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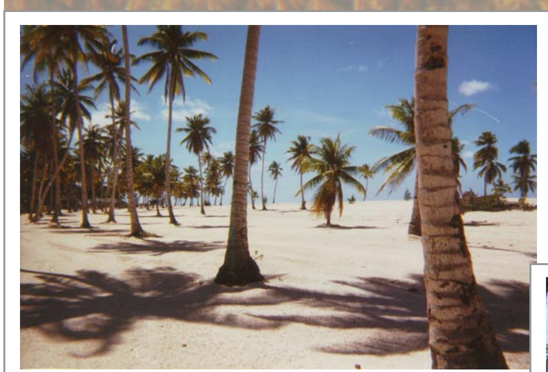
Rongelap Resettlement Support—Preliminary Report Part 1

In-Situ Gamma Spectrometric Measurements around the Service and Village Area on Rongelap Island



Terry Hamilton
Steven Kehl
James Brunk
Frank Gouveia
William Robison

This report was prepared in partial fulfillment of LLNL program level goals and actions supporting the Rongelap Atoll settlement as formally outlined under a Memorandum of Understanding (MOU) between the U. S. Department of Energy (DOE), the Rongelap Atoll Local Government (RALGOV), and the Republic of the Marshall Islands (RMI).

LLNL Marshall Islands Program

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Table of Contents

List of Tables

List of Figures

Summary—*The combined remedial measures of limited soil removal and addition of coral fill have been very effective in reducing the external ^{137}Cs exposure in and around the proposed service and village area on Rongelap Island. The average effective dose for a year's occupancy within the village has been reduced from about 19 to 0.6 mrem y^{-1}, and is below the target level of 1 mrem y^{-1} recommended to RALGOV. Some additional actions could be taken to reduce the external dose around specific sites but on the basis of the data presented in this report, it appears that the resettlement contractor has met the basic requirements for this phase of the project.*

Introduction

The Lawrence Livermore National Laboratory (LLNL) is responsible for providing monitoring, verification and expert assistance in support of resettlement activities on atolls affected by the US nuclear testing program in the Marshall Islands. Our scientific studies have also formed the basis for recommendations concerning remediation of islands to reduce doses to returning populations. Remediation work on Rongelap Island called for limited soil removal and addition of crushed coral around the service and village areas to reduce external radiation exposure, and application of potassium chloride fertilizer around the agricultural areas – a preventive measure used to minimize the uptake of cesium-137 (^{137}Cs) into locally grown foods.

The objective of the present study was to verify the effectiveness of limited soil removal and addition of crushed coral on reducing the external exposure from residual ^{137}Cs in soils of the service and village area, and provide necessary feedback and recommendations to RALGOV and their contractors.

Recommendations Concerning Soil Remediation

Recommendations for remediation of soil called for the removal of 10 inches (25 cm) of surface soil and addition of coral fill around the service and village area to minimize external gamma and alpha/beta exposures in areas where people spend most of their time. Soil profile data developed by LLNL show that over 90% of the ^{137}Cs activity is contained within the upper 10 inches (25 cm) of the soil column (Figure 1). It is also common practice in the Marshall Islands to use crushed coral around houses for both appearance and to minimize resuspension of dust. The addition of crushed coral around the village area on Rongelap will provide the added benefit of reducing exposures to residual gamma and beta radiation emanating from the underlying contaminated soil. The overall goal was to reduce the external ^{137}Cs gamma exposure rate to or less than 0.17 μR h^{-1} or about 19 Bq kg^{-1} of ^{137}Cs in dry soil. This corresponds to an effective dose target level of ~1 mrem y^{-1} (or 0.01 mSv y^{-1}). We also recommend soil remediation around individual homes erected outside the central village area—this would involve replacing the surface 10 inches of existing soil with 8–10 inches of coral fill up to a distance of 10 meters around each house.

