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LLNL-TR-601552-REV-1

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March 6, 2013

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This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Abstract

In November 2011 an Advanced Hypersonic Weapon (AHW) flight test vehicle impacted on the tarmac of the helipad on Illeginni Island. It did not impact in soil/grass area where the Be and U from the ICBM tests are distributed. The exposed soil in the berm created by the impact was analyzed for both U and Be. This soil has been covered by the tarmac for decades and represents uncontaminated coral soil The U concentration in the berm soil is 1.9 $\mu g\ g^{-1}$ that is about the average concentration for U observed in coral soil in the Marshall Islands and other atolls around the world. The Be concentration in the soil was less than 0.003 $\mu g\ g^{-1}$.

The mean concentration of U in 16 soil samples collected around the tarmac at 1 meter distance from the tarmac is 22 $\mu g\ g^{-1}$ that is far below the USEPA guidance for U in residential soil of 230 $\mu g\ g^{-1}$ and even the USAKA environmental standard (UES) of 47 $\mu g\ g^{-1}$ that is based on soluble U salts. Similarly, the mean Be concentration in the 16 samples is 2.1 $\mu g\ g^{-1}$ that again is far below USEPA and UES guidance of 160 $\mu g\ g^{-1}$ for residential soil.

The concentration of both U and Be in air are many orders of magnitude below the USEPA and UES guidance for the general public.

Introduction.

On November 11, 2011 a flight test vehicle for the AHW program targeted for Kwajalein Atoll impacted on the tarmac surrounding the helipad on Illeginni Island at Kwajalein Atoll (light grey area in Figures 1 and 4. The AHW flight test vehicle contained no DU or Be. The impact point on Illeginni Island was not in the area where previous flight tests of the Peace Keeper and Minuteman (ICBM) missiles have impacted on the island over many years depositing low concentrations of DU and Be in the soil on the helipad end of Illeginni Island.

During the ICBM missile flight test program a large grid system consisting of many 25m by 25m squares was established on the contaminated portion of the island in the helipad area (Figure 1). Soil samples were collected on the intersections of the rectangles, the midpoints of the sides of the each square, and in the middle of each square. A total of 117 samples were collected and analyzed for U and Be. The results of the analysis of Be and DU in the soil collected from this grid can be found in Reference 1 (Robison et al., 2010) where they are compared with the current USEPA guidance for U and Be in residential soils in the United States. The concentration of Be and DU in air are also summarized in the 2010 report and compared to the latest USEPA guidance for the general public. Some of the 2010 report results will be summarized here as well for the ease of the reader.

After the last ICBM mission the concentration of the DU and Be in the soil were measured over the contaminated "throw-out zone" resulting from the RV impacts on the island. In addition, hi-volume air samplers were run for extended periods of time (3 to 5 weeks) downwind of the deposition area after each mission in which a land impact occurred in order to determine the concentration of the DU and Be in air that could potentially be inhaled by persons visiting the island (Robison et al., 2006; Robison et al., 2010).

The USEPA also recommended that the entire contaminated area resulting from the ICBM missile RV impacts on the island should be divided into 0.5 acre parcels and the concentrations of DU and Be should be calculated for each 0.5 acre parcel to compare with the current EPA guidance for residential soils in the United States. The USEPA recommended 3 to 5 samples be collected from each half-acre parcel. We did a much more dense sampling pattern than that as can be seen in Figure 2. The 0.5 acre parcels are color-coded and the results of the DU and Be concentration in the soils of each 0.5 acre parcel are shown in Table 1 and 2 using the same color-code scheme. The current EPA guidance for both Be and U are listed on the respective figures. The average concentration of DU and Be in the 0.5 acre parcels is far below the USEPA guidance of 230 $\mu g\ g^{-1}$ for residential soils in the United States and below the UES guidance of 47 $\mu g\ g^{-1}$ that is based on soluble uranium salts and is not really relevant to the totally insoluble DU on Illeginni Island.

AHW impact area and sample collection strategy.

