APPENDIX A

CHRONOLOGY OF EVENTS IN THE HISTORY OF THE RADIATION HEALTH HAZARD OF URANIUM MINING AND ITS CONTROL: 1940-1972

1940 Recommendation by Evans and Goodman that radon exposures to man should not exceed 10 picocuries per liter of air.

1947 A.E.C. samples several uranium mines. It finds radon concentrations comparable to those recorded for Central European mines where high lung cancer rates were reported.

1949 Several meetings of officials from Colorado, AEC, research groups, and U.S. Public Health Service, concerning health hazards in uranium mines; conclude there is possibility of "severe internal radiation hazards in many operations."

1949 Researchers meet with representatives of industry and inform them of environmental findings; U.S. P.H.S. formally invited to conduct study of uranium mines and mills and workers in them.

1950 Field work begins in P.H.S. studies of uranium mines and mills and health of uranium workers.

1951 Researchers identify principal hazard as internal alpha radiation to lungs from radon daughters attached to dust.

1951 Industrial Hygiene Engineers visit principal mining companies to inform them of study findings. No effects among American miners yet found but mine ventilation stressed in light of European experience. P.H.S. continues medical and environmental surveys.

1951 Conferences held for official agency representatives and mining companies to inform them of environmental findings with discussion of methods for measuring radon and its daughters in mines.

1952 Meetings with state health officers on future of P.H.S. study. Extensive environmental survey work begun.

1953 Medical examination of miners, environmental mine surveys and mortality study of non-uranium miners begun (resisted by large mining companies and during 1953 no arrangements could be made with any of them). Utah State Health Department surveyed all mines operated in Utah and U.S. Bureau of Mines conducted some environmental measurements of mines located on Indian Land.

1953 Conference of A.E.C., N.C.I., P.H.S., and Colorado State Health Department; agreed that enough environmental evidence existed to define problem and that control was likely to come only with extensive evidence of injury to American miners. A long term epidemiological study was thought necessary to do this.

1953 Publication of method for measurement of radon daughters in air.

1954 Publication of reports on control of radon daughters in mines by ventilation.

1954 Medical teams dispatched to remote mining areas in an attempt to include all uranium miners in an epidemiological study. Environmental survey work continued.

1955 Seven-state Conference on Uranium Mining Health Problems held in Salt Lake City, Utah. Agreement reached on standard for atmospheric concentration of radon daughters (300 pico curies per liter of air) but as practical consequence

little improvement noted. Census of uranium miners begun, and continued annually until 1972.

1956 First practical field method for measurement of radon daughter concentrations in mine air published.

1956 Uranium mines in South Africa and Belgian Congo visited to explore the possibility of doing mortality studies on their workers who had been exposed to radon and radon daughters for many years. Records on negro workers found to be inadequate.

1957 Second extensive medical study conducted.

1957 Publication of book by P.H.S.: "Control of Radon Daughters in Uranium Mines and Calculations on Biologic Effects." This officially proposed a radon daughter standard of 1 Working Level as 1.3×10^5MEV/L of potential alpha energy.

1958 Study reveals that four uranium miners died of lung cancer, not statistically significant. Some state mine inspectors feel they cannot require control measures on the basis of available data. New Mexico State Health Department decides the data justifies enforcement of ventilation measures and this was required in statutes.

1959 Mine surveys and medical work continue. Joint Committee on Atomic Energy Hearings held on Workmen's Compensation and Atomic Energy. U.S. P.H.S. prepares testimony on uranium mining health hazard. Seminars held to instruct mine personnel in techniques of radon daughter evaluation and control.

1960 Third general medical examination conducted. Life table analysis of mortality experience of study group (1950-1959) reveals a significant excess of lung cancer deaths among men with three or more years uranium mining. American Standards Association makes recommendation that maximum permissible concentration of radon be set at 1 Working Level as defined by P.H.S.

1960 Secretary Fleming (DHEW) holds meeting of Governors of uranium producing states to discuss health hazards of uranium mining and P.H.S. findings.

1961 As a result of Governors' Conference, Colorado obtains funds and initiates a control program. Inspection and control work added to duties of mine inspectors in Utah, Wyoming, New Mexico. Only Arizona lacks such program. Salt Lake meetings held with operators to discuss P.H.S. findings. Wyoming and Utah Mine Operators' Associations respond with disbelief.

1962 Congress appropriates $50,000 for continuation of P.H.S. uranium studies, and additional funds sought from other sources. Annual sputum cytology program begun in an attempt to detect early stages of cancer development.

1963 Continuation of medical, environmental, census, and mortality analysis. P.H.S. findings presented at 1963 Symposium on Radiologic Health and Safety in Uranium Mining and Milling, Vienna, Austria.

1964 Study of lung cancer histologic types show predominance of one type which is peculiar among uranium miners.

1965 Study demonstrates existence of exposure-response relation between airborne radiation and lung cancer incidence. Smoking excluded as confounding factor in that relationship.

1966 Federal Radiation Council begins study of Radiation Hazards in Uranium Mining.

1966 Passage of Federal Metal and Nonmetallic Mine Safety Act which extends federal authority over radiation control in uranium mines.

