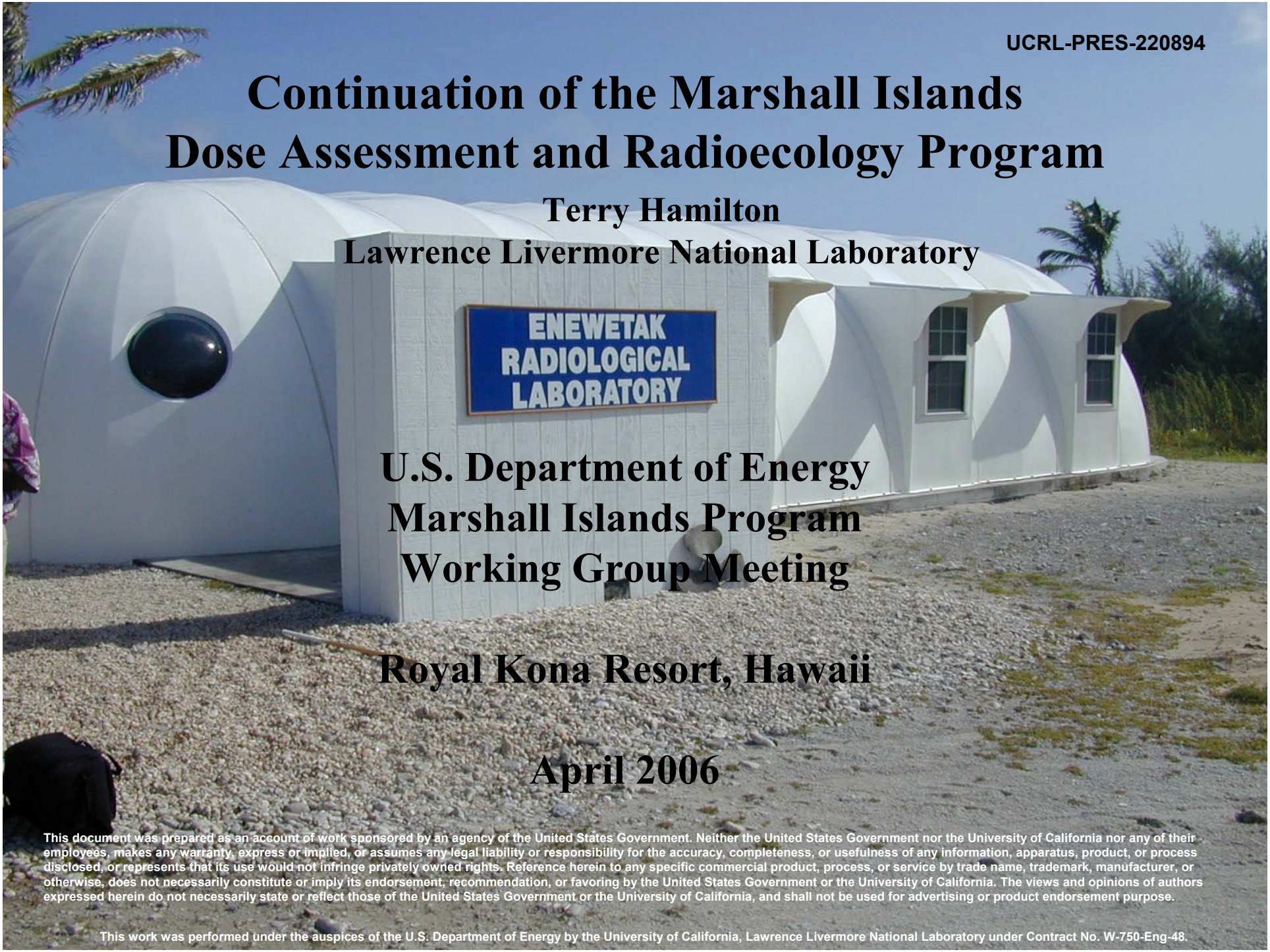
UCRL-PRES-220894

Continuation of the Marshall Islands Dose Assessment and Radioecology Program

Terry Hamilton
Lawrence Livermore National Laboratory



U.S. Department of Energy Marshall Islands Program Working Group Meeting

Royal Kona Resort, Hawaii

April 2006

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Outline of Presentation

- Provide an overview of new features developed for the LLNL Marshall Islands website

  Title: Marshall Islands Dose Assessment & Radioecology Program

  Address: http://eed.llnl.gov/mi/

- Report on the activities and findings of our field program including recent missions to Enewetak, Bikini and Rongelap Atolls
- Provide an update of our resettlement support activities on Rongelap Atoll

Background

Radiation dose is a generic term used to describe the amount of radiation a person receives (*dose to directly proportional to risk*)

[the conventional unit for dose is the millirem (mrem)]

How do we measure dose?