The AHW vehicle impacted on the tarmac of the helipad shown as light grey in Figures 2 and 4. It did not impact in soil/grass area where the Be and U from the ICBM tests is distributed (the color coded areas coded in Figure 2). The asphalt tarmac that is about 3 inches deep (the light grey area surrounding the helipad (see Figures 2 and 4). The crater formed as a result of the RV impact produced a circular berm of new soil that has been covered by the tarmac during all the years of the ICBM flight tests and thus represents original coral island soil that is uncontaminated by previous tests. Sixteen total samples were collected from the berm and that includes two duplicate samples of two of the sample sites. The samples were collected at 45^0, 90^0, 135^0, 180^0, 225^0, 270^0, and 315^0 (Figure 3) around the berm.

Fourteen soil samples were also collected at one meter distance from the tarmac around all four sides of the tarmac where DU and Be were deposited during the ICBM flight tests (Figure 4). These samples were collected just to reconfirm previous results of Be and U in the soil because the AHW vehicle impact did not influence this portion of the Island.

The Hi-volume air samplers were positioned downwind from the impact area as shown in Figure 4. The air samplers were run for three weeks and the total volume of air through the filters was about 85,470 m^3 (~302,000 ft^3).

Results

The U mean concentration and standard error of $1.9 \pm 0.17\ \mu g\ g^{-1}$ shown in Table 3 for the newly exposed soil from the berm caused by the RV impact is about the average value for U in coral soils around the world (Robison et al., 2001, 2006, 2010). Mean values for corals around the world range from about 1.7 to 2.3 $\mu g\ g^{-1}$. This is also the range we have found in the Marshall Islands (Robison et al., 2001).

The concentration of Be is less than 0.0027 $\mu g\ g^{-1}$ for Be (Table 3). This new value for the Be is much lower than previously reported Be concentrations in coral soil in our other reports. This is the result of increased analytical sensitivity for Be in the ICP mass-spectrometry facility at LLNL. The new value for the Be provides the natural concentration of Be in coral soil and it is very, very low. Thus the Be concentrations in soil previously reported in references 1 and 2 (and repeated here) are definitely a result of the small amounts of Be dispersed upon impact of the ICBM RV's that contained the DU and Be.

Mean U concentration and standard error for sixteen soil samples collected in the deposition area of the ICBM tests on all sides of the helipad is $22 \pm 8.8\ \mu g\ g^{-1}$ (Table 4). Thus, the U concentration around the tarmac is far below USEPA guidance for residential soils of $230\ \mu g\ g^{-1}$ and even below the UES guidance of $47\ \mu g\ g^{-1}$ that is based on soluble Uranium salts that is not relevant to the totally insoluble DU on Illeginni island.

The Be mean concentration and standard error for the sixteen soil samples collected in the deposition area of the ICBM tests on all sides of the helipad is $2.1 \pm 0.58\ \mu g\ g^{-1}$. Thus, the Be concentration around the tarmac is far below the USEPA and UES guidance for residential soils of $160\ \mu g\ g^{-1}$.

The resulting concentrations of U and Be in the air on Illeginni after the AHW impact is shown in Figure 5 and listed as date 2012 on the X axis. The concentrations of U and Be in air are orders of magnitude below the USEPA and UES guidance over all the years we have made the measurements.

Conclusions

The impact of the AHW vehicle on Illeginni Island added no DU or Be to the current inventories of those elements in the soil on Illeginni Island nor did it cause any redistribution of the preexisting DU and Be inventories on the island.

References:

1.Robison, W.L., V.E. Noshkin, T.F. Hamilton, C.L. Conrado, K.T. Bogen, (2001), An Assessment of the Current Day Impact Various Materials Associated with the U. S. Nuclear Test Program in the Marshall Islands. Lawrence Livermore National Laboratory report, UCRL_LR-143980.

2. Robison,W. L., T.F. Hamilton, R.E Martinelli, F.J Gouveia, T.R. Lindman, S. C. Yakuma, (2006), The Concentration and Distribution od Depleted Uranium (DU) and Be in soil and air on Illeginni Island at Kwajalein Atoll. Lawrence Livermore National Laboratory report, Livermore, CA UCRL-TR-222048.