1967 Hearings, Joint Committee on Atomic Energy, Radiation Exposure of Uranium Miners, Washington, 1967.

1967 Secretary of Labor, Willard Wirtz promulgates 12.0 W.L.M. per year standard (effective immediately) with gradual transition to 4.0 W.L.M.: Johnson administration authorizes January 1, 1971 as date for enforcement of 4.0 W.L.M.

1967 Federal Radiation Council issues Report No. 8. Guidance for the Control Radiation Hazards in Uranium Mining.

1968 National Academy of Sciences - National Research Council reviews the data on uranium miners. It concludes that uranium miners should not smoke cigarets and their radon daughter exposure should be kept low.

1969 Interagency Uranium Miner Review Group created to study new standard. Joint Committee on Atomic Energy holds hearings to postpone 4.0 W.L.M. Termination of A.E.C. contracts with uranium suppliers marks end of Department of Labor authority over radiation conditions in mines.

1969 I.U.M.R.R.G. requests postponement of 4.0 W.L.M. standard to continue its study which is granted by President Nixon for a period of six months. Federal reorganization results in Federal Radiation Council being dissolved and its duties transferred to the Environmental Protection Agency.

1969 P.H.S. given additional money to update and evaluate mortality study of uranium miners.

1970 National Academy of Sciences - National Research Council endorses the new P.H.S. study.

1970 The Environmental Protection Agency recommends the 4.0 W.L.M. standard and Bureau of Mines abdicates its standard setting responsibilities and announces it will enforce radiation standards recommended by the E.P.A.

1971 Publication by P.H.S. of Monograph "Radon Daughter Exposure and Respiratory Cancer: Quantitative and Temporal Aspects."

1971 The 4.0 W.L.M. goes into effect July 1971 as opposed to January 1971 and two days later a petition for Variances from the maximum standard is published in the Federal Register. Secretary of Bureau of Mines Advisory Committee, Boyle, challenges the P.H.S. data used for setting the new standard.

1972 Hearings on Variances from standard held in Albuquerque. Bureau of Mines rules that it will permit variances to maximum standard under specified conditions.

APPENDIX B

FOOTNOTES

1. H. Peter Metzger. The Atomic Establishment. New York, Simon and Schuster, 1972, p. 118.

2. Frank E. Lundin, Jr., Joseph K. Wagoner, and Victor E. Archer. Radon Daughter Exposure and Respiratory Cancer: Quantitative and Temporal Aspects. U.S. Department of Health, Education and Welfare, Public Health Services, 1971, p. xvii (Preface).

3. Geno Saccomanno. Incidence of Cancer of the Lung Among Uranium Miners: 1954-1972. Unpublished paper.

4. U.S. Congress, Joint Committee on Atomic Energy. Radiation Exposure of Uranium Miners. Hearing, 90th Congress, 1st Session, May-August, 1967. Washington, Government Printing Office, 1967, p. 603. (Testimony by Mr. Duncan Holaday).

5. Woodward and Fondiller. Probable Numbers and Costs Through 1985 of Lung Cancer Cases. Reprinted in Hearings before Joint on Atomic Energy. Ibid., pp. 992-1015. Other estimates put the number of deaths at 529. Ibid., p. 143.

6. Lundin. Op. cit., p. 72, citing G. Agricola, De Re Mettalica, (Basel: n.n. 1597).

7. For a list of references on the Schneeburg and Joachimsthal mining studies see: Ibid., p. 72; see also Duncan Holaday, W. David and H. Doyle. An Interim Report of a Health Study of the Uranium Mines and Mills. (Unpublished paper prepared for the Federal Security Agency, Public Health Service, Division of Occupational Health, and the Colorado State Department of Public Health, May, 1952), p. 4.

8. Robert L. Rock and D. K. Walker. Controlling Employee Exposure to Alpha Radiation in Underground Uranium Mines. Vol. I. Washington, Department of Interior, Bureau of Mines, 1970.

9. Egon Lorenz. Radioactivity and Lung Cancer: A Critical Review of Lung Cancer in the Mines of Schneeberg and Joachimsthal. Journal of the National Cancer Institute. 5:1-5, 1955. Cited in Metzger, op. cit., p. 120.

10. Information supplied by Charles A. Rasor, Atomic Energy Commission geologist, in an address ("Uranium Ores of the Colorado Plateau and Their Procurement") at the San Juan Sub-Section of AIME, Ouray, Colorado, June 23, 1951, p. 1, (speech supplied by Gilman Ritter, Director, Mining Division, Lucius Pitkin, Inc., Grand Junction, Colorado).

11. P. W. Jacoe. Report on the Uranium Study. (Unpublished paper prepared for the Colorado Department of Public Health, Division of Occupational and Radiological Health, August 1964, p. 1, 3; see also H. N. Doyle, Radiation Hazards in Uranium Mining. (Unpublished paper prepared for the U.S. Public Health Service, Occupational Health Program, 1957).