In the Marshall Islands there are two main components that we need to be concerned about;

(1) the external radiation environment, and

(2) internally deposited radionuclides (food, water, air)

DOSE	=	EXTERNAL	+	INTERNAL
		(environ. monitoring)		(whole body counting & plutonium bioassay)

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Bikini Atoll

People & Events | Environmental Characterization | Remediation Options | Prospects for Resettlement | Bikini Fact Sheet (PDF)

http://eed.llnl.gov/mi/photos.php?id=24 Internet

Marshall Islands: Utrōk Atoll - Microsoft Internet Explorer

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Address http://eed.llnl.gov/mi/utrok.php

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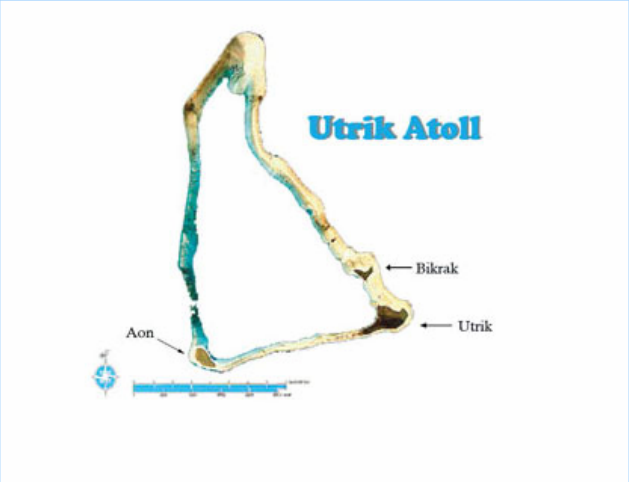
Utrōk Atoll

People & Events | Historical Data



People and Events on Utrōk Atoll

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Marshall Islands: Measurement Data from the Individual Radiological Surveillance Program - Microsoft Internet Explo...

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Measurement Data from the Individual Radiological Surveillance Program

Introduction | Individual Measurement Database

Please refer to the following menu to access individual (de-identified) measurements data:

Rongelap Measurement Data
(Includes Resettlement Workers)
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

Enewetak Measurement Data
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

Utrōk Measurement Data
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

Other Atoll Measurement Data
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

Introduction

Whole-body counting provides a direct measure of the total amount of cesium-137 present in the human body at the time of measurement. The amount of cesium-137 detected is usually reported in activity units of kilo-Becequerel (kBq), where 1 kBq equals 1000 Bq and 1 Bq = 1 nuclear transformation per second (t s^{-1}). The detection of plutonium-239 (^{239}Pu) and

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Select Personal ID Submit

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NAL ID:
Select Personal ID Submit

Utrōk Measurement Data
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Select Personal ID Submit

Other Atoll Measurement Data
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

Select Personal ID
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EN00003
EN00004
EN00005
EN00006
EN00007
EN00008
EN00009
EN00010
EN00011
EN00012
EN00013
EN00014
EN00015
EN00016
EN00017
EN00018
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EN00030

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Enewetak Measurement Data
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Utrōk Measurement Data
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Whole-body counting provides a direct measure of the total amount of cesium-137 present in the human body at the time of measurement. The amount of cesium-137 detected is usually reported in activity units of kilo-Becequerel (kBq), where 1 kBq equals 1000 Bq and 1 Bq = 1 nuclear transformation per second (t s^{-1}). The detection of plutonium-239 (^{239}Pu) and

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Address http://eed.llnl.gov/mi/resultsAll.php?id=EN00797&island=Enewetak

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Individual Measurement Data

Enewetak Atoll

Personal ID	Age Type	Gender	Collection Date	RadioNuclide	Activity	Error	MDA	Method
EN00797	Adult	Male	10/20/05	Cesium-137	0.00 kBq	± 0.00	0.06	NaI_WBC