The combination of limited soil removal and application of coral fill was expected to not only provide a very significant reduction in the external exposure but also help reduce the potential internal exposure to alpha emitting radionuclides [e.g., plutonium-239 (^{239}Pu), plutonium-240 (^{240}Pu), amercium-241 (^{241}Am)]. Although alpha emitting radionuclides are not expected to be a significant contributor to

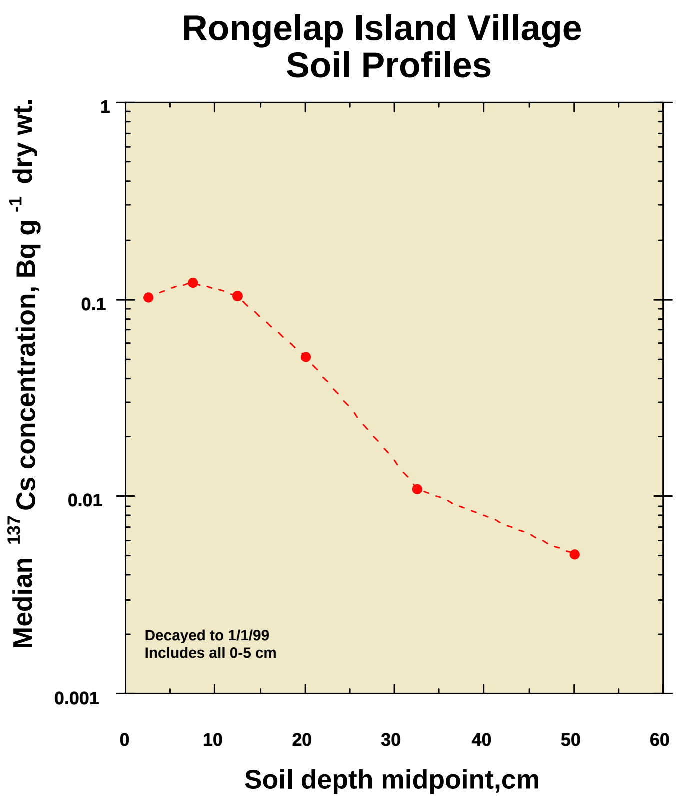

Figure 1. Average ^{137}Cs depth distribution in soils from the Rongelap service and village area.

the annual effective dose, plutonium is a concern to the Rongelap people and addition of a layer of clean, crushed coral around the village will help minimize any potential exposures to plutonium from inhalation and / or ingestion of contaminated soil–especially to infants and children as identified in the Kohn report (Kohn, 1989).

Soil scraping operations were completed in April 2000 and an *in-situ* gamma survey conducted shortly after. Limited surface soil removal reduced the average gamma exposure within the service and village area to about 0.7 μR h^{-1}. This level of exposure converts to an external effective dose of 4.8 mrem y^{-1}, and represents a 4 to 5 fold reduction in the total average external dose attributable to ^{137}Cs prior to any cleanup operations. This information was presented to RALGOV leaders and their contractors during an informal meeting on Rongelap during May 2000. At that time, we recommended that some additional soil be removed from selected sites including the beach frontage areas where residual levels of ^{137}Cs in soil remained relatively high. There was no requirement made to re-survey these areas prior to the application of the coral fill. It was also shown experimentally (Figure 2) that addition of 6 inches (15 cm) of coral fill could reduce the gamma flux by an additional factor of 5 down to the recommended target level of 1 mrem y^{-1}.