12. Holaday, et. al. Op. cit., p. 4.

13. Jacoe. Op. cit., p. 1. (By early 1949 members of the Colorado State Health Department and the Atomic Energy Commission were agreed on the probability that "severe internal radiation hazards existed in many (mining) operations.") (See also the remainder of the Jacoe report.)

14. Ibid., p. 1.

15. Ibid., p. 2.

16. Ibid., p. 4.

17. Proceedings of the Second United Nations Conference on Peaceful Uses of Atomic Energy. Geneva, United Nations, 21, 62, 1958. Cited in Metzger, op. cit., p. 120.

18. Arthur D. Little Inc. An Assessment of the Economic Effects of Radiation Exposure Standards for Uranium Miners. Commissioned by the Atomic Energy Commission in 1970. The report concluded that somewhat better ventilation measures than those advocated by the French would add only 3% to the cost of mining uranium. This position was also adopted by the National Academy of Science and the National Research Council in their report on the problem in 1971. See also National Academy of Science and the National Research Council. Epidemiological Studies of Uranium Miners. Prepared for the Interagency Uranium Mining Review Group, January, 1971.

19. Jacoe. Op. cit., p. 10.

20. The control of radiation environments in uranium mines was completely a matter of individual state action since the authority of numerous federal agencies had rarely been interpreted to extend to the extraction of uranium ore from the earth. For example, despite the fact that the Atomic Energy Commission was the sole purchaser of extracted uranium ore until nearly 1970 and the owner of more than a dozen uranium mines, it interpreted its regulatory authority to include "source material . . . after removal from its place of deposit in nature." (A.E.C. Commissioner Ramey in testimony before the Joint Committee on Atomic Energy, op. cit., p. 159.) The Bureau of Mines obtained responsibility for setting and enforcing radiation standards with the passage of the 1966 Federal Metal and Nonmetallic Mine Safety Act. Prior to the passage of this act, however, it had not enforcement authorities. The Department of Health, Education and Welfare featured in providing technical assistance in the matter of health standards and the control of health conditions. It included no enforcement measures. (See the Federal Radiation Council,

Staff Report No. 8, "Guidance for the Control of Radiation Hazards in Uranium Mining," September 1967, p. 2). The Department of Labor did have authority to control mining conditions under the provisions of the Walsh-Healy Act of 1936 and the Atomic Energy Commission was advised that it too had authority over mining procedures and methods of operation under the Walsh-Healy Act at hearings held by the Joint Committee on Atomic Energy in 1959 entitled "Employee Radiation and Workmen's Compensation," cited in Metzger, op. cit., p. 130.

21. Jacoe. Op. cit., p. 10.

22. Proceedings of the Governors' Conference on Health Hazards in Uranium Mines, United States Department of Health Education and Welfare, Public Health Service. Denver, December 16, 1960.

23. Ibid., p. 22.

24. "In 1961, as a result of the Governors' Conference, Colorado obtained sufficient funds to employ five additional mines inspectors (D.O.H. supplied about $10,000 additional worth of equipment) and initiate a control program in June, 1961. None of the legislatures in the other states provided funds for additional men so different actions were taken in each case. In Utah, the U.S. Bureau of Mines assisted the state mine inspector in surveying uranium operations and a control program was initiated. The Division of Occupational Health entered into a contract with the New Mexico State Health Department which, among other items, provided funds with which to employ an engineer to assist the state mine inspector in his control program. The control program in Wyoming was added to the regular duties of the mine inspectors. In Arizona, the mine inspector could not obtain authority to regulate exposure to radon and its daughters . . ." Jacoe, op. cit., p. 16-17.

25. Hearings before Joint Committee on Atomic Energy, op. cit., p. 106. (Testimony by Lou Gehrig, Acting Surgeon General, United States Public Health Service.)

26. Statement by Willard Wirtz, Secretary of Labor, in a news release ("Radiation Standards for Uranium Mining") on June 10, 1967, p. 3 and 4. The quality goal widely adopted by the states was 1 Working Level or 12 Working Level Months.

Bureau of Mines Findings in Inspections of 164
Uranium Mines Between April and August, 1967

Working level range	Number of mines	Percentage of mines
0.0 - 0.3	39	23.8
0.4 - 1.0	34	20.7
1.1 - 3.0	41	25.1
3.1 - 5.0	14	8.5
5.1 -10.0	24	14.6
10.1 and over	12	7.3
	164	100.0%

Source:
Testimony of Secretary of Labor Wirtz before the Joint Committee on Atomic Energy Hearings, op. cit., p. 757.

Levels of Radiation in Uranium Mines at which State Mine Inspectors Issue Close Mine Orders, 1967

State	Working Level at which Mine Closed
Arizona	n.a.
Colorado	3.0*
New Mexico	5.0**
Wyoming	10.0
Utah	n.a.

*The American Standards Association recommendations adopted by the State of Colorado recommends that mines be closed when working level readings of 10.0 or more are discovered, however, the state mine inspector applied more stringent standards.

**The New Mexico mine inspector issues an order to correc within 24 hours to all mine operators found to have mine radiation levels of 3.0 working levels or more.

