PDR 40-8745

104 Davey Laboratory
The Penn. State University
University Park
Pa., 16802

3 August 1980

Director, Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C., 20555

Gentlemen:

Enclosed are my comments on NUREG-0687, Draft EIS on the Bison Basin Solution mining project. Please note x that the opinions and calculations presented are not necessarily those of The Pennsylvania State University, which is well known as a collection of free thinkers. Affiliation for identification only.

My comments are contained in this letter, an eight page statement and a ten page appendix titled: "Comments on NUREG-0332".

There are several misprints in NUREG-0687. On page 4-1 it is stated that during the three- month mining period, about 126 kg (1600 lb) of uranium.... Now, 126 kg is not equivalent to 1600 lb. On page 4-34, Section 4.11.3, it is stated that the benefit of the production up to 0.9×10^6 kg (1×10^6 lb). These are not equivalent also. Page 2-39, Reference # 13 is NUREG-0332. This document as published in 1977 is clearly marked DRAFT. The FINAL version was apparently never prepared.

I hope that the final statement adresses the issues raised herein and enclosed.

Sincerely,

Wm. A. Lochstet

Wm. A. Lochstet, Ph.D.

17014

8008200 - Ø35

Comments on NUREG-0332

by

Dr. William A. Lochstet
The Pennsylvania State University
November 1977

In the document NUREG-0332 (Draft), the NRC estimates the excess deaths per 0.8 gigawatt-year electric (GWy(e)) to be about 0.5 for an all nuclear economy and about 15 to 120 for the use of coal(Ref. 1). These estimates are much too small because they ignore the health effects due to the slow release of radon-222 resulting from the decay of radioactive components of the coal, uranium mill tailings, and of the tailings from the uranium enrichment process.

If the health effects are estimated by the procedure used by the NRC, then the excess deaths are about 600,000 in the nuclear case and twentythousand for coal. The estimates presented here are all based on the production of 0.8 GWy(e).

Radon Produced by the Uranium Fuel Cycle

The production of 0.8 GWy of electricity by a LWR will require about 29 metric tons of enriched uranium for fuel. With uranium enrichment plants operating with a 0.2% tails assay, 146 metric tons of natural uranium will be required. In the absence of the LMFBR, 117 metric tons of depleted uranium would be left over. With a uranium mill which extracts 96% of the uranium from the ore (Ref. 2), a total of 90,000 metric tons of ore is mined, containing 152 metric tons of uranium. The uranium mill tailings will contain 2.6 kilograms of thorium-230 and 6 metric tons of uranium. As Pohl has pointed out (Ref.3) the thorium - 230 decays to radium - 226, which in turn decays to radon - 222. This process results in the generation of $3.9x10^8$ curies of radon-222, with the time scale determined by the $8x10^4$ year half life of thorium - 230.

The 6 metric tons of uranium contained in the mill tailings decay by several steps to radon - 222 thru thorium - 230. This process occurs on a time scale governed by the $4.5x10^9$ year half life of uranium - 238, the major isotope present (99.3%). The total amount of radon - 222 which will result from this decay is $8.6x\ 10^{11}$ curies.

The 117 metric tons of depleated uranium from the enrichment process is also mainly uranium - 238 which also decays. The decay of these enrichment tailings results in a total of $1.7x10^{13}$ curies of radon - 222. This is listed in Table 1, along with the other radon yields.

It is instructive to compare these quantities of activity to the activity of the fission products which result from the use of the fuel which they are associated with. The total fission product inventory resulting from 0.8GWy(e) with half lives of 25 years or more is about 10^7 curies. This is much less than any of the numbers in Table 1. We should be more careful with these tailings.

Radon Produced by the Coal Fuel Cycle

Item 2 i of Appendix A of NUREG-0332 (Ref. 1) assumes a 75% capacity factor, which for a 1000 MWe plant would produce only 0.75 GWy(e). A capacity factor of 80% will be used here. The production of 0.8 GWy(e) by a coal plant operating at 40% efficiency, using 12,000 BTU per pound coal would require 2.5 million short tons of coal. This is close to the value of 3 million tons suggested on page 9 of NUREG-0332 (Ref. 1).

