faculty, served on graduate committees (M.S. and Ph.D.) for Geology, Environmental Engineering, Coastal Engineering, and Civil Engineering graduate students. Considerable involvement in ground-water pollution aspects of the Cross Florida Barge Canal controversy, with testimony given to Florida Legislative committees, the State of Florida Cabinet, and the U. S. Presidential Council on Environmental Quality. Principal expert witness in ground water for EDF and the Department of Interior in court proceedings (U.S. Government vs. Florida Canal Authority) in August, 1973, Sept., 1969 to July, 1975.

Research Associate, Desert Research Institute and Nevada Center for Water Resources Research. Activities primarily research in ground water and hydrogeology. Principal Investigator or co-investigator in research dealing with the following: hydrologic safety, AEC underground nuclear detonation; investigation of land subsidence in Las Vegas Valley and the development of the theory of mechanics; investigation of the hydrogeology of Las Vegas Valley for feasibility of artificial recharge; delineation of ground-water flow systems using studies of fluid potential, water chemistry, isotopes, and other methods: paleohydrologic investigations in Nevada (surface and ground water); stratigraphic studies of alluvial basins; documentation of mudlump formation and hydrologic relationships causing formation, and developing a theory for mechanics of formation; investigations of carbonate-terrain hydrology in Nevada using tritium and hydrogeochemical techniques; exploration and development of ground water in a number of arid areas for federal, state, and private agencies; investigation of techniques for delineation of ground-water flow systems. Other activities included guest and substitute lecturing in ground water, hydrogeology, and physical geology, and direction of graduate student research in the Great Basin on hydrologic problems, July, 1963 to Sept., 1969.

Graduate Research Assistant, Montana State University (the Montana State University experience consisted of 1/2-time teaching of geology laboratories and two winters of snow avalanche research), Sept., 1962 to June, 1963.

Geologist, GS-7, U.S. Geological Survey, field mapping in the Lemhi Range and Beaverhead Range, Idaho and Montana, May, 1962 to Sept., 1962.

Graduate Teaching Assistant, Montana State University, Sept., 1960 to June, 1962.

Apprentice Geologist, Pan Petroleum Corp., Field-reconnaissance mapping in Western Alaska, April, 1959 to Aug., 1959.

PROFESSIONAL AFFILIATIONS

Geological Society of America
National Water Well Association
Sigma Xi

PROFESSIONAL HONORS AND OTHER PROFESSIONAL ACTIVITIES:

DRASTIC Advisory Board Member, National Water Well Assoc., 1986-1987

Invited Speaker, 15th Annual Rocky Mountain Groundwater Conference on Today's Groundwater Issues, Phoenix, Arizona, Sept. 1986, "Total Basin Concept - Groundwater Flow Systems"

Invited Speaker, International Workshop on Regional Aquifers, Sponsored by the Institute of

Geophysics, UNAM, Mexico City, Feb., 1985, "Hydrogeology of regional systems in the Great Basin"

Co-Leader, Field trip, White River Hydrological (Karst) System, S.E. Nevada, 6th Conference on Karst Hydrogeology and Speleology (Friends of the Karst), Sept. 1979

Moderator, Water Supply Planning Session, AWRA Conference "Water Resource Management in a Changing Society," Sept., 1979, Las Vegas

Geological Society of America Meinzer Award Committee, term 1977-1980

Elected to DRI Faculty Senate, 1975-1978

Moderator, Special Session on Ground-Water Quality, Las Vegas Valley, NWWA Tech. Meeting, Las Vegas, 1976

Selected as resident international consultant in the field of ground water to the Mexican Government by the World Bank and UNDP, 1973-1975

Trustee: Florida Defenders of the Environment (1970-1977) FDE Scientific Committee Co-Chairman (1971-1974)

Appointed Chairman, Environmental Impact Committee City of Gainesville-Alachua Co. joint committee (Jan. 1973; resigned Aug., 1973)

Elected Foundation Advisory Member, Environmental Information Center, Florida Conservation Foundation, Inc., 1972

Elected member University of Florida Presidential Faculty Concerns Committee, 1971

Appointed member of University of Florida Ad Hoc Com. on Environmental Programs, 1971

Designated Program Moderator (1970 Nat. GSA Evening Discussion of Hydrology Section)

Member of the U.S. delegation to the Inter. Assoc. of Sci. Hydrol., Symposium Hydrology of Deltas, Bucharest, Rumania, 1969

Granted first sabbatical leave offered to DRI faculty, 1969

Elected to DRI Faculty Organization, 1968 to 1969

Program Chairman, Sigma Xi Luncheon Lecture Series at University of Nevada, 1965 to 1966

Co-Author of scientific paper nominated for the G.S.A. Meinzer Award, 1965

NSF Basin and Range Field Conference Co-leader, 1965

INQUA Great Basin Field Conference Co-leader, 1965

Sigma Xi (Nominated at Montana State University for M.S. thesis).