Source:
Joint Committee on Atomic Energy, Hearings, op. cit., p. 355.

27. The Walsh-Healy Act of 1936 provides that no part of a contract with the Government will be performed "under working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees engaged in the performance of said contract." Statement by Secretary of Labor Wirtz, Ibid., p. 3.

28. Secretary of Labor Wirtz testimony before Joint Committee on Atomic Energy, op. cit., pp. 45-93.

29. The 12 W.L.M. standard for radiation exposure was recommended by the International Commission on Radiological Health (1954); the Commonwealth of Massachusetts (1957); the Public Health Service (1957); the American Standards Association (1960); the Atomic Energy Commission (1960) and New York State (1963). Testimony by Dr. Evans before the Joint Committee on Atomic Energy, Ibid., p. 281.

30. When the Environmental Protection Agency ruled to retain the 4.0 Working Level Month maximum exposure standard it emphasized that "the exposure level of concern was not 'low' in the context of usual occupational radiation protection practices; an annual exposure greater than 4 W.L.M. would probably result in a dose in rems (1 WLM=2 rad=6 rems) to the critical tissue of the lung that exceeds occupational radiation standards

generally accepted in the nuclear industry. Federal Register, Vol. 36, No. 132, (July 9, 1971). Indeed, a standard of .1 Working Level would mean future death rates among uranium miners of more than three times the normal death rate from respiratory cancer. Testimony by the Surgeon General, Joint Committee on Atomic Energy, Ibid., p. 61.

31. U.S. Congress, Joint Committee on Atomic Energy. Radiation Standards for Uranium Mining. Hearing, 91st Congress, 1st Session, March, 1969. Washington, Government Printing Office, 1969.

32. "The Interagency Uranium Mining Radiation Review Group (IUMRRG) was established to assist the Federal Radiation Council in its periodic review of radiation protection in uranium mines. It was composed of representatives from agencies of the Council: The Department of Health, Education and Welfare, the Department of Agriculture, the Department of Interior, the Department of Labor, the Department of Commerce, the Department of Defense, and the Atomic Energy Commission. The Surgeon General, U.S. Public Health Service was appointed the chairman," Federal Register, Vol. 36, No. 101, May 25, 1971.

33. Variance: Mandatory Standards Relating to Exposure to Concentrations of Radon Daughters, 57.25 to Part 57, Subchapter N, Chapter I, Title 30, Code of Federal Regulations, described in Federal Register, Vol. 37, No. 124, June 27, 1972. See also the Leglislative Department of the United Steelworkers of America, Legislation . . . and You, Vol. 3 , 1972, pp. 210-223.

34. Based on correspondence between James Boyd, Chairman to the Department of Interior, Secretary's Advisory Committee, and the Secretary of the Interior, November 30, 1971. Memo exchanged entitled "Request for Information on Mine Radiation Standards." "From our investigations of this matter it appears to the Committee that there is at least some question as to the validity of some of the data which have been used in support of conclusions now cited as authoritative . . . ."

35. Jacoe. Op. cit., p. 1.

36. Atomic Energy Commission, Domestic Uranium Production. Circular 5 and Circular 6. Revised, Amended October 9, 1953.

37. William Liscum Borden. There Will Be No Time: The Revolution in Strategy, (1946). Cited in Philip M. Stern, The Oppenheimer Case: Security on Trial. New York, Harper and Row, 1969. Pp. 90-91.

38. Stern. Op. cit., pp. 193 and 196.

39. Statement by Robert Rock, mining geologist, in a personal interview, Denver, Colorado, April 27, 1973.

40. Statement by Norman Blake, director of Colorado Bureau of Mines, in a personal interview, Denver, Colorado, October 17, 1972.

41. Joint Committee on Atomic Energy, Hearings, (1967) op. cit., p. 54.

42. Duncan Holaday, W. David and H. Doyle. An Interim Report of a Health Study of the Uranium Mines and Mills. (Unpublished paper prepared for the Federal Security Agency, Public Health Service, Division of Occupational Health and the Colorado State Department of Public Health, May, 1952. P. 4.

43. Metzger. Op. cit., pp. 115-144.

44. Joint Committee on Atomic Energy, Hearings (1969). Op. cit., p. 128.

45. Statement by Ludwig Koch, Executive at Continental Oil Company, in a personal interview, Denver, Colorado, July 13, 1973.

46. Joint Committee on Atomic Energy, Hearings (1967) op. cit., p. 159.

47. Ibid., p. 243.

48. Ludwig Koch. Op. cit., (personal interview).

49. Joint Committee on Atomic Energy, Hearings (1967) op. cit., p. 260.

50. Ibid., p. 260.

51. Norman Blake. Op. cit., (personal interview).

52. Jacoe. Op. cit., p. 21.

53. Statement by Thomas High, Chief Mine Inspector, District 4, in a personal interview, Denver, Colorado, April 13, 1973.