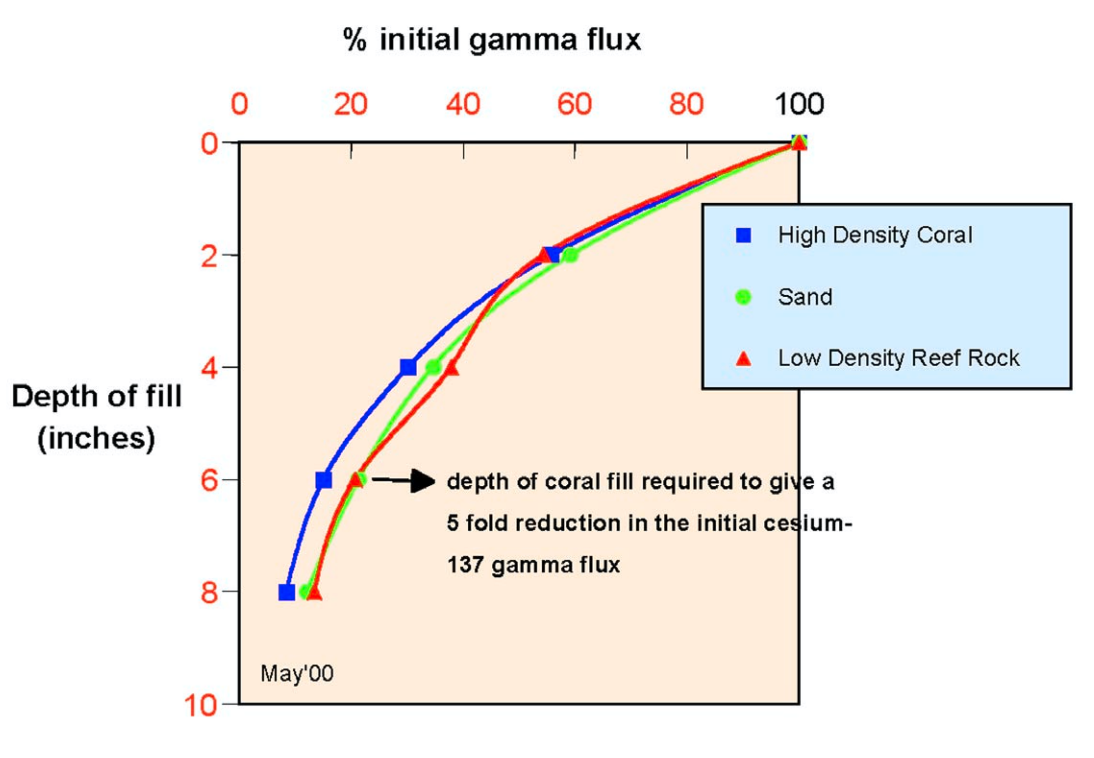

Figure 2. Relative ^{137}Cs flux rates versus depth of coral fill.

Background

The proposed service and village area of 36.1 acres (14.7 hectares) is located along the lagoon fringe of Rongelap Island. Existing structures (as of March 2001) include a generator building, reverse osmosis plant, water storage tanks and two storage/equipment buildings within the central service area; a whole body counting (WBC) building; a refurbished church; an old dispensary building; a temporary trailer complex utilized by DOE/LLNL, a workers resettlement camp consisting of trailers and mess/living quarters, and a new field station. The initial gamma survey was conducted in 1999 over much of this area and served as a baseline for subsequent measurements. No soil has been removed from around the central service areas, nor around the roads, the WBC building, the old dispensary or close to the DOE/LLNL trailer complex. The new field station is located outside the original perimeter of the proposed service and village area (28.1 areas or 11.4 hectares)—this area was de-brushed but little or no surface soil was removed. Based on recommendations from LLNL, additional soil was removed from several sites after the May 2000 survey to remediate those areas containing higher than expected ^{137}Cs dose rates. Some of these same areas have again been identified in this report as possible sites for further remediation.

The last *in-situ* gamma survey was performed over a total area of 36.3 acres (14.7 hectares) as the boundaries of the village area were expanded slightly with the addition of coral fill. A total of 400 site locations were established on a 20 m grid over the area using a Geographical Positioning System (GPS) referenced to a survey marker previously established by local contractors. It is estimated that the gamma site locations before and after soil removal, and again after addition of the coral fill were re-established to an accuracy of about ± 10 cm.

The gamma surveys were conducted with Surveillance and Measurement Systems (SAM 935 units) provided by Berkeley Nucleonics (CA, United States). These units use a thallium-activated sodium iodide 3" × 3" detector, and allow for full and isotopic-specific dose rate measurements in real time. The total gamma flux at the detector is a function of the source-activity and source-depth distributions, the energy of the gamma rays, and soil properties (soil composition, density, and moisture content). In field gamma spectrometry, the exposure rate at one meter above ground can be inferred directly from *in-situ* gamma flux measurements, i.e., the total peak area counts, by using flux to exposure rate calibration factors. A SAM unit and tripod configuration as used in the field are shown in Figure 3. Count times ranged from 5 to 15 minutes. Background and quality control counts were performed on a daily basis using standard ^{137}Cs point sources.

