LAWRENCE LIVERMORE LABORATORY

April 4, 1977 410322

Mr. Joe Deal
Division Safety, Standards and Compliance
USERDA
Washington, D.C. 20545

Dear Joe,

At your request we have made a rapid, overview assessment of the potential impact upon the marine environment of disposing of contaminated soil in Cactus Crater and on Runit Island. We understand our response is in answer to questions imposed by Congressional Committees before which you testified.

In the attached paper we have tried to address the major impacts of the proposed crater disposal and to delineate the magnitude of potential impacts due to Pu. In view of the fact that such assessments are not of a trivial nature and are directed toward programs which require large scale field efforts and expenditures of large sums of money, it would be beneficial to both you and to us if more lead time was available to thoroughly evaluate the questions generated by concerned groups.

We hope the attached comments will be adequate for your response to the house committee.

Sincerely,

V. Noshkin for
W. L. Robison
William L. Robison
Environmental Sciences Division

Victor E. Noshkin
Victor E. Noshkin
Environmental Sciences Division

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Att.

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Consideration of Impacts of Soil Disposal on Northern Runit (Yvonne) Island and the Marine Environment

1. Terrestrial Disposal

The present proposed method for handling the terrestrial contaminated soils involves movement to Northern Runit Island and eventually fabricating a mix with cement and capping the resulting soil-cement matrix with 18" of high strength concrete. As long as the concrete cap is intact, remobilization of Pu in the above ground soil to the groundwater would be minimal and the terrestrial plutonium inventory (except that in contact with the groundwater) under the cap would be unavailable to the marine environment. However, the freshwater runoff from the concrete cap might very well cause more rapid remobilization of residual radionuclides in the soil around the perimeter of the cap and could conceivably cause rapid soil erosion around the cap perimeter. This pathway would increase the radionuclide transport rate to the island groundwater around the cap. The ground area affected by runoff is unknown until the cap dimensions are established. The freshwater will have an additional impacts on the near shore marine environment. Coral, for example, is very sensitive to water salinity. Salinity changes which could occur during one heavy rain storm from runoff would be enough to affect growth. It is recommended that some thought be given to designing a water catchment system around the bottom of the cap to reduce the impact of freshwater runoff. Such a cistern would have added advantages in that a valuable resource, mainly quantities of freshwater, would be available to future inhabitants.

The present estimated inventory of $^{239+240}Pu$ on Runit Island is 10 curies.[1] Based upon 1972 survey data[2] it is possible, although not likely, that an addition 10 curies of $^{239+240}Pu$ (associated with soil) could be brought to Runit Island for disposal. If this contaminated soil were spread on the northern end of Runit Island, plutonium would be expected to leach from the soil to the groundwater and subsequently reach the lagoon. The rate of remobilization would be similar to the rates presently assessed from available island data. Our best estimate, based on average groundwater residence times on Runit, present plutonium concentration in soil and groundwater, is that it will require more than 10^4 years to remobilize the present plutonium inventory from the island soil to the groundwater by natural processes. It is estimated that presently 0.23 mCi of $^{239+240}Pu$ annually migrates to the lagoon via groundwater at Runit. 0.23 mCi represents less than 0.01% of the current plutonium inventory in the water in the entire lagoon.[2] Therefore if the Runit terrestrial plutonium inventory were doubled (i.e., an additional 10 Ci), the groundwater concentration would eventually double and then contribute an estimated 0.02% to the lagoon inventory as measured in 1972. We have found that the concentrations of plutonium in the lagoon water has been essentially non-varient over the last 10 to 15 years since testing stopped. However, we are not in a position to predict what the lagoon inventory will be in hundreds and thousands of years from now. The concentration of plutonium in fish is related to the concentration of plutonium in water. Therefore an increase in water conçentration of 0.01% will increase present fish concentrations by 0.01% and subsequent dose to man through consumption of marine products by 0.01%.

To develop a conservative estimate of the impact of adding an additional 10 Ci of plutonium to the Runit Island inventory, one could assume that the plutonium concentration in the lagoon water immediately off shore the northern end of Runit Island results from terrestrial groundwater contributions. It is estimated that the plutonium inventory on the northern end of the island (300 m x 250 m) near Cactus Crater is 1.1 curies. Recent data[3] shows, however, that the plutonium detected in the near shore water is derived from other sources such as the sediments and the reef as well as groundwater. The estimated plutonium groundwater contribution,[3] derived from this recent data,[3] appears to be less than 20% of the measured near shore concentration. Therefore, if an additional 10 Ci were placed on the northern end of Runit, plutonium concentrations in the off shore water would eventually increase. During Oct. 1975 the $^{239+240}$Pu concentration in the off shore water of northern Runit was 97 fCi/l. For comparitive purposes, if 10 additional curies of $^{239+240}$Pu were present in northern Runit during this period, it is estimated that the off shore water concentration would only be twice as high as the value observed.

If it is then assumed that man's only marine diet consists entirely of fish equilibrated with this increased water concentration, the dose to man from this food pathway, calculated as in the 1972 dose assessment,[2] would be on the order of a few mrem.