54. Bureau of Mines, Report for the Years 1950-1951. Denver, Colorado: n.n. 1952.

55. Bureau of Mines. Report for the Year 1970. Denver, Colorado: n.n. 1971.

56. Colorado Mining Association. Policy Statement, 1953.

57. Joint Committee on Atomic Energy. Hearings (1967) op. cit., p. 173.

58. Ibid., p. 47.

59. Ibid., p. 47.

60. Statement by P.W. Jacoe, Colorado Department of Health, in interview with Metzger, cited in Metzger, op. cit., p. 126.

61. Statement by Willard Wirtz, Secretary of Labor, in a news release ("Radiation Standards for Uranium Mining") on June 10, 1967. P. 3-4.

62. Metzger. Op. cit., p. 119

63. Otis Dudley Duncan. From Social System to Ecosystem. Sociological Inquiry, Vol. 31 (1961):145.

64. Ibid., p. 145.

65. The arrows are meant only to suggest the existence of cause, influence or response at work in the uranium situation.

66. Amitai Etzioni. Modern Organizations. Englewood Cliffs, Prentice-Hall, 1964. P. 6.

67. See Daniel Katz and Robert J. Kalhn. The Social Psychology of Organizations. New York, John Wiley and Sons, Inc., 1966. Harold L. Wilensky. Organizational Intelligence. New York, Basic Books, Inc., 1967. Max Weber. The Theory of Social and Economic Organization, trans. A. M. Henderson and Talcott Parsons. New York, The Free Press, 1947.

68. Statement by Jim Dougherty, federal mine inspector, in a personal interview, Denver, Colorado, April 27, 1973.

69. James D. Thompson. Organizations in Action. New York, McGraw Hill, 1967. See also Shirley Terreberry. The Evolution of Organizational Environments. A.S.Q., Vol. 12, No. 4, March, 1968:590-613. William Dill. Environment as an Influence on Managerial Autonomy. A.S.Q., Vol. 2, No. 4, March, 1958:409-443.

70. Aaron Wildavsky. The Politics of the Budgetary Process. Boston, Little Brown and Company, 1964.

71. See Paul R. Lawrence and Jay W. Lorsch. Organizations and Environment: Managing Differentiation and Integration. Cambridge, Harvard Graduate School of Business Administration, 1967. Charles Perrow. A Framework for the Comparative Analysis of Complex Organizations. A.S.R., Vol. 32, No. 2, April, 1967.

72. Richard Hall. Organizations: Structure and Process. Englewood Cliffs, Prentice Hall, Inc., 1972. Pp. 301-2.

73. See Brian Aldrich. Relations Between Organizations: A Critical Review of the Literature. Unpublished paper, University of Minnesota, 1970, cited in Hall, op. cit., and Eugene Litwak and Lydia Hylton. Interorganizational Analysis. A.S.Q., Vol. 6, No. 4, March, 1962. James D. Thompson and William J. McEwen. Organizational Goals and Environment: Goal Setting as an Interaction Process. A.S.Q., Vol. 23, No. 1, Feb. 1958.

74. William M. Evan. The Organization-Set: Toward a Theory of Interorganizational Relations. In Approaches to Organizational Design, ed. James D. Thompson. Pittsburgh, University of Pittsburgh Press, 1966.

75. Norton Long. The Local Community as an Ecology of Games. A.J.S., Vol. 64, No. 3, 1958, pp. 251-61.

76. David Rogers. 110 Livingston Street: Politics and Bureaucracy in the New York City School System. New York, Vintage Books, 1969.

77. Philip Selznick. TVA and the Grass Roots. New York, Harper Torchbook, 1966.

78. The majority of the information on mines was obtained from the Colorado Bureau of Mines. Two types of intra-office files were consulted. Information Reports supplied general yearly information on mine ownership and operation. Inspection Reports provided yearly accounts of government enforcement activities. Information on mine radiation environments was obtained from the Public Health Service. Information on labor organizations was supplied by the unions associated with the Colorado mining industries and the Atomic Energy Commission, Western Division in Grand Junction, Colorado. A.E.C. records showed the mills to which each uranium mine transferred ore and the distance in miles from mine to mill. Labor organizations supplied information on the affiliation of the uranium mills under consideration.

79. Approximately 400 of the original 923 uranium mines were eliminated from consideration for three reasons. These are explained in the following: First, if there was a question as to the identity of the mine over time. This problem arose in cases where a mine name changed from year to year; and where ownership transfers were incorrectly reported by agents maintaining the mining archives. Second, if mine records were missing. In cases where a mine operated for only a very short time, for example, mining records were not maintained. Only a small fraction of the mines excluded from study was rejected for this reason. Third, if there failed to be at least one direct measurement of a mine's health environment during the twenty year study period. Health assessments were made by the Public Health service. They are quantitative indicators and the same measuring scale has been used over the entire study period. Frequently, however, indirect methods of assessment were employed. These methods included extrapolations from previous years' measurements of mine radiation and estimations based on radiation values obtained from other mines in the same locality. While several studies have employed indirect assessments to explore the relationship between radiation exposure and lung cancer, it was felt that this study required more sensitive indicators of mine radiation. A mine was included in the project if at least one of its twenty health assessments between 1950 and 1969 was derived from actual measurements at the mine site; it was excluded if it failed to undergo at least one such on-site measurement.