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Individual Measurement Data

Enewetak Atoll

Personal ID	Age Type	Gender	Collection Date	RadioNuclide	Activity	Error	MDA	Method
EN00034	Adult	Male	05/23/01	Cesium-137	0.20 kBq	± 0.01	0.09	NaI_WBC
EN00034	Adult	Male	09/06/01	Cesium-137	0.22 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	10/05/01	Cesium-137	0.24 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	11/07/01	Cesium-137	0.20 kBq	± 0.02	0.09	NaI_WBC
EN00034	Adult	Male	12/06/01	Cesium-137	0.17 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	02/11/02	Cesium-137	0.23 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	03/18/02	Cesium-137	0.18 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	05/27/02	Cesium-137	0.35 kBq	± 0.02	0.10	NaI_WBC

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					kBq	0.02		
EN00034	Adult	Male	06/26/02	Cesium-137	0.37 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	01/08/03	Cesium-137	0.22 kBq	± 0.02	0.10	NaI_WBC
EN00034	Adult	Male	12/01/03	Cesium-137	0.15 kBq	± 0.02	0.16	NaI_WBC
EN00034	Adult	Male	01/14/04	Cesium-137	0.16 kBq	± 0.02	0.17	NaI_WBC
EN00034	Adult	Male	02/10/04	Cesium-137	0.19 kBq	± 0.02	0.17	NaI_WBC
EN00034	Adult	Male	06/24/04	Cesium-137	0.28 kBq	± 0.04	0.17	NaI_WBC
EN00034	Adult	Male	07/22/04	Cesium-137	0.34 kBq	± 0.03	0.15	NaI_WBC
EN00034	Adult	Male	09/30/04	Cesium-137	0.17 kBq	± 0.03	0.15	NaI_WBC
EN00034	Adult	Male	01/27/05	Cesium-137	0.19 kBq	± 0.03	0.15	NaI_WBC
EN00034	Adult	Male	04/11/05	Cesium-137	0.48 kBq	± 0.04	0.17	NaI_WBC
EN00034	Adult	Male	08/29/05	Cesium-137	0.53 kBq	± 0.04	0.16	NaI_WBC
EN00034	Adult	Male	11/08/05	Cesium-137	0.34 kBq	± 0.03	0.15	NaI_WBC
EN00034	Adult	Male	08/02/01	Plutonium-239	0.26 uBq/24 h void	± 0.53	1.50	CAMS/LLNL
EN00034	Adult	Male	08/02/01	Plutonium-240	-0.03 uBq/24 h void	± 0.57	4.30	CAMS/LLNL

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Dosimetric Data and Methodology

Introduction | Dose Methodology

Introduction

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Enewetak Individual Dose Reports
SELECT YOUR PERSONAL ID:
EN00034 Submit

Utrōk Individual Dose Reports
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

Other Atoll Individual Dose Reports
SELECT YOUR PERSONAL ID:
Select Personal ID Submit

In general, nuclear transformations emit energy and/or particles in the form of gamma rays, beta particles and alpha particles. Tissues in the human body may adsorb these emissions with the potential for any deposited energy to cause damage and disrupt biological function of cells. The general term used to quantify the extent of any health risk from radiation exposure is referred to as the dose. The equivalent dose is defined by the average absorbed dose in an organ or tissue weighed by the average quality factor for the type and energy of the radiation causing the dose. The effective dose equivalent (as applied to the whole body) is the sum of the average dose equivalent for each tissue weighted by tissue weighing factors. The SI unit of

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Address http://eed.llnl.gov/mi/resultsRecent.php?id=EN00034&island=Enewetak

Program volunteers also receive hard copy dose reports in a format similar to that shown below

Melele ko ilo Pepa in – Renej am wot im jab bar an J

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Lawrence Livermore National Laboratory
Marshall Islands Individual Radiological Surveillance Program

Drettan Dose ilo Enbwin loe ilo Juon Iio (Annual Radiation Dose Report for Calendar Year) **2005**

ID Nomba (Identification Number) **EN00034**

Monitoring Program	Type of Dose	Dose Equivalent mrem (mSv)
Whole Body Counting	CEDE	**1.99 (0.0199)**
Plutonium Bioassay (if available)	CEDE	**N/A (N/A)**