The internal dose rate calibration factors used by the SAM units are derived from a single point calibration using a standard ^{137}Cs point source parallel to the detectors axis of symmetry. The units are certified by Berkeley Nucleonics as being accurate (www.berkelynucleonics.com) based on direct comparisons with calibrated laboratory instruments recognized as industry standards for low dose measurements. However, about 85% of the unscattered gamma rays incident on a detector at one meter above the ground arrive at angles from 50 to 80 degrees from the vertical with most of the gamma rays originating from distances of 1 to 5 meters radius from the detector. As the time of publication, the angular response characteristics of the detectors were not known and, therefore, have not been considered in converting the gamma flux to dose equivalents. Rather than wait for a full scientific report showing details of the dose rate calibration and certification, the authors felt it was important to release this preliminary report as soon as possible to provide immediate feedback to RALGOV

Figure 3. A Surveillance and Measurement System (SAM 975 unit) with a 3" × 3" NaI detector suspended at 1 meter above ground (Rongelap Island, LLNL *in-situ* gamma survey, April 2001)

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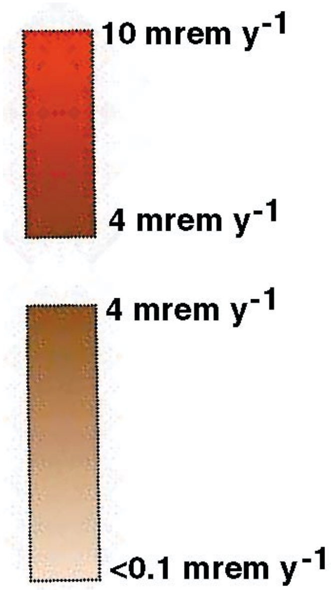
and their contractors on the effectiveness of soil removal and addition of coral fill on the external exposure conditions. Moreover, we have compared SAM data with established benchmarks sites on Bikini Islands and the results were in excellent agreement with measurements performed by the International Atomic Energy Commission (IAEA). A full scientific report on the measured external exposure from ^{137}Cs within the service and village area will be issued on completion of Phase I resettlement support activities.

Results and Discussion

The average exposure rate measured in the service and village area after removal of surface soil was 0.7 ± 0.5 μR h^{-1} with a range between 0.02 and 4.2 μR h^{-1}. This corresponds to an average external effective dose of 4.8 ± 3.1 mrem y^{-1}. These data were derived from 353 site locations within the original boundary of the service and village area (28.1 acres or 11.4 hectares). The external dose conditions over the entire village area are represented in the contour plot shown in Figure A-4. The dark-shaded areas contain elevated ^{137}Cs dose rates compared with the light-shaded areas. Several areas with significantly higher dose rates (shaded in red) were identified to the supervising resettlement contractor as requiring further remediation. We were advised that this work was completed prior to the addition of coral fill.

The addition of coral fill was completed about 10 months after soil scraping. One of DOE's main undertakings in providing environmental monitoring support for resettlement was to conduct an *in-situ* gamma survey to confirm the effectiveness of the combined actions of the initial soil removal and addition of coral fill. The average exposure rate measured in the service and village area was about 0.10 ± 0.12 μR h^{-1} with a range between 0 and 1.2 μR h^{-1}. These data show that the addition of coral fill was very effective in providing an additional reduction in ^{137}Cs gamma exposure. A 7 fold reduction in the gamma exposure rate was observed over the site to give an average dose equivalent of 0.6 ± 0.8 mrem y^{-1}. The effect of the coral fill can be readily identified by comparing the frequency distribution of dark shaded areas in Figs. 4a and 4b. The depth of coral fill measured on a total of 30 sites around the service and village area averaged 6.8 ± 2.2 inches (17.2 ± 5.7 cm) with a range from <3 to 12 inches (8 to 30 cm). The reduction in the external gamma on addition of the coral fill appears to be very consistent with what was demonstrated experimentally (Figure 2).

While the average dose rate is below the proposed target level of 1 mrem y^{-1}, we have identified several sites within the service and village area where additional remediation could be performed (as shown in detail in the photographs contained in Appendix 1). A summary of the sites showing higher than average dose rates is also represented in Figure 5. The highest dose rates within the village were observed in and around the area containing the whole body counting building and DOE camp (see Figure 5). This area has not been scraped nor has any coral fill been added. Presumably this will be done when the new dispensary building is erected. We also observed higher than average dose rates (equivalent to 0.6 μR h^{-1} or 4 mrem y^{-1}) in and around what was described as a Japanese historical site (see Figure 5). The other areas identified as higher than average included the area between the lagoon road and beach to the north-east of central service area (this area does not appear to have been scraped nor any coral fill added); the area extending from the service area towards the interior of the island where the original resettlement camp was erected (this area contains only a minimal amount of coral fill added as part of a test plot during the initial phases of the project); the area surrounding the field station (this area was outside the original service and village area—we recommend adding more coral fill around the building); the central service area and