80. Lewis Anthony Dexter. Elite and Specialized Interviewing. Chicago, Northwestern University Press, 1970, and Raymond Gorden. Interviewing: Strategy, Techniques and Tactics. Homewood, The Dorsey Press, 1968.

81. See Chapter 2, HISTORY OF THE PROBLEM.

The Working Level (WL) is employed as a unit of radon daughter product concentration. Its value is defined as any combination of radon daughters in 1 liter of air that will result in the ultimate emission of 1.33×10^5 of potential alpha energy. See Federal Radiation Council, Guidance for the Control of Radiation Hazards in Uranium Mining. Staff Report No. 8, September, 1967, p. 11.

82. Paul A. Samuelson. Economics: An Introductory Analysis, (7th ed.). New York, McGraw Hill, 1967. Pp. 76-77.

83. Bureau of Mines. Report for the Years 1950-1951. Colorado, August 15, 1952. Pp. 13-14.

84. Colorado Mining Association, National Western Mining Conference. Resolutions and Declaration of Policy. Denver, Colorado, 1970. P. 4.

85. American Mining Congress. Newsletter. July, 1967.

86. Minutes of Meeting of the Atomic Industrial Forum, Committee on Mining and Milling. August 16, 1971.

87. Official meetings include Governmental Hearings, State-Wide Conferences and other meetings listed in the Chronology of the Problem by Robert J. Catlin. Uranium Mining Health and Safety. March 23, 1971.

88. United Steelworkers of America. Background on Variance Proposal for Radon Daughters Standard. December 17, 1971. P. 1.

89. Statement by Sam Franklin, former director of United Mineworkers, District 50, in personal interview. Denver, Colorado, April 24, 1973.

90. Statement by Wilbur McCready, former organizer for United Mineworkers, District 50, in a personal interview. Denver, Colorado, April 25, 1973.

91. The mill and processing plant phase of the uranium industry did experience union influence. Between 1950 and 1969, approximately one-third to one-half of uranium mills to which Colorado miners shipped ore were represented by unions. Unions representing this group of workers were the United Mineworkers, District 50, the A.F. of L., and the Oil, Chemical and Atomic Workers. Labor organizers interviewed in the project suggested that union influence in the mines was indirectly exercised through the uranium processing mills and plants. Their theory was that since mill workers and underground miners were in contact with one another in the course of shipping ore, benefits that accrued to the unionized mill workers sometimes filtered down to the miners. Some interviewees held that management used the automatic transmission of mill worker benefits to underground miners as a means to thwart attempts to organize in the mines.

    In order to test this thesis, a comparison was made between mines which shipped and mines which did not ship ore to unionized mills. The organizers thesis would predict that mines having regular shipping contracts with unionized mills would have lower radiation levels. Such was not the case. Although a sizeable percentage of mines in the project did ship to unionized mills, the percentage varied from year to year. There is no clear explanation for this variation. Moreover, there were no obvious consequences for radiation levels flowing from shipping ties. While for 15 of the 20 years under investigation mines affiliated with unionized mills did display lower radiation than their non-union counterparts, the magnitude of these differences was not very great. In 1950, 1952, 1961, 1963, 1965, and 1966, mines shipping to nonunionized mills exhibited lower radiation. Thus, affiliation with unionized mills was not associated with lower radiation in mines in any regular manner. See the following tables for details.

Annual Percentage of Mills to Which Colorado Mines Shipped Uranium That Were Represented by a Labor Organization, 1950-1969

Year	Percentage mills represented by a union	Year	Percentage of mills represented by a union
1950	33.3	1960	33.3
1951	33.3	1961	44.4
1952	33.3	1962	55.5
1953	28.6	1963	62.5
1954	25.0	1964	37.5
1955	37.5	1965	42.9
1956	33.3	1966	37.5
1957	37.5	1967	37.5
1958	37.5	1968	37.5
1959	37.5	1969	50.0

Source:
The Sample of Colorado uranium mines.

Annual Percentage of Mines that Shipped Ore to Unionized Mills, 1950-1969

Year	Percentage mines shipping to unionized mills	Year	Percentage mines shipping to unionized mills
1950	50.0	1960	64.5
1951	62.1	1961	77.4
1952	52.4	1962	92.8
1953	48.8	1963	93.0
1954	47.9	1964	51.1
1955	59.4	1965	57.7
1956	65.6	1966	61.9
1957	66.2	1967	67.2
1958	62.4	1968	75.8
1959	65.8	1969	78.8

Source:
The sample of Colorado uranium mines.

A Comparison of Mean Radiation Levels Between Mines That Shipped Ore to Unionized Mills and Mines That Shipped Ore to Non-Unionized Mills, 1950-1969

Year	Radiation levels (in W.L.) in mines that shipped ore to	
	Unionized Mills	Non-unionized mills
1950	28.5	24.5
1951	25.2	28.5
1952	23.7	23.2
1953	21.8	37.6
1954	19.2	21.5
1955	14.6	15.4
1956	11.4	12.5
1957	16.3	22.0
1958	10.2	13.9
1959	14.4	18.2
1960	11.7	12.5
1961	10.6	5.5
1962	5.6	6.7
1963	3.2	2.5
1964	3.1	3.5
1965	3.7	2.6
1966	2.8	2.7
1967	1.4	1.9
1968	1.4	2.0
1969	0.5	0.9

Source:
The sample of Colorado uranium mines.