3. Robison, W.L., T.F. Hamilton, R.E Matinelli, F.J. Gouveia, S.R. Kehl, T.R. Lindman, S.C. Yakuma, (2010), Concentration and Distribution of Depleted U (DU) and Beryllium (Be) in soil and air on Illeginni Island at Kwajalein Atoll after the Final Land-Impact Test. Lawrence Livermore National Laboratory report, Livermore, CA LLNL-TR-428476.

Figure 1. The location of soil samples collected on Illeginni Island (U, Be concentrations for each site).

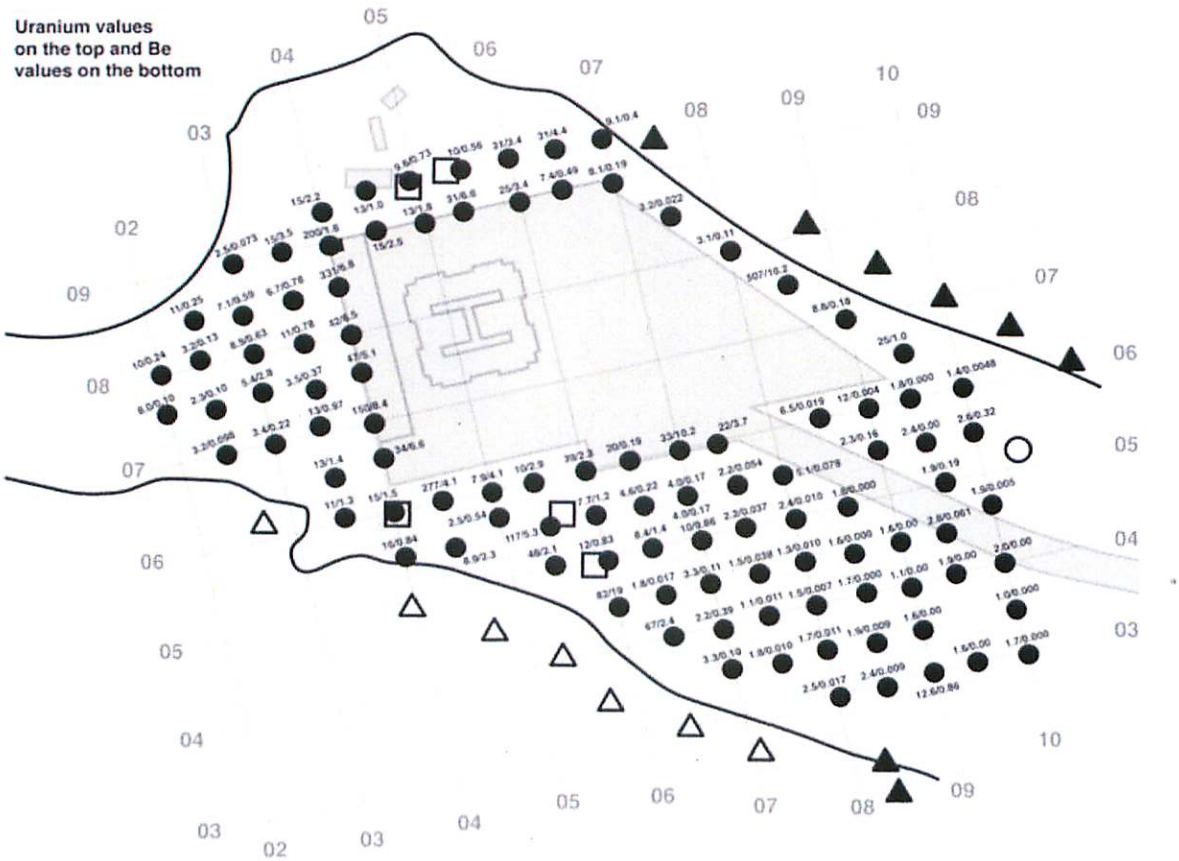

Figure 2. Color-coded 0.5 acre plots sampling sites and data.