There is great variability in the amount of uranium contained in coal. An analysis of coal samples at one TVA plant reported by the EPA (Ref. 4) indicates a range of almost a factor of ten in uranium content. Eisenbud and Petrow (Ref. 5) report a value of about 1 part per million. A recent survey by the USGS based on several hundred samples suggests that in the United States coal contains an average of 1.8 part per million of uranium(Ref. 6). Both values of 1.0 and 1.8 ppm will be used here. Thus 2.5 million tons of coal will contain between 2.3 and 4.1 thousand kilograms of uranium. Using the assumption of NUREG-0332 (Ref. 1) that there is 99% particulate removal from plant emissions, 1% of this uranium will be dispersed into the air and the remainder carted away as ashes for land burial. Table 1 indicates that with 1.0 ppm coal the uranium in the resulting ash will decay to a total of 3.2×10^{11} curies of radon - 222, while the stack emissions will lead to 3.2×10^{9} curies. For 1.8 ppm coal the values are 5.8×10^{11} curies from ash and 5.8×10^{9} curies from emissions.

Evaluation of the Health Effects

It is necessary to evaluate the number of deaths which result from the release of one curie of radon - 222. For the purpose of this evaluation the population and population distributions are assumed to remain at the present values. This should provide a good first estimate.

NUREG-0332 (Ref. 1) suggests that a release of 4,800 curies of radon - 222 from the mines (page 11) would result in 0.023 excess deaths (Table 1a, page 18). This provides a ratio of 4.8×10^{-6} deaths per curie. Data from Chapter IV of GESMO (Ref. 7) suggests a value of 1.7×10^{-6} deaths per curie as a lower limit. The value of 4.8×10^{-6} deaths per curie will be used here as the NRC estimate. It is understood that this is very approximate.

The EPA has evaluated the health effects of a model uranium mill tailings pile. They estimate a total of 200 health effects (Ref. 8, page 73) for a pile which emits at most 20,000 curies of radon - 222 for 100 years. The resulting estimate is 1.0×10^{-4} deaths per curie and will be used here as the EPA estimate.

Evaluation of Health Effects - Nuclear

At present some recent uranium mill tailings piles have 2 feet of dirt covering. In this case the EPA estimate (Ref. 8) is that about 1/20 of the radon produced escapes into the air. This factor of 20 is listed in Table 1 and is used to find the effective releases. Thus the 3.9×10^{8} curies of radon which results from thorium in the mill tailings results in a release of 1.9×10^{7} curies into the atmosphere, which with the NRC estimate of 4.8×10^{-6} deaths per curie results in 90 deaths. With the EPA estimate 1900 deaths result. A similar treatment applied to 8.6×10^{11} curies of radon from the uranium in the mill tailings results in 200,000 dead for the NRC estimate and 4.3 million for the EPA estimate. It is here assumed that no future generation will see fit to take any better care of the mill tailings than is presently practiced.

The uranium enrichment tailings are presently located in the eastern part of the country. It is assumed that these are buried near their present locations. Radon will not escape so easily through wet soil. A reduction factor of 100 is used to estimate this effect. The accuracy of this estimate depends on the particulars of the burial which can only be projected. An additional factor of 2 is used to reduce the effect due to the fact that much of this radon would decay over the ocean rather than populated land areas. No compensation is taken for the greater population density near the point of release as compared to the uranium mill tailings piles of the western states. With this total reduction factor of 200 the NRC estimate is 400,000 dead while the EPA value is 8 million.

Evaluation of Health Effects - Coal

It is assumed that the ashes from the coal plants will be buried in a manner similar to the tailings from the uranium enrichment process. Thus a reduction factor of 200 is used in this case also. Again the higher population density is ignored.