92. American Mining Congress. News Bulletin. July 28, 1972.

93. Remarks by Jesse C. Johnson, Director Division of Raw Materials, Atomic Energy Commission, in an address before the Fourth annual conference of the Atomic Industrial Forum. New York, October 28, 1957, ("Uranium Production in the United States"), p. 9.

94. Although initial plans called for the cessation of all government purchases by the end of 1966, a "stretch-out" program was adopted by the Atomic Energy Commission in 1962 which delayed the termination of government procurement. Under the new program, a portion of the production formerly scheduled for delivery to the Atomic Energy Commission in 1963-1966 was deferred for delivery until 1967 and 1968. In addition, the A.E.C. agreed to purchase an equal quantity of ore until 1969 and 1970, but at lower prices. Thus, A.E.C. purchasing was effectively extended until 1970 and it was not until 1971 that uranium was sold exclusively on the open market.

95. Atomic Energy Commission Uranium Concentrate Reserves, 1947-1971

Year	Tons of Uranium-oxide	Year	Tons of Uranium-oxide
1947	2200	1960	231785
1948	2200	1961	178885
1949	2200	1962	167738
1950	3000	1963	160231
1951	5800	1964	150921
1952	7346	1965	144702
1953	15203	1966	140835
1954	27582	1967	147741
1955	67595	1968	160819
1956	164055	1969	204080
1957	210109	1970	246100
1958	225644	1971	273200
1959	240996		

Source:

Atomic Energy Commission, Statistical Data of the Uranium Industry, (January 1, 1972) p. 14. ("Uranium Ore Reserves and Production").

96. Atomic Energy Commission, Release of September 7, 1968, as reported in Release No. O-178, October 13, 1971. "A.E.C. Seeks Public Comment on Proposed Uranium Supply Policies."

97. Remarks by Wilfred E. Johnson, Commissioner, U.S. Atomic Energy Commission, in an address ("Status of the Uranium Producing Industry"), to the American Mining Congress in Las Vegas, Nevada, October 13, 1971.

98. Projected United States Uranium Requirements and Supplies, 1971-1975

Year	Requirements	Contracted Deliveries	Cululative Inventory	Inventory as % of Requirements
1971	6,900	12,800	13,300	193
1972	10,200	11,300	14,400	141
1973	14,000	13,000	13,400	96
1974	16,700	11,800	8,500	51
1975	18,400	12,000	2,100	11

All figures = tons of uranium-oxide.

Source:

American Mining Congress, Comments to the Secretary of the Atomic Energy Commission, December 6, 1971, p. 3.

99. Joint Committee on Atomic Energy. Authorizing Appropriates for the Atomic Energy Commission for Fiscal Year 1970: July 8, 1971.

100. Digest of Lung Cancer Cases, Department of Labor and Employment, Division of Labor, Workmen's Compensation Section, Denver, Colorado.

101. U.S. Congress, Joint Committee on Atomic Energy. Employee Radiation Hazards and Workmen's Compensation. Hearing, 86th Congress, 1st Session, March 1959. Washington, Government Printing Office, 1959. P. 419.

102. Information supplied by Ronald C. Jaynes, Senior Referee, Division of Labor, Workmen's Compensation, in personal interview in Denver, Colorado, November 2, 1972.

103. The Denver Post. February 8, 1957. P. 17.

104. _____. December 16, 1960. P. 13.

105. _____. August 30, 1962. P. 19.

106. _____. March 10, 1967. P. 34.

107. _____. April 20, 1967. P. 67.

108. _____. April 24, 1967. P. 13.

109. _____. May 21, 1967. P. 37.

110. _____. May 22, 1967. P. 16.

111. Paul A. Samuelson. Economics: An Introductory Analysis, (7th ed.). New York, McGraw-Hill Book Co., 1967. Pp. 369-70.

112. Union Carbide Corporation. Data on Mine Radiation Control in Union Carbide Mines. Unpublished paper, April, 1971, p. 1.

113. Statement by Elzie Ray, mine inspector in Colorado's District 2, in personal interview. Denver, Colorado, April 23, 1973.

114. Joint Committee on Atomic Energy. Hearings (1967) op. cit., p. 156.

115. Morton Mintz and Robert K. Warner. Big Oil Companies Acquire Grip on Competing Fuels. Washington Post, August 23, 1970.

116. For example, S.2882, introduced by Senator Yarborough and H. R. 14558, introduced by Representative O'Hara, authorized the Secretary of Labor to pay supplemental workmen's compensation benefits to persons receiving state payments for disabilities or deaths due to lung cancer caused by radiation in uranium mines. Senate Bill 1927, introduced by Senator Metcalf also called for the federal government to subsidize states making compensation payments for injuries, disabilities and deaths due to exposure to radiation while mining or processing uranium. Senators

Allot and Dominick also introduced legislation in 1967 to compensate persons injured or killed as a result of mining radioactive materials. Their bill, S.2686, called for the extension of federal civil service benefits to the victims of radiation induced lung cancer.