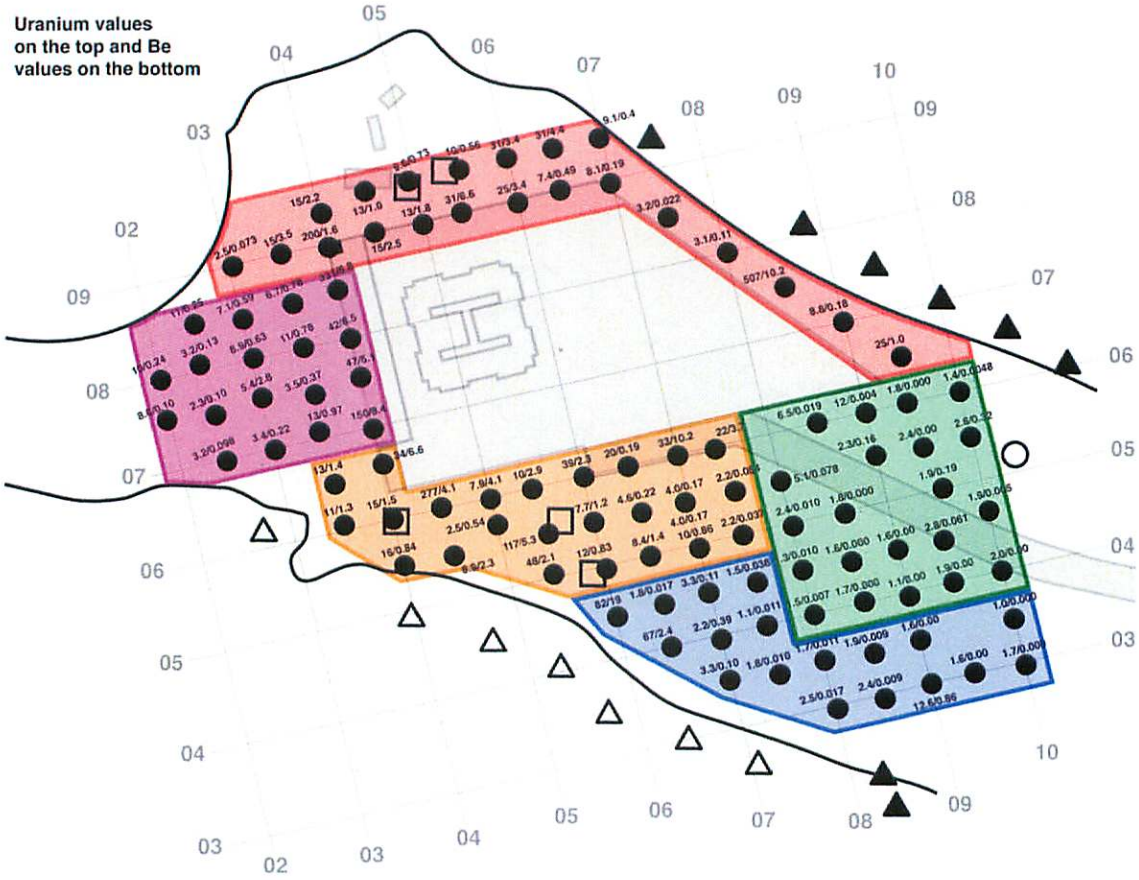

Figure 3. The location of soil samples collected from the berm of the AHW crater.