Drettan Dose ilo Juon Iio (Total Calendar Year Dose) = 1.99 (0.0199) mrem

Notes:

1. Bwe en emman ad melele, drettan dose eo ilo juōn iiō non jukjuk im bed ko einwōt an walok tok jen agency ko ibelaak in lal-in, ej 100 mrem. Emōj an Republic eo an Marshall Islands kille juōn wawein eo ebinlok ikijjien jerbal in kareo non jikin ko turōk-turear in ailiñkein im raar jermatmat jen radiation kin jonane 15 mrem juōn iiō. Jekjek in ear kōmman ekkar non melele ko raar itok jen United States Environmental Protection Agency (EPA) eo iumwin Comprehensive Environmental Response Compensation im Liability Act (CERCLA) eo.
2. Jouj im kebaak takneijen ro an whole body count elañe enej wor am kajitok ikijjien report in nanñinmej eo am.

Notes:

1. For perspective, the annual dose limit for the public as recommended by international agencies is 100 mrem per year. The Republic of the Marshall Islands has adopted a more restrictive standard for cleanup of radioactively contaminated sites in the northern Marshall Islands of 15 mrem per year, as recommended by the United States Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
2. Please contact your local whole body counting technician(s) if you have any que

You can also view and track doses delivered to program volunteers (de-identified) for previous year

The most recent year for which there is data is 2005. Please get counted

For previous years, click here.

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Marshall Islands: Committed Effective Dose Equivalent: Enewetak - Microsoft Internet Explorer

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Committed Effective Dose Equivalent: Enewetak

Based on Whole Body Counting & Plutonium Urinalysis

Personal ID	Gender	Year	CEDE Cs-137	CEDE Pu	Combined	Units
EN00034	Male	2001	0.96	0.11	1.07	mrem
EN00034	Male	2002	1.62	N/A	1.62	mrem
EN00034	Male	2003	0.86	N/A	0.86	mrem
EN00034	Male	2004	1.02	N/A	1.02	mrem
EN00034	Male	2005	1.99	N/A	1.99	mrem

Where CEDE is the Committed Effective Dose Equivalent for the given element and Combined is the Total Calender Year Dose due to both measurements. For further information see Daniels, *et al.* (2005).

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Livermore, CA 94551

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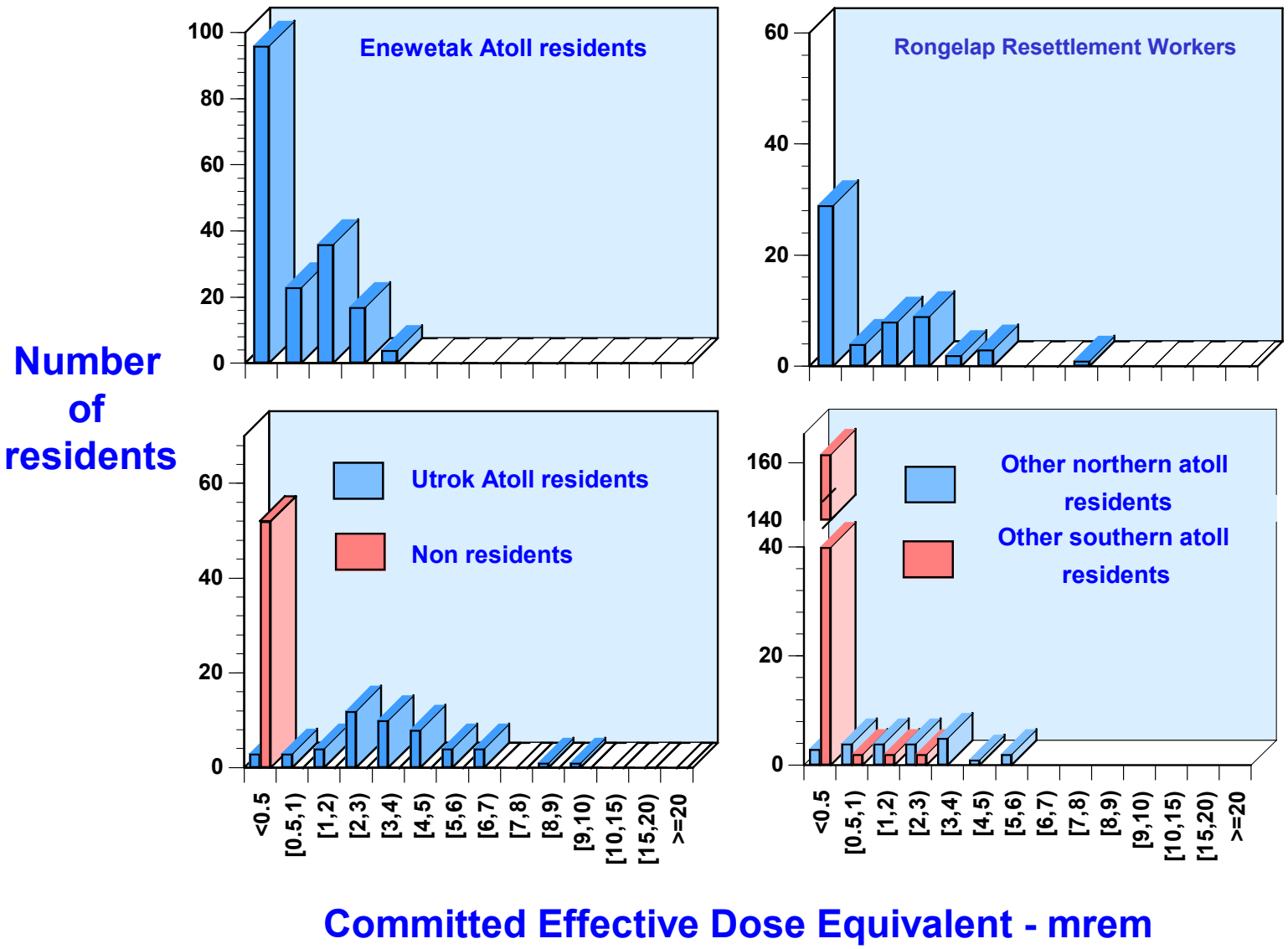
Summary Dosimetric Data for Calendar Year 2005 Based on Whole Body Counting