CONSULTING EXPERIENCE:

Consultant to the U.S. Nuclear Regulatory Commission on Yucca Mountain, Nevada, 1982 to 1984.

Consultant to Government of Ecuador, ground-water development for irrigation, Rio Guayas Basin, 1982 to 1983.

Consultant to USAID, University of Wisconsin, and OTDC, Government of Tunisia, on design and feasibility of potable water development for dispersed populations in Central Tunisia, Feb.-Mar., 1980.

Consultant for the organization, and participant in "Seminar on Development and Rational Management of Groundwater of the Yucatan Peninsula" sponsored by the Banco de Mexico, S.A., Dec. 3-7, 1979, Merida, Yucatan, Mexico, 1979.

Consultant to Mexico, reviewer of all ground-water studies by CPNH 1973-77, Comision del Plan Nacional Hidraulico, ASRH, July 1977. State of Florida, Div. of State Planning, Water Element of State Comprehensive Plan, Panel of Experts, review of water element, 1977.

State of Florida, Dept. of Planning: testimony to the Florida Cabinet on hydrologic impacts of Cross Florida Barge Canal, June, 1976.

Ground-water consultant to Arthur D. Little, Inc. on bi-national water-resource development project for Colombia and Venezuela. Consultant to Mexico, organization of PNH-sponsored symposium entitled "La Sobreexplotacion de Agua Subterranea en Algunas Partes del Mundo," Mexico City, Dec., 1975.

Nevada and California (1969-1973): runoff/erosion studies with respect to timbering activities in the Sierra Nevada (1972, major lumber company). Florida: lake dewatering hydrogeological studies for Lake Apopka (1970, Citrus Growers). Numerous

hydrogeological studies for land developers as senior hydrologic consultant for the firms Eco Impact, Inc. and Environmental Science Engineering, Inc. (1972-73). Solid-waste disposal and site suitability for Alachua County (1972). Three landfill sites located, evaluated, and subsequently adopted by the County. Landfill monitoring, Alachua County (1972-73). OffShore Nuclear Power Plant site evaluation - aspects of tectonic history and seismic hazards (major engineering firm, 1973).

Nevada and California (1963-1969): ground-water exploration and water supply development in arid terrain for U.S. Fish and Wildlife Service, Nevada State Parks, and several development and mining firms; ground-water supply and contamination studies, U.S. Gypsum.

PUBLICATIONS AND REPORTS:

- Mifflin, M. D., Johnson, C. L., and Johnson, R. J., 1989, Hydrogeologic assessment, Upper Muddy River Valley, Nevada: Mifflin & Associates, Inc., 46 p., Appendices.
- Mifflin, M. D. and J. Quade, 1988, Hydrogeology and paleohydrology of the Carbonate Rock Province of the Great Basin: Geol. Soc. Amer. Field Trip Guidebook, 1988 GSA Centennial, Annual Meeting.
- Mifflin, M. D., 1988, Region 5, Great Basin, in Back, W., Rosenshein, J. S., and Seabar, eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, vol. 0-2, p. 69 to 78.
- Mifflin, M. D., Ed., 1988, Review of consultation draft of the site characterization plan, Yucca Mountain Site, Nevada research and development area, Nevada (DOE/RW-0160), January 1988): Mifflin & Associates, Inc., 247 p.
- Mifflin, M. D. and J. Quade, 1987, Estimating climate change from hydrologic response: Water Forum '86, ASCE Proceedings, Aug. 4-6, 1986, Long Beach, California.
- Mifflin, M. D., et al., 1987, Technical review comments on the environmental assessment: Yucca Mountain site, Nevada Research and Development Area, Nevada (May 1986, Vols. I, II, III [DOE/RW-0073]): Mifflin and Assoc., Inc., 187 p.
- Mifflin, M. D. and M. E. Morgenstein, Eds., 1985, Technical review comments on the draft environmental assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada: WRI-DRI, 169 p.
- Mifflin, M. D. and D. E. Zimmerman, 1984, Ground-water availability in the lower Meadow Valley Wash near Glendale, Nevada: WRC-DRI, 52 p.
- Glancy, P. A., R. L. Jacobsen, and M. D. Mifflin, 1984, The hydrogeology of the Carson and Truckee River Basins, Nevada: in Western Geological Excursions, 1984 Annual Meeting, Geol. Soc. Amer., vol. 3, Lintz, J. (Ed.), p. 52-146.
- Woessner, W. W., M. D. Mifflin, D. E. Zimmerman, and K. E. Sullivan, 1983, Meadow Valley Wash exploration program, October and November: WRC-DRI, 47 p.
- Mifflin, M. D., A. Elzeftawy, S. W. Wheatcraft, and J. W. Hess, 1982, Henderson, Nevada rapid infiltration basin siting and monitoring study: WRC-DRI Project Report, 100 p.
- Mifflin, M. D., 1982, Preliminary report on the Jean Correctional Facility test/production well: WRC-DRI Memo. Rept. to Nevada Legislature Intrinsic Finance Committee, 5 p.
- Elzeftawy, A. and M. D. Mifflin, 1982, Soil sample analyses from borings of the RIB site for the City of Henderson: WRC-DRI Letter Report to URS/City of Henderson, 8 p.
- Mifflin, M. D., 1982, Exploration and development of a ground-water supply for the southern Nevada Correctional Center, Jean, Nevada: WRC-DRI, 43 p. and Appendices.
- Zimmerman, D. E., M. D. Mifflin, and K. E. Sullivan, 1982, Construction and testing of wells NPC-2, NPC-11, NPC-25, and NPC-34, Meadow Valley Wash Field: WRC-DRI, 203 p.
- Mifflin, M. D. and A. Elzeftawy, 1982, Lateral hydraulic conductivity of the alluvial sediments near the RIB site: WRC-DRI Letter Report to City of Henderson, 6 p.
- Mifflin, M. D., 1982, Preliminary results of additional test holes for the determination of the useful life of the test/production well, Jean Correctional Facility: WRC-DRI Memo. Rept. to Nevada Legislature Intrinsic Finance Committee, 4 p.
- Elzeftawy, A., M. D. Mifflin, R. L. Skaggs, and M. J. Miles, 1981, TIMET waste leach liquor as a soil stabilizer: WRC-DRI Project Report, 64 p.
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- Hydrologic and salinity analysis of the lower Virgin River Basin, Nevada and Arizona: WRC-DRI Project Report, 171 p.
- Mifflin, M. D. and A. Elzeftawy, 1981, Soils, geology and hydrogeology of the Laughlin area, Nevada: WRC-DRI Project Report, 75 p.
- French, R. H., M. D. Mifflin, and J. Edkins, 1981, Salt storage in the lower Las Vegas Valley: WRC-DRI Project Report, 270 p.
- Mifflin, M. D. and J. Harrill, 1981, Hydrogeologic characteristics of the Great Basin: Geol. Soc. Amer. Abstracts with Programs, vol. 13, no. 7.
- Dickson, B. H., M. D. Mifflin, and M. E. Vollbrecht, 1980, Potable water for dispersed populations in central Tunisia: Regional Planning and Area Development Project, University of , 101 p. (in English and French).
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- Mifflin, M. D., 1979, Ground water of the Rio Elqui Valley, Region IV, Chile: UNDP, Project Chi/69/535.
- Hess, J. W. and M. D. Mifflin, 1978, A feasibility study of water production from deep carbonate aquifers in Nevada: Desert Research Institute, Water Resources Center, Pub. No. 4i054, 125 p.
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- Mifflin, M. D., 1967, Hydrogeology: in A Reconnaissance of the Technology for Recharging Reclaimed Waste Water into the Las Vegas Ground-Water Basin: Desert Research Institute, Tech. Rept. Series H-W, Pub. No. 2, p. 14-29.
- Mifflin, M. D., 1967, Formation of mudlumps in Pyramid Lake, Nevada: Geol. Soc. Am., Program 1967 Annual Meeting, p. 149-150 (Abst.).
- Mifflin, M. D., 1967, Strange things are rising in Pyramid Lake, Nevada: State Journal, Science in Nevada, July 2, 1967 Issue.
- Maxey, G. B., M. D. Mifflin, P. A. Domenico, and A. McLane, 1966, Geology and water resources of Red Rock Ranch: Mim. Rept. to the Red Rock Ranch Stockholders, 48 p., 2 maps.
- Maxey, G. B. and M. D. Mifflin, 1966, Occurrence and motion of water in carbonate rocks of Nevada: Annual Meeting of the Amer. Assoc. for the Advancement of Science, Berkeley, California, Dec. 28-29, 1965. Published in Natl. Speleol. Soc. Bull., vol. 28, no. 3, July, 1966.
- Morrison, R. B., M. D. Mifflin, and M. Wheat, 1965, Rye Patch Dam Pleistocene stratigraphy: INQUA VII Congress, Northern Great Basin and California Guidebook, p. 28-33.