The particulate which is released into the air by the coal plant is taken to contain 1% of the contained uranium. Since most such plants are in the eastern part of the country it is estimated that half will fall into the ocean rather than onto land. A second factor of 2 is used to reduce the effect of the resulting radon due to the fact that some of this radon will decay over ocean as with the radon from the uranium in the enrichment tailings. Again no compensation is taken for the greater population density near the point of release. This gives the total reduction factor of 4 shown in table 1.

With these reduction factors applied to the radon released by the ashes and emissions, in the two cases of 1.0 ppm and 1.8ppm uranium content coal, the health effects are calculated. These are shown in Table 1, and range from 7,700 dead from ashes and 3,800additional dead from airborn emissions for 1.0 ppm coal in the NRC estimate to 290,000dead from ashes and 140,000 dead from airborn releases in the case of 1.8 ppm coal in the EPA estimate.

Discussion

It is obviously very difficult to estimate with any precision how many health effects result from the release of a given curie of radon - 222 from some specific site in the west. The estimates presented here differ by a factor of 20. This might best be used as a range of expected deaths. The reduction factors used here are crude estimates in some cases, and could be improved upon. Changes in public policy could also change the manner in which this material is disposed, thus greatly changing these factors. In particular deep burial could practically eliminate the escape of radon to the atmosphere (Ref. 8).

It is important to compare Table 1 here with Table 1 of NUREG-0332 (Ref. 1), which shows 0.47 dead for the nuclear case and at most 120 dead for coal. These last numbers totally ignore the effects of long term radon emissions, which result in at least 100 times higher mortality. These long term effects are not only significant, but dominate the effect.

It is important to use Table 1 to compare the relative risk of the nuclear and coal option in their present forms. In this case deaths due to all causes considered in NUREG-0332 can be ignored as insignificant, since they are so small. The absolute number of deaths per curie released is irrelevant since it enters in both cases. The relative risk is determined solely by the quantities of radon - 222 generated and the reduction factors. Unless there is a clear decision to treat coal ashes differently from uranium enrichment tailings, the health effects from the tailings will be 50 times greater since there is

50 times more uranium there. The nuclear option remains more hazardous than coal unless the releases from all of the tailings piles can be reduced below the releases from the airborn particulates of the coal plant. This is not the present policy.

Additional Comment

There is a typographical error on page 25 of NUREG-0332. Reference #33 is listed there as being in volume 148 of Science, whereas it appears in volume 144.

Acknowledgment

The above comments were inspired by the 5 July 1977 testimony of Dr. Chauncey R. Kepford in the matter of the Three Mile Island Unit 2 (Docket No. 50-320) operating license entitled: " Health effects Comparison for Coal and Nuclear Power".

Table 1

Energy Source Excess Mortality per 0.8 GWy(e) due to Radon - 222 emissions

Origin of Radon	Radon Generated Curies	Reduction Factor	Deaths NRC	Deaths EPA
<u>Nuclear</u>				
Thorium in Mill Tails	3.9×10^{8}	20	90	1900
Uranium in Mill Tails	8.6×10^{11}	20	200,000	4.3×10^{6}
Uranium in Enrichment Tails	1.7×10^{13}	200	400,000	8×10^{6}
<u>Coal</u> 1.0 ppm U				
Ashes	3.2×10^{11}	200	7,700	1.6×10^{5}
Air Particulate	3.2×10^{9}	4	3,800	8×10^{4}
<u>Coal</u> 1.8 ppm U				
Ashes	5.8×10^{11}	200	14,000	2.9×10^{5}
Air Particulate	5.8×10^{9}	4	6,800	1.4×10^{5}

References

1 "Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives" NUREG-0332, Draft, U.S. Nuclear Regulatory Commission (September 1977)

2 "Environmental Analysis of The Uranium Fuel Cycle, Part I - Fuel Supply" EPA-520/9-73-003-B, U.S. Environmental Protection Agency, (October 1973)