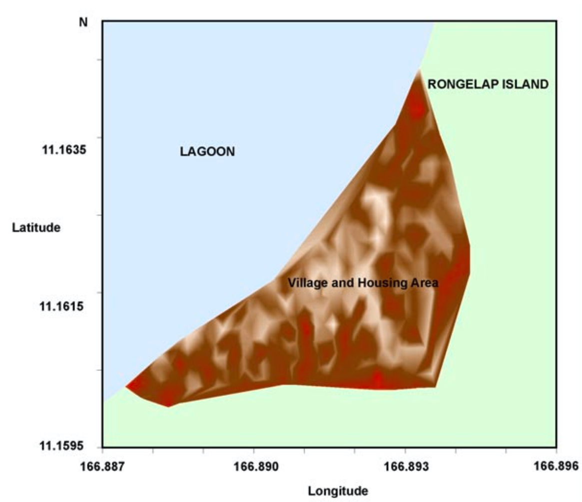


Figure 4a. ^{137}Cs dose rates after removal of surface soil (Rongelap Island, May 2000).

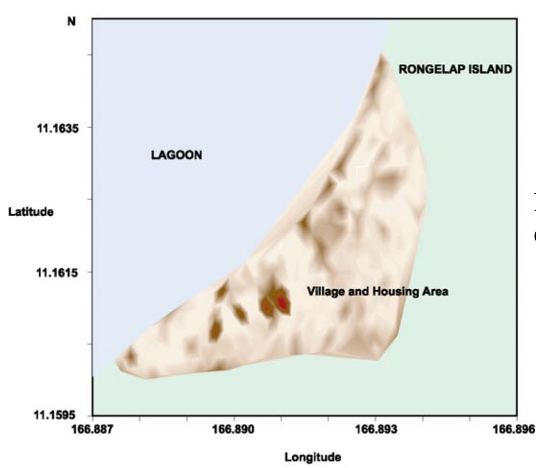


Figure 4b. ^{137}Cs dose rates after addition of coral fill (Rongelap Island, April 2001).

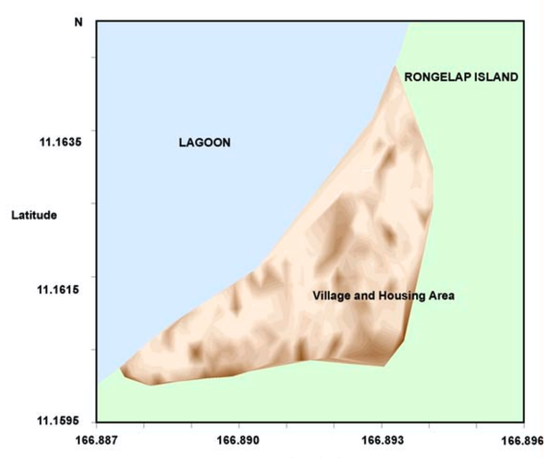


Figure 4c. ^{137}Cs dose rates after final remediation work (proposed).

roads (remain unscrapped with no coral fill), and several other areas used for storage of equipment, plant, debris and / or containers. The latter have been identified in Appendix 1. Typical dose rates on the road surfaces and within the general service area tend to be 2–-6 times higher than the average. These areas were not scraped and do not contain any coral fill. We were informed that this whole area will eventually be paved and that up to 12 inches of soil will be removed as part of the normal paving process.

It is also interesting to note that observed dose rates around the base of coconut trees were slightly higher (although they remain extremely low) than those areas either between trees or in open fields. Dose rates measured directly adjacent coconut trees varied from <1 to about 2 mrem y^{-1}. The higher dose rates are presumably related to the quantity of dark soil remaining around the base of the trees, and the fact that areas immediately adjacent to trees contained lesser amounts of coral fill. We do not suggest the need for further remediation around these areas because of potential damage to the trees for little or no direct benefit in reducing the average dose conditions over the entire village site.