	Enewetak Population Group	Rongelap Atoll (Resettlement Workers + others)	Utrōk Population Group [Utrik Is. Residents]	Other Marshall Islanders [northern atoll residents]	Grand Total
WBC OPERATIONAL SUMMARY					
Number of Personnel Counts	256	138	110 [52]	193 [25]	**697**
Measurable ^{137}Cs	71%	75%	51% [92%]	14% [80%]	_
Number of Volunteers	208	57	103	192	**560**
DOSE (MREM PER YEAR)					
Average	0.8	1.2	1.7 [3.5]	<0.5 [2.3]	_
Range	0 - 3.5	0 -7.5	0 - 9.5	0 - 5.4	_

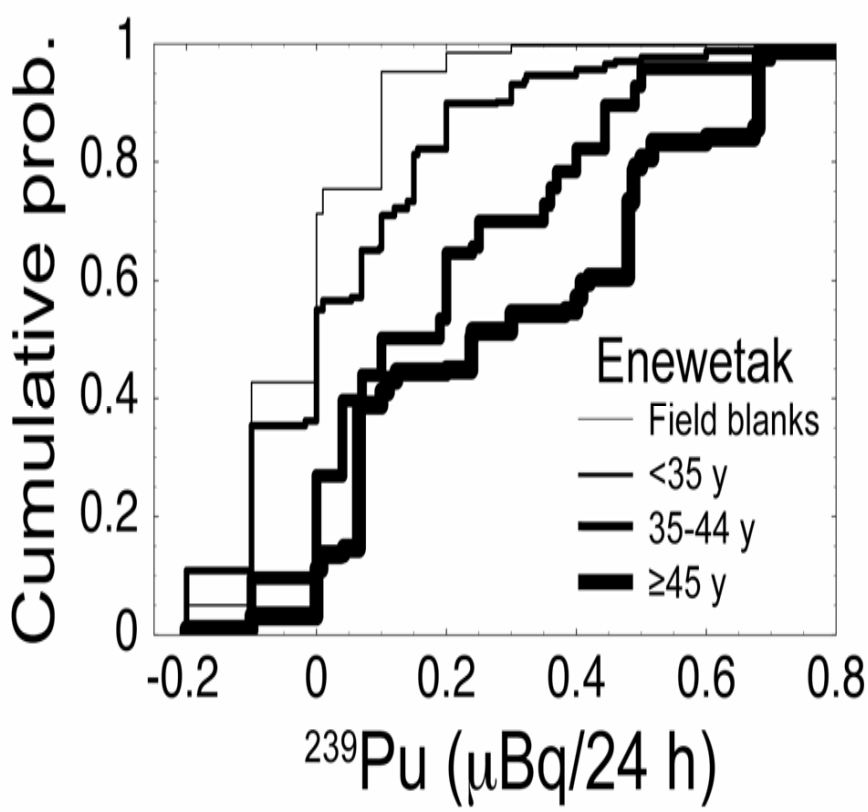
Results of the Whole Body Counting Program - 2005