3 R.O. Pohl, "Health Effects of Radon - 222 from Uranium Mining" Search, 7(5),345-350 (August 1976)

4 P.H. Bedrosian, D.G. Easterly, and S.L. Cummings, "Radiological Survey Around Power Plants Using Fossil Fuel" EERL 71-3, U.S. Environmental Protection Agency, (July 1970)

5 M. Eisenbud, and H.G. Petrow, " Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuels," Science 144,:288-289 (1964)

6 V.E. Swanson et al, "Collection, Chemical Analysis, and Evaluation of Coal Samples in 1975", Open-file report 76-468, U.S. Department of the Interior, Geological Survey, (1976)

7 "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors," NUREG-0002. U.S. Nuclear Regulatory Commission, (August 1976)

8 See Ref. 2

Environmental Impact of the
Bison Basin
Solution Mining
Project

by

William A. Lochstet, Ph.D.

The Pennsylvania State University*

August 1980

The Nuclear Regulatory Commission (NRC) has apparently attempted to evaluate the environmental and public health consequences of the operation of the Bison Basin project (Ref. 1). The radiological impact is calculated using the usual NRC procedure of evaluating dose commitments for 50 years due to one year's intake for people within 80 kilometers of the plant (Ref. 1, Rx Sec. 4.5.7.1). Unfortunately, this ignores the major impacts which lie outside of these limits in time and distance. This project should be compared with other solution mining projects such as the Irigaray project (Ref. 2), and the Highland project (Ref. 3). These environmental impact statements were criticized on much the same grounds, for ignoring the long term and distant impacts of these operations (Ref. 2, P. A-60; Ref. 3, P. A-55). These criticisms are largely valid for the Bison Basin evaluation also.

The deleterious health consequences of breathing Radon-222 in air have long been known. At first, the kx concern was focused on the miners in deep mines. In 1976, Pohl pointed out that the thorium-230 in conventional mill tailings decays indirectly to radon-222 with a time scale determined by the 8 x 10^4 year half life of the thorium(Ref. 4). The release of this radon into

* The opinions and calculations contained herein are my own, and not necessarily those of The Pennsylvania State University, which is well known as a collection of independent thinkers.

the air leads to a very slow accumulation of health consequences. Recently, Kepford has pointed out that a similar situation exists with respect to the uranium-238 parent of thorium-230(Ref. 5). These positions have been supported by the 1977 memorandum of Dr. Walter H. Jordan of the ASLBP (Ref. 6). These matters have been addressed by Dr. R. L. Gotchy of the NRC staff on two occasions (Refs. 7 and 8). These arguements will be considered here in the case of the Bison Basin project.

Since there is no mill tailings pile produced by a solution mining project, there is no environmental impact. In this respect the impact of solution mining is ~~ix~~ less than for conventional open pit or underground mining. The largest impact is that associated with the uranium product. The project is expected to produce 4.54×10^5 kg of U_3O_8 (Ref. 1, P. 1-2), which will contain 3.85×10^5 kg of uranium (99.3% U-238). Present operations of the gaseous diffusion enrichment plants result in an output of about 1/5 of the feedstock as fuel, and 4/5 as enrichment tails. Thus, the enrichment tails will contain 3.06×10^5 kg of uranium - 238 , which in the course of time will decay radioactively to produce a total of 4.37×10^{13} Curies of radon-222.

Since the half life of radon-222 is only 3.8 days, radon produced deep underground decays before it escapes into the atmosphere. The amount actually escaping into the air depends on the barriers in the way. It is assumed that there is no reprocessing of spent fuel, and that the uranium in the spent fuel in managed very well so that there is no radon released to the air from this source. At present, some recent mill tailings piles have 2 feet of dirt covering. In this case the EPA has estimated that 1/20 of the radon escapes into the air (Ref. 9). At present the enrichment tails have been located in the eastern part of the country, and no disposal has been suggested. It is assumed that this material will be buried near its present locations. Since the soil in the east is usually wet, and this decreases radon mobility, it will be assumed that 1/100 of the radon escapes into the air. This estimate could easily be in error by a factor of 10.