Assuming that the roads and central survey area will be paved, and additional soil removed and / or coral fill added to the sites described above (see Appendix 1), then

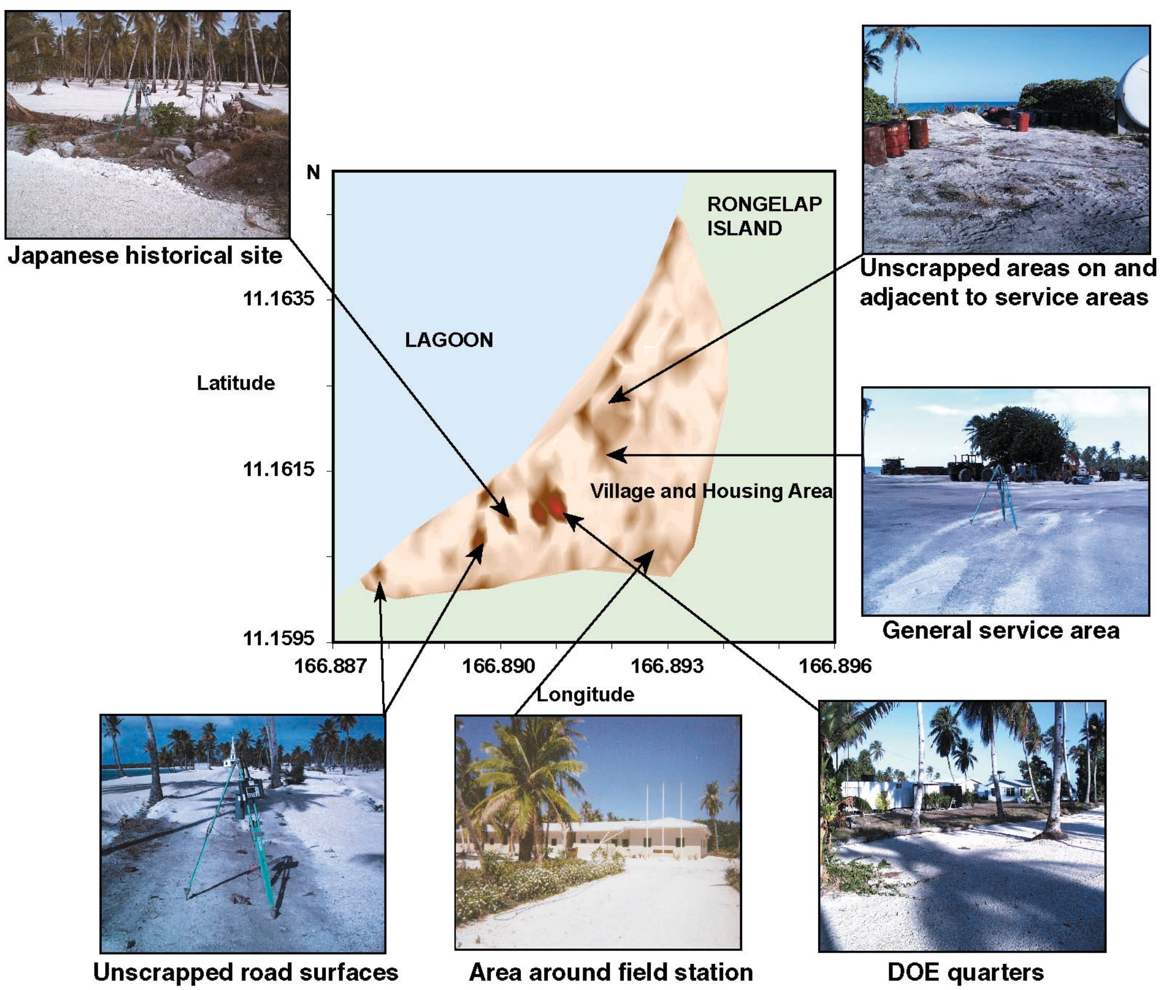


Figure 5. Visual description of sites round the service and village area showing higher than average ^{137}Cs dose rates (April 2001).

the final dose rate conditions within the service and village area will resemble those shown in Figure 4c. The ^{137}Cs average dose equivalent from a year's occupancy on island will have been reduced to about 0.4 mrem y^{-1} or well below the target level of 1 mrem y^{-1}.