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- Domenico, P. A. and M. D. Mifflin, 1965, Water from low-permeability sediments and land subsidence: Am. Geophy. Union, Water Resources Research, vol. 1, no. 4, p 563-576.
- Domenico, P. A., M. D. Mifflin, and A. Mindling, 1965, Geologic controls on land subsidence, Las Vegas Valley, Nevada: Proceedings 4th Annual Symposium on Engineering Geology and Soils Engineering, Moscow, Idaho, p. 113-121.
- Mifflin, M. D. and P. A. Domenico, 1964, Part II, Hydrogeology: in Seismology, Hydrogeology and Meteorology of the Proposed Nuclear Power Plant Site in Mason Valley, Nevada: Desert Research Institute Mim. Report to Sierra Pacific Power Co., 14 p.
- Mifflin, M. D., G. B. Maxey, P. A. Domenico, D. A. Stephenson, and J. R. Hardaway, 1964, Hydrological investigations of the Sand Springs Range, Fairview Valley and Fourmile Flat, Churchill County, Nevada: VELA UNIFORM, Project SHOAL, AEC Report VUF-1001, p. 239-364.
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- Mifflin, M. D., 1964, Lahontan well #3 step-drawdown test and interpretations: Desert Research Institute Letter Report to Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, 8 p.
- Mifflin, M. D., 1964, Hydrology of the Lahontan Basin, Northwestern Nevada: INQUA VII Congress, Northern Great Basin and California Guidebook, p. 25-28.
- Mifflin, M. D., 1963, Preliminary report on the ground-water possibilities in the Valley of Fire State Park, Nevada: Desert Research Institute Letter Report of Sept. 19, 1963, to Dean L. Kastens, Director of the Nevada State Park Service, 6 p.
- Mifflin, M. D., 1963, A discussion of the hydrology and hydrogeology in the Sand Springs Range, Churchill County, Nevada: Northwest Science, Spokane, Washington Meeting, Dec. 1963 (Abst.).
- Mifflin, M. D. and G. B. Maxey, 1963, Preliminary report of the geology and hydrology of the Settlemeyer Site, Carson Valley, Nevada: Desert Research Institute Mim. Rept. to Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, 13 p.
- Mifflin, M. D., 1963, Geology of a part of the southern margin of the Gallatin Valley, Southwest Montana: M.S. Thesis, Montana State University, Bozeman, Montana, 111 p.; Program of the 16th Annual Meeting, Geol. Soc. Am., Rocky Mtn. Sect. (Abst).

STUDIES DIRECTED AND/OR COAUTHORED IN MEXICO (In Spanish by Plan Nacional Hidraulico, Secretary of Water Resources, Mexico):

- Ground-Water Reconnaissance and Availability, Region Closed Basins, No. Central Mexico, 1976.
- Ground-Water Reconnaissance of Region Rio Lerma Basin, Central Mexico, 1976.
- Ground-Water Reconnaissance and Availability, Region Rio Bravo, 1975.
- Ground-Water Reconnaissance and Availability, Region NW Pacific coast, NW Mexico, 1975.
- Ground-Water Availability, Exploitation and Policy, National Water Plan of Mexico, in Plan Nacional Hidraulics de Mexico (1974) (1975), 1975.
- Ground-Water Reconnaissance and Availability, Region Papaloapan, SE Mexico, 1974.