2. Crater Disposal

The low tide volume of Cactus Crater in 3.4 x 10^4 m^3. Quantities of soil in excess of this volume will have to be mounded and extended onto the island. The impact of additional Pu in the terrestrial environment is discussed in part 1. The proposed method for disposing of Pu contaminated soil in Cactus Crater consists of forming a soil-cement slurry and filling the crater with the soil-cement mixture.

Dye studies[3] indicate that soluble material in crater water is transported to the island groundwater reservoirs and to the surrounding marine environment. The crater water is presently recharged both by surface and groundwater inputs. Once the crater is filled with the soil-cement, the fill will be in contact with and be an integral part of the island groundwater system. Over a period of time any crater fill below groundwater level will be subject to erosion and leaching. These processes will mobilize Pu and introduce levels to the groundwater system and subsequently to the marine environment.

If, for example, it were possible to fill the crater with soil containing all 10 curies of plutonium expected to be transferred to Runit (using no cement), the average soil concentration would be approximately 280 pCi/gm. From available data,[3] it can be computed that the groundwater in contact with this soil would contain, on the average, 5.0 pCi/l of plutonium. The average residence time of the groundwater at Northern Runit is 0.2 years. Therefore 0.5 mCi of plutonium could be expected to be annually discharged through groundwater flow from a 10 curie crater fill. The quantity will slowly decrease with time since the amount leaving follows an exponential loss curve. Cactus Crater is approximately 2% of the island area. If the crater is filled with 10 curies of plutonium and not fixed with cement, 2% of the island will contribute over 50% of the annual quantity of plutonium entering the lagoon with groundwater. The plutonium in the lagoon water immediately east of the crater, will then increase in proportion to the quantity of plutonium in the crater fill. However, fixing the soil with concrete will lessen the immediate impact on the marine ecosystem since we feel that this procedure will retard leaching or remobilization rates. On the other hand we cannot assess how long the concrete mixture will last when it is in contact with sea water for hundreds to thousands of years. To further minimize marine problems associated with crater fill, it is recommended that if the crater is filled, the fill be composed of the lesser contaminated soils from other islands. The more contaminated soil should be disposed of on the ground surface of Runit. The marine impact scales directly with the total quantity of plutonium disposed of in the crater. The concentration of Pu in fish from this new source and eventual dose to man via the marine pathway will again scale proportionally with the quantity in the crater which contributes in part to the quantities found in the water in the local off shore environment.

The least impact from plutonium (discussed in the previous section) on the Runit marine environment would be to eliminate crater disposal and place all relocated soil on North Runit Island as a soil-cement mixture. If the freshwater impacts can be reduced, the material could be capped to further reduce plutonium impacts on the marine environment.

3. Some Additional Considerations:

   A. The magnitude of the Pu doses discussed above are calculated using the most current dose models and the presently accepted transfer parameter for Pu. We are continually assessing the models, and the key parameter in the models, as more research data become available. If new data indicate that predicted Pu doses should be revised we will immediately re-evaluate Pu doses via the marine and terrestrial foodchains at Enewetak.

B. The question to which this response is directed concerned the impact of Pu upon the marine environmental as a result of disposal of contaminated soil near Cactus Crater. Therefore we have directed our assessment at the Pu question. However, it should be recognized that other radionuclides are also present in the soil and that ^{90}Sr, ^{137}Cs and ^{241}Am, for example, will also be remobilized at rates very different from those discussed for plutonium.

C. The leaching and remobilization of radionuclides from the contaminated soil which have been discussed above are based upon data obtained with current water flow patterns across the reef and in and out of Cactus Crater.

The impact of altering water circulation patterns across the reef and around the entire northern end of Runit Island resulting from filling the crater and mounding soil and concrete to heights of 30 feet, is unknown.

D. It is recognized that it will be necessary to establish a water monitoring system to detect any unanticipated problems which could impact on the marine environment from the soil fill. It would be desirable to maintain the existing wells around the crater since rates and fluxes of material from the crater to the well sites are established. Quantities of dye, such as Rhodamine B, could be added to the soil fill during clean up operations. Detection of any quantity of this dye in the lagoon water or groundwater would provide an early warning of possible structural defects and identify routes of contaminated water flow. In addition, continued radiological surrveillance should be maintained on marine food products in the local marine environment.

E. Cactus Crater is a valuable environmental aquarium. It would be difficult to duplicate such a structure anywhere else in the world. Destroying the crater will result in the loss of a very unique natural laboratory both from point of view of radionuclide studies and mariculture experiments. Efforts should be made to protect this now natural structure during clean up. The radionuclides in the crater water and sediment make various marine experiments feasible which would be difficult or impossible to conduct elsewhere. Types of experiments could include basic chemical studies of plutonium in salt water systems and defining recycling processes of plutonium by biotic and chemical means in terrestrial and aquatic environments. The natural outdoor laboratory could be operated by the existing MPML at Enewetak and be made available to investigators for radiological and marine studies.

[1]V. E. Noshkin, K. M. Wong, K. Marsh, R. Eagle, G. Holladay and R. W. Buddemeier, Plutonium Radionuclides in the Groundwaters at Enewetak Atoll, In IAEA Symposium Series "Transuranium Nuclides in the Environment", IAEA, Vienna, 1976 (pp. 517-543).

[2]Enewetak Radiological Survey, NVO-140, Oct. 1973.

[3]V. Noshkin, unpublished data (1977).

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