To evaluate the health consequences of such a release, it is necessary to know the population at risk. Since the exact demography of the future is unknown, a baseline is provided by using the present population in its current distribution. The NRC has recently done this, assuming a U.S. population of 300 million (Ref. 7, Page 3), with the result that the release of one curie of radon-222 from a typical tailings pile in a western state will result in a total dose of 0.56 Person - rem to the bronchial epithelium. Since radon released from an eastern state will result in some of it decaying over the ocean rather than populated areas, as would be the case for a western state, a reduction factor of 2 will be used in calculating the health effects. With all these factors, the total dose is 1.22 x 10^{11} person-rem to the bronchial epithelium.

The NRC estimate of cancer risk is 22.2 deaths per million person-rem for the bronchial epithelium(Ref. 7, page 7) and is derived from WASH-1400 and GESMO. Even though this estimate is too low, it will be used here. The result is 2.7 million deaths. These deaths must not be overlooked in the final environmental impact statement.

Section 4.5.7.4 lists the population dose commitment to the bronchial epithelium for the total population within 80 km of the project to be 3.4 person-rem. This is apparently based on a maximum of 499 curies of radon-222 expected to be released from the project (overestimate) (Ref. 1, P. C-4). Using the data on page 1-2 (Ref. 1) it would appear that the plant will operate for a total of 2.5 years. In this time 1247 Ci will be released to the air. Using the factors presented above, this would result in 698 person-rem total to the bronchial epithelium, or 0.015 deaths. This dose commitment is much larger than the NRC estimate of 3.4 person-rem. People beyond 80 km cannot be excluded. The fact that this may be x below' background is irrelevant to the evaluation of the impacts of this project. The federal action at question here is Bison Basin, not background.

Section 2.3.10.4 (Ref. 1) describes the x solid wastes gener ted by the project. In particular, the evaporation pond will contain uranium, thorium-230 and radium-226 (Ref. 1, Table 2.10). With a flow rate of $33 m^3$/day and 2.5 years of operation, this pond will accumulate 589 kg of uranium. The decay of this material will result in the production of 8.4×10^{10} Ci of radon-222. The exact disposal of this material is unclear, so that the EPA estimate of 1/20 radon release will be used. In this case the total population dose is 2.3×10^{9} person-rem to the bronchial epithelium, resulting in 50,000 deaths. This is not insignificant. It is noted that the applicants proposal to cover this with 1.5 m of natural fill does not meet NRC standards, and would quickly erode away allowing radon escape greater than the 1/20 assumed above. For these reasons, it should be a condition of the license that this material be removed every three to six months and disposed of in an existing mill tailings pile. This should be arranged before the xxx license is granted. The contract for this disposal should be presented before license is granted. Periodic removal would prevent a default option from resulting.

It should be noted that the solution mining at Irigaray (Ref. 2) and Highland (Ref. 3) involved the use of ammonia, and ammonium bicarbonate. This involves the introduction of nitrogen compounds into the aquifer, which is difficult to remove completely. Thus total restoration is not possible.

The Bison Basin applicant will instead use sodium bicarbonate, sodium carbonate, sodium hydroxide and hydrogen peroxide. It would seem xxx that the impact on the aquifer is less with this leaching process. This is clearly a step in the proper direction!

Section 2.2.1.5 (Ref. 1) presents material from the Draft document NUREG-0332, which compares the generation of xx electricity from coal or nuclear power (Ref. 8). This document is in considerable error in its comparison. Attached as an appendix, is my comments on this report. It should also be noted that this report assumes conventional mining for the nuclear option, which is irrelevant for a solution mining operation.

The well field is described in section 2.3.10.1 (Ref. 1). The use of PVC or fiberglass for the well casing seems less than conservative. The use of only three centralizers in 100 meters of pipe casing is also rather lax. It would be useful to describe how there will not be a repeat of xx a recent accident in which a drill tool breeched a casing and led to contamination of an overlying aquifer. The well abandonment proposal to fill with mud seems like an invitation for later connection of aquifers. It would be better to drill out the casing and fill the entire space with cement. The long - term stability of PVC of fiberglass is not clear. Filling with concrete would be better, than cement.