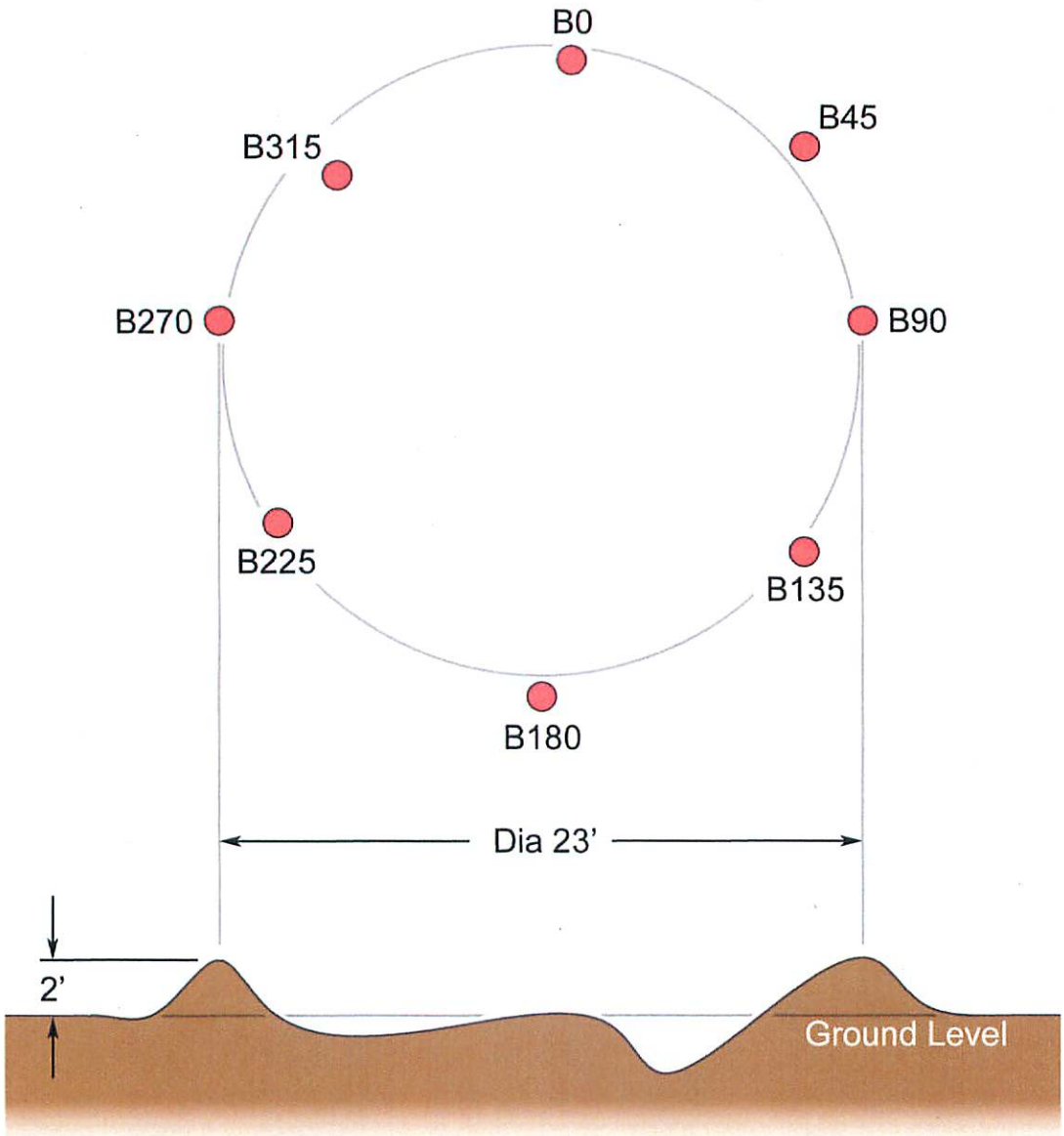

Table 1. The concentration of U in the soil in the five color-coded 0.5 acre parcels and the comparison to current U.S. EPA guidelines.