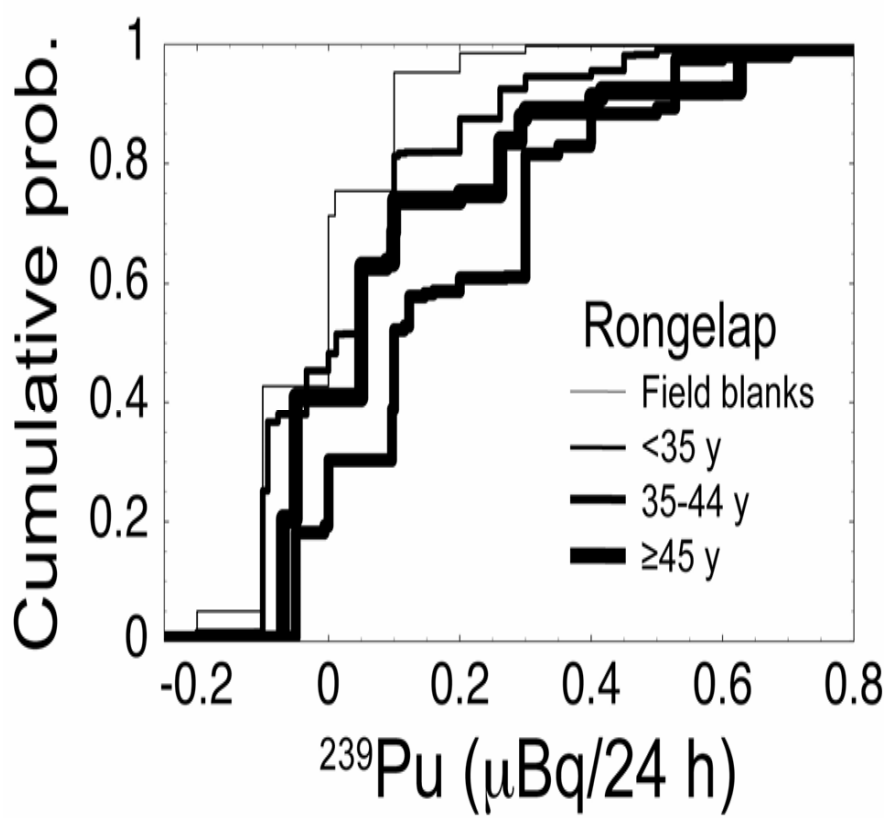


Update on Special Request from the UALG

- During March 2006, the DOE/BN arranged for 7 volunteers to come in from Utrōk Atoll and receive a whole body count and plutonium urinalysis test
- The whole body counts were all within the range that we see for other Utrōk Atoll resident volunteers
- The bioassay samples are presently being shipped to Livermore
- Results of the bioassay tests will become available in the summer ‘06

Results of the Plutonium Bioassay Programs on Enewetak and Rongelap (2001-2005)





Bioassay Monitoring, cont'd

Plans for the future;

1. **Collect and analyze *baseline* bioassay samples from the resettled population on Rongelap (initially looking for up to 50 volunteers). Resample in later years.**
2. **Collect and analyze bioassay samples from the resident population on Utrōk Atoll (initially looking for up to 50 volunteers).**

Selection criteria :

Largely being left up to the local atoll leaders based on the following recommendations;

For the Rongelap cohort, it makes sense to collect people as they resettle Rongelap (special requirements for children!).

With respect to Utrōk, we would like to collect males and females who are either in their late teens/early 20's OR are 45 years of age or older and have previously participated in the Brookhaven program.

Part 2. Update on our Field Sampling Program on Bikini Atoll