117. Joint Committee on Atomic Energy. Hearings (1967) op. cit., p. iii.

118. Joint Committee on Atomic Energy. Hearings (1969) op. cit.,.

119. See Mark J. Green (ed.) The Monopoly Makers: Nader Study Group Report on Regulation and Competition. New York, Grossman Publishers, 1973; and Louis Kohlmeier, The Regulators: Watchdog Agencies and the Public Interest. New York, Harper and Row, 1969.

120. Peter M. Blau and Otis Dudley Duncan. The American Occupational Structure. New York, John Wiley and Sons, Inc., 1967. P. 171.

121. G. T. Nygreen. Interactive Path Analysis. American Sociologist 6:1 (February):37-43; and Otis Dudley Duncan. Path Analysis: Sociological Examples. A.J.S., Vol. 72, 1966, pp. 1-16.

122. Ibid., p. 13.

123. National Safety Council, Accident Facts: 1972. Chicago, 1972, p. 3.

124. President's Report on Occupational Safety and Health. Commerce Clearing House, ed. May 22, 1972, p. 111.

125. See Robert Sherrill. Asbestos, The Saver of Lives, Has a Deadly Side. The New York Times Magazine. January 21, 1973, and Paul Brodeur, Annals of Industry: Casualties of the Workplace. The New Yorker, October 29, 1973-November 26, 1973..

126. Joseph A. Page and Mary-Win O'Brien. Bitter Wages: Ralph Nader's Study Group Report on Disease and Injury on the Job. New York, Grossman Publishers, 1973. Chapter 5 ("Pennies and Posters").

127. See: Rex A Lucas. Men in Crisis: A Study of a Mine Disaster. New York, Basic Books, 1969. Jack Weller. Yesterday's People. Lexington, Ky., University of Kentucky Press, 1966. Herman R. Lantz. People of Coal Town. New York, Columbia University Press, 1958.

128. Lantz, Ibid.

129. C. Weisel and M. Arny. Psychiatric Study of Coal Miners in Eastern Kentucky Area. American J. Psych, February, 1952. P. 619.

130. L. G. Schultz. Rural America: Our Gross National Product. Social Welfare in Appalachia. Vol. 2, 1970, p. 8.

131. Cited in a contract report by the Naval Ammunition Depot at Crane Indiana for the Bureau of Mines. Chapter III (Personality and the Mine Social System). P. 19.

132. Alice Hamilton. Exploring the Dangerous Trades. (Boston:[n.n.], 1943) Cited in Page and O'Brien, op. cit., p. 147.

133. Brodeur. Op. cit., p. 47.

134. Page and O'Brien. Op. cit., chapter 5 ("Pennies and Posters").

135. Ibid., p. 145.

136. U.S. Congress, House Hearings on the Occupational Safety and Health Act. Part 2, 1969, p. 866. Cited in Page and O'Brien, Ibid., p. 79.

137. Ibid., p. 204.

138. U.S. Code Congressional and Administrative Notes. Leglislative History: Federal Metal and Non metallic Mine Safety Act, 1966. P. 2848.

139. Ray Davidson. Peril on the Job: A Study of Hazards in the Chemical Industries. Washington, Public Affairs Press, 1970.

140. Bruce Archern. Murderous Machines. New Society, 9, 1967. P. 248.

141. Davitt McAteer. Safety in Mines: A Look at the World's Most Hazardous Occupation. Unpublished paper prepared for the Center for the Study of Responsive Law. Washington, 1972.

142. Ibid., p. 46.

143. Page and O'Brien, op. cit., p. 200.

144. See Brodeur, op. cit., and Sherrill, op. cit.

145. Morton Mintz. By Prescription Only. Boston, Beacon Press, 1967.

146. The Nader studies refer to the following works: James S. Turner, The Chemical Feast: Report on the Food and Drug Administration, New York, Grossman Publishers, 1970; Mark Green, The Closed Enterprise System, New York, Grossman Publishers, 1970; John Esposito, Vanishing Air, New York, Grossman Publishers, 1970; Robert Fellmeth, The Nader Report on the Federal Trade Commission, New York, Grossman Publishers, 1969; and Ralph Nader and Mark J. Green, Corporate Power in America, New York, Grossman Publishers, 1973.

147. K.C. Davis. Discretionary Justice. ([n.p.], [n.n.], 1969). P. 59.

148. Statement by Donald Walker, Director of Bureau of Mines Federal Inspection Staff, Region 8, in personal interview. Denver,Colorado, April 27, 1973.

149. Richard Curtis and Elizabeth Hogan. Perils of the Peaceful Atom. New York, Ballentine Books, 1969. Pp. 31-32.

☆ U S GOVERNMENT PRINTING OFFICE 1975-657-603/5548 Region No. 5-11