Coord.	Blue	Coord.	Green	Coord.	Orange	Coord.	purple	Coord.	Red
08, 04	1.5	08.5, 06	6.5	03.5, 06.5	13	02.5, 08.5	11	04, 09.2	15
08.5, 04	1.7	09, 06	12	04, 06.5	35	03, 08.5	7.1	04.5, 09.5	13
09, 04	1.1	09.5, 06	1.8	03.5, 06	11	03.5, 08.5	6.7	05, 09.5	9.5
09.5, 04	1.9	10, 06	1.4	04, 06	15	04, 08.5	331	05.5, 09.5	10
10, 04	2.0	08, 05.5	5.1	04.5, 06	277	02, 08	10	06, 09.7	31
08, 03.5	1.7	09, 05.5	2.3	05, 06	7.9	02.5, 08	3.2	06.5, 09.5	30
08.5, 03.5	1.9	09.5, 05.5	2.4	05.5, 06	10	03, 08	8.9	07, 09.5	9.1
09, 3.5	1.6	10, 05.5	2.6	06, 06	39	03.5, 08	11	03, 09	2.5
10, 3.5	1.0	08, 05	2.4	06.5, 06	20	04, 08	42	03.5, 09	15
08, 03	2.5	08.5, 05	1.8	07, 06	33	02, 07.5	8	04, 09	200
08.5, 03	2.4	09.5, 05	1.9	07.5, 06	22	02.5, 07.5	2.3	04.5, 09	15
09, 03	12.6	08, 04.5	1.3	04, 05.5	16	03, 07.5	5.4	05, 09	13
09.5, 03	1.6	08.5, 04	1.6	04.5, 05.5	8.9	03.5, 07.5	3.5	05.5, 09	31
10, 03	13	09, 04	1.6	05, 05.7	2.5	04, 07.5	47	06, 09	25
06, 04.5	82	09.5, 04.5	2.8	05.5, 05.5	155	02.5,07	3.2	06.5, 09	7.4
06.5, 04.5	1.8	10, 04.5	1.9	06, 05.5	7.7	03, 07	3.4	07, 09	8.1
07, 04.5	3.3	08, 04	1.5	06.5, 05.5	4.6	03.5, 07	13	07.5, 08.5	3.2
07.5, 04.5	1.5	08.5, 04	1.7	07, 05.5	4.0	04, 07	150	08, 08	3.1
08, 04.5	1.3	09, 04	1.1	07.5, 05.5	2.2	Median	8.5	08.5, 07.5	507
06.5, 04	67	09.5, 04	1.8	05.5, 05	48	Mean	37	09, 07	8.8
07, 04	2.2	10, 04	2.0	06, 05	12	No.	18	09.5, 06.5	25
07.5, 04	1.1	Median	1.9	06.5, 05	8.4	Stdev	81	08.5, 06	6.5
08, 04	1.5	Mean	2.7	07, 05	10	Stderr	19	09, 06	1.6
07, 03.5	3.3	No.	21	07.5, 05	2.2			09.5, 06	1.6
07.5, 03.5	1.8	Stdev	2.5	Median	12			10, 06	1.4
08, 03.5	1.7	Stderr	0.54	Mean	32			08, 05.5	5.1
08, 03	2.5			No.	24			09, 05.5	2.3
Median	1.8			Stdev	61			09.5, 05.5	2.4
Mean	8.0			Stderr	12			10, 05.5	2.6
No.	27							Median	9.1
Stdev	19							Mean	35
Stderr	3.8							No.	29
								Stdev	98
								Stderr	18

USEPA Screening Levels: U = 230 mg kg^{-1}
UES Screening Levels: U = 47 mg kg^{-1}

Red = mean of 1 to 6 replicates

Table 2. The concentration of Be in the soil in the five color-coded 0.5 acre parcels and the comparison to current U.S. EPA guidelines.