The shipment of yellow cake as a wet slurry eliminates the health impact of a yellow cake dryer(Ref. 1, p 2-28). The section on transportation accidents for these shipments should be expanded(Section 4.6.2.1 of Ref. 1). In particular it is stated that potential risks for slurry shipment are less than for dru yellow cake (Ref. 1, P. 4-28). This statement needs considerable discussion, and data to back it up.

Section 4.4.2.5 states that monitor wells will be sampled every two weeks (Ref. 1, P. 4-10). This period should either be decreased, or some justification given for the time period chosen, whatever it is.

It is shown above that the operation of this project will, under reasonable assumptions result in the deaths of 2.7 million people. It is impossible to say that such deaths far into the future are impossible. Our inability to be precise does not remove our responsibility under NEPA to evaluate the effects. There is no cutoff date after which deaths do not count. Footnote 12 of NRDC v. USNRC, 547 F. 2nd 633 (1976) states in part:

> We note at the outset that this standard is misleading because the toxic life of the wastes under discussion far exceeds the life of the plant being licensed. The environmental effects to be considered are those flowing from reprocessing and passive storage for the full detoxification period.

This requires full consideration of all health effects for the full detoxification period. The half life of uranium-238 is 4.5×10^9 years. In that time half of the effects might be expected.

Consideration of external events such as background is irrelevant. NEPA requires full consideration of all the costs and all the benefits of the federal action being considered. Background radiation is not a federal action. This cost benefit assessment must be made fully and in good faith to comply with NEPA as was discussed by the court in Calvert Cliffs Coordinating Committee v. USAEC, 449 F. 2nd 1109 (1971):

> We conclude that Section 102 of NEPA mandates a particular sort of careful and informed decision-making process and creates judicially enforcable duties.... But if the decision was reached procedurally without individualized consideration and balancing of environmental factors--conducted fully and in good faith-- it is the responsibility of the courts to reverse.

Thus, it is required that the analysis be carried out honestly, without ruling out any costs - or benefits - procedurally. there is no basis in law or science for an arbitrary cutoff in time (as 50 years was used in Ref. 1) or distance from the facility(as 80 kilometers was used in Ref. 1). Such an arbitrary cutoff is improper.

References

1 "Draft Environmental Statement related to operation of Bison Basin Project, Ogle Petrolium." NUREG-0687, Draft, U.S. N.R.C., (June 1980)

2 "Final Environmental Statement related to operation of Irigaray Solution Mining Project, Wyoming Mineral Corp,." NUREG-0481, U.S. N.R.C., (September 1978)

3 "Final Environmental Statement related to operation of Highland Uranium Solution Mining Project , Exxon Minerals Compahy, USA.", NUREG-0489, (November 1978)

4 R.O. Pohl, "Health Effects of Radon-222 from Uranium mining", Search, 7(5), 345-350 (August 1976)

5 Testimony of Dr. Chauncey R. Kepford, "Health Effects Comparison xx for Coal and Nuclear Power" in the matter of Three Mile Island Unit 2 (docket # 50-320) operating license hearings.

6 Memorandum of Dr. Walter H. Jordan, Atomic Safety and Licensing Board Panel (ASLBP) to James R. Yore, Chairman, ASLBP, (21 September 1977)

7 Affidavit of R.L. Gotchy, "Appendix", "Radiological Impact of Radon-222 Releases", USNRC, in the matter of Three Mile Island Unit 2 (Docket # 50-320),(20 January 1978)

8 "Health Effects Attributable to coal and nuclear fuel cycle alternativesx, Draft", NUREG-0332, Draft, R.L. Gotchy of US NRC, (September 1977)

9 "Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply" EPA-520/9-73-003-B, U.S. Environmental Protection Agency, (October 1973)