Conclusions

In-situ gamma spectrometry studies conducted by the Lawrence Livermore National Laboratory have been able to clearly demonstrate that the combined remedial measures of limited soil removal and addition of coral fill within the proposed service and village area on Rongelap Island have been very effective in reducing the external ^{137}Cs gamma exposure. It is estimated that the average effective external dose from a year's occupancy within the village will be around 0.6 ± 0.8 mrem y^{-1} or below the target level of 1 mrem y^{-1}. Some additional actions could be taken to reduce the external dose around specific sites / areas. A final assessment of the external gamma exposure within the service and village area could be made after completion of these activities.

Acknowledgement

We very much appreciate the excellent support provided by Bechtel Nevada in the field phase of this project. We are particularly thankful to Richard Giles, Judy Honda, Capelle DeBrum and all our Marshallese field crew. We also thank Rayla Bradsher for assistance in preparing this report. This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No.W-7405-Eng-48.

References

Memorandum of Understanding among the United States Department of Energy and the Government of the Republic of the Marshall Islands and the Rongelap Atoll Local Government, entered into on 4/9/99.

Kohn, H.I. (1989) Rongelap reassessment project report, corrected edition, March 1, 1989. Report to the President and Congress of the United States Pursuant to the Compact of Free Association of 1985. Rongelap Reassessment Project, 1203 Shattuck Avenue, Berkeley, CA. (need to check if this is the correct reference related to Pu exposure in children).

Appendix A

Recommendations for further remediation around the Rongelap village area

Table A-1. Suggestions for remediation of sites containing higher than average external dose rates

Site description	Observed dose rates (mrem y^{-1})	Recommendations	Picture files
Roads surfaces and around the general service areas of the village	<1-6	Not scraped - the process of paving of these surfaces will reduce the external gamma to well below the 1 mrem y^{-1} target level	Figures A-1 and A-2
Area containing the WBC and dispensary buildings and the DOE trailer complex	<1-10	Not scraped - soil could be removed from around buildings / structures and replaced with 6-8 inches of crushed coral and sand	Figure A-3
Japanese historical site	~5	Loose soil and debris - soil and other debris could be selectively removed by hand while retaining the integrity of the building walls / foundation	Figure A-4
Original contractor camp and trailer complex	<1-3	Low level of coral fill- need to add additional 4-6 inches of fill around this entire site	Figure A-5
Beach frontage N-W of service area and adjacent asphalt plant	<1-3	Either no soil removed and / or contain low levels of coral fill. Some soil could be removed from between the beach and lagoon road, and replaced with coral fill. Additional fill should be added to those areas contain little or no fill that are not scheduled to be paved	Figure A-6
Site containing old debris and construction materials (adjacent Reverse Osmosis Plant building)	<1-3	Not scraped - soil could be removed and replaced with coral fill	Figure A-7
Mounds of soil and other debris around village area	<1-3	Mounds of soil / debris or not scraped- could remove mounds of soil and cover areas with coral fill	Figure A-8

Unscrapped road surfaces

Figure A-1. Road surfaces and around the general service areas of the village.

Unscrapped areas and dark colored fill around generator building.

Unscrapped areas and lack of coral fill in service area between buildings.

Unscrapped surfaces around the general service area.

Figure A-2. Road surfaces and around the general service areas of the village continued.

Unscrapped areas around the whole body counting (WBC) and old dispensary buildings.

Unscrapped area around the DOE trailer complex.

Figure A-3. Whole body counting building and DOE trailer complex.

Figure A-4. Japanese historical site—mounded dark soil and debris.

Lack of coral fill between newly constructed garages and original resettlement camp.

Lack of coral fill in the area surrounding original construction camp.

Figure A-5. Original contractor camp and trailer complex.

Figure A-6. Beach frontage N-W of service area and adjacent asphalt plant.

Figure A-7. Site containing old debris and construction materials adjacent to the reverse osmosis plant building.

Mounds of dark soil / fill placed on the beach adjacent church.

Mounds of soil and unscrapped surfaces around debris piles and construction materials, tanks.

Mounds of dark soil and unscrapped surfaces with no coral fill

Mounds of dark soil and debris

Mounds of dark soil adjacent beach.

Unscrapped surfaces adjacent traffic area

Figure A-8. Mounds of soil and other debris around the village area.

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