Coord.	Blue	Coord.	Green	Coord.	Orange	Coord.	Purple	Coord.	Red
08, 04	0.007	08.5, 06	0.019	03.5, 06.5	1.4	02.5, 08.5	0.25	04, 09.2	2.2
08.5, 04	0.0	09, 06	0.004	04, 06.5	6.6	03, 08.5	0.59	04.5, 09.5	1.0
09, 04	0.0	09.5, 06	0.00	03.5, 06	1.3	03.5, 08.5	0.78	05, 09.5	0.73
09.5, 04	0.0	10, 06	0.0048	04, 06	1.5	04, 08.5	6.8	05.5, 09.5	0.56
10, 04	0.0	08, 05.5	0.078	04.5, 06	4.1	02, 08	0.24	06, 09.7	3.4
08, 03.5	0.11	09, 05.5	0.16	05, 06	4.1	02.5, 08	0.13	06.5, 09.5	4.4
08.5 ,03.5	0.009	09.5, 05.5	0.00	05.5, 06	2.9	03, 08	0.63	07, 09.5	0.4
09, 3.5	0.00	10, 5.5	0.32	06, 06	2.3	03.5, 08	0.78	03, 09	0.073
10, 03.5	0.00	08, 05	0.01	06.5, 06	0.19	04,08	6.5	03.5, 09	3.5
08, 03	0.017	08.5, 05	0.00	07, 06	10.2	02, 07.5	0.1	04, 09	1.6
08.5, 03	0.009	9.5, 05	0.19	07.5, 06	3.7	02.5, 07.5	2.3	04.4, 09	2.5
09, 03	0.86	08, 04.5	0.01	04, 05.5	0.84	03, 07.5	2.8	05, 09	1.8
09.5, 03	0.00	08.5, 04	0.00	04.5, 05.5	2.3	03.5, 07.5	0.37	05.5, 09	6.6
10, 03	0.00	09, 04	0.00	05, 05.7	0.54	04, 07.5	5.1	06, 09	3.4
06, 04.5	19	09.5,04.5	0.061	05.5, 05.5	5.3	02.5, 07	0.098	06.5 ,09	0.49
06.5, 04.5	0.017	10, 04.5	0.005	06, 05.5	1.2	03, 07	0.22	07, 09	0.19
07, 04.5	0.11	08, 04	0.007	06.5 ,05.5	0.22	03.5,07	0.97	07.5, 08.5	0.022
07.5, 04.5	0.038	08.5, 04	0.00	07, 05.5	0.2	04,07	8.4	08, 08	0.11
08, 04.5	0.01	09, 04	0.00	07.5 , 05.5	0.054	**Median**	**0.71**	08.5, 07.5	10.2
06.5, 04	2.4	09.5, 04	0.00	05.5, 05	2.1	**Mean**	**2.1**	09 ,07	0.18
07, 04	0.39	10,04	0.00	06, 05	0.83	**No.**	**18**	09.5, 06.5	1.0
07.5, 04	0.011	**Median**	**0.00**	06.5, 05	1.4	**Stdev**	**2.7**	08.5, 06	0.019
08, 04	0.007	**Mean**	**0.04**	07, 05	0.86	**Stderr**	**0.6**	09, 06	0.004
07, 03.5	0.10	**No.**	**21**	07.5, 05	0.037			09.5, 06	0.0
07.5, 03.5	0.01	**Stdev**	**0.1**	**Median**	**1.4**			10, 06	0.005
08, 03.5	0.011	**Stderr**	**0.02**	**Mean**	**2.3**			08, 05.5	0.078
08, 03	0.017			**No.**	**24**			09, 05.5	0.16
Median	**0.01**			**Stdev**	**2.4**			09.5, 05.5	0.0
Mean	**0.86**			**Stderr**	**0.5**			10, 05.5	0.32
No.	**27**							**Median**	**0.49**
Stdev	**3.7**							**Mean**	**1.5**
Stderr	**0.7**							**No.**	**29**
								Stdev	**2.3**
								Stderr	**0.4**

USEPA and UES screening levels for Be in soil: 160 mg kg^{-1}

Red = mean of 1 to 6 replicates

Table 3. Micrograms U per gram berm soil

Location	U, $\mu g\ g^{-1}$
B 0	2.4
B 45	1.4
B 90	2.1
B 90	2.2
B 135	2.1
B 180	1.6
B 225	2.1
B 270	2.1
B 315	1.7
B 315	1.7
Mean	**1.9**
No.	**10**
Stdev	**0.30**
Stderror	**0.17**

For more data on the concentration of U in coral soils see: Robison et al., 2001

Be in the berm soil samples were all $< 0.0027, \mu g\ g^{-1}$

Table 4. Sixteen soil samples between the helipad and the ocean

	Uranium $\mu g\ g^{-1}$ **soil**	**Be** $\mu g\ g^{-1}$ **soil**
1	27.8	4.4
2	19.6	6.7
3	22.2	5.9
4	25.5	6.0
5	22.7	2.3
6	19.8	0.94
7	9.2	2.2
8	8.7	1.1
9	10.8	0.46
10	5.1	0.35
11	4.4	0.24
12	4.4	0.22
13	3.3	0.07
14	149.7	0.25
15	11.2	1.4
16	6.1	0.97
Mean	**22**	**2.1**
Stdev	**35**	**2.3**
Stderr	**8.8**	**0.58**

Figure 4. The location of the Hi-volume air samplers (red triangles) after the AHW test and the location of the 14 random sampling sites around the helipad.

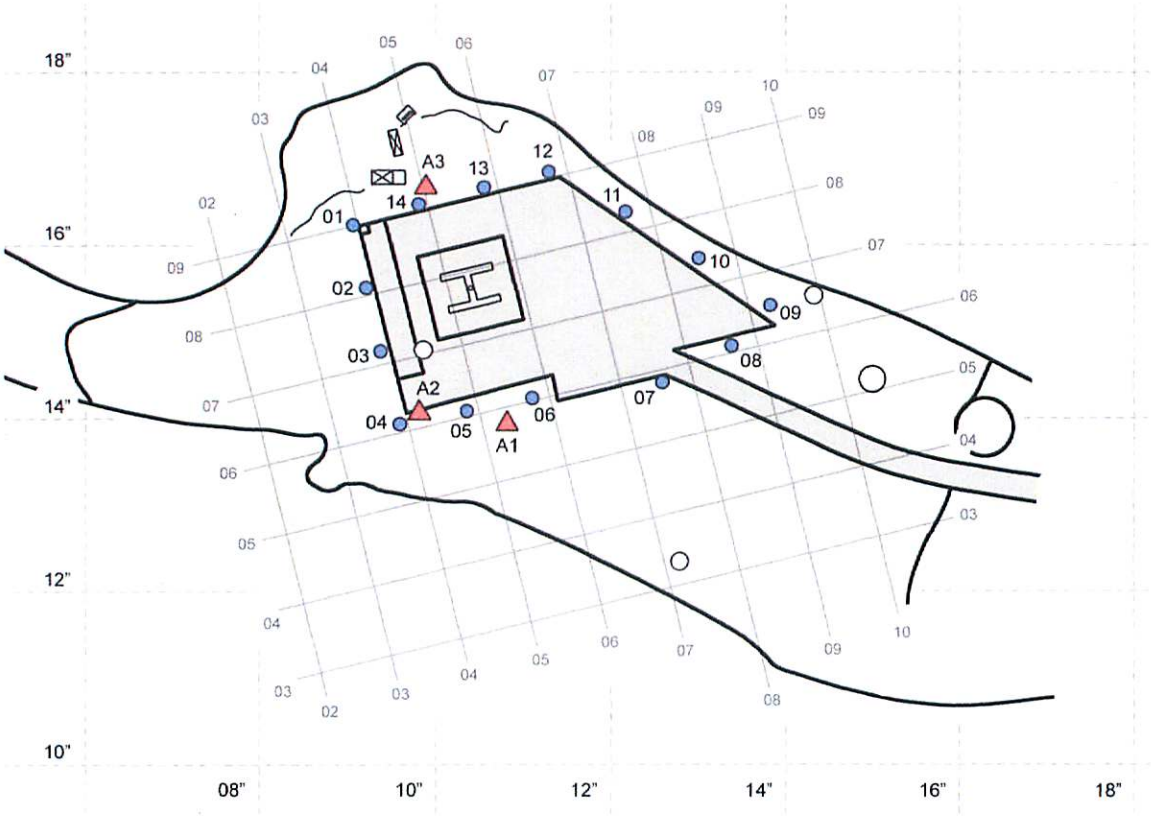

Figure 5. The concentration of U and Be in air on Illeginni Island since 1992. BG represents the background concentration of U and Be in air that was measured on Gagan and Gellinam Islands on the east side of Kwajalein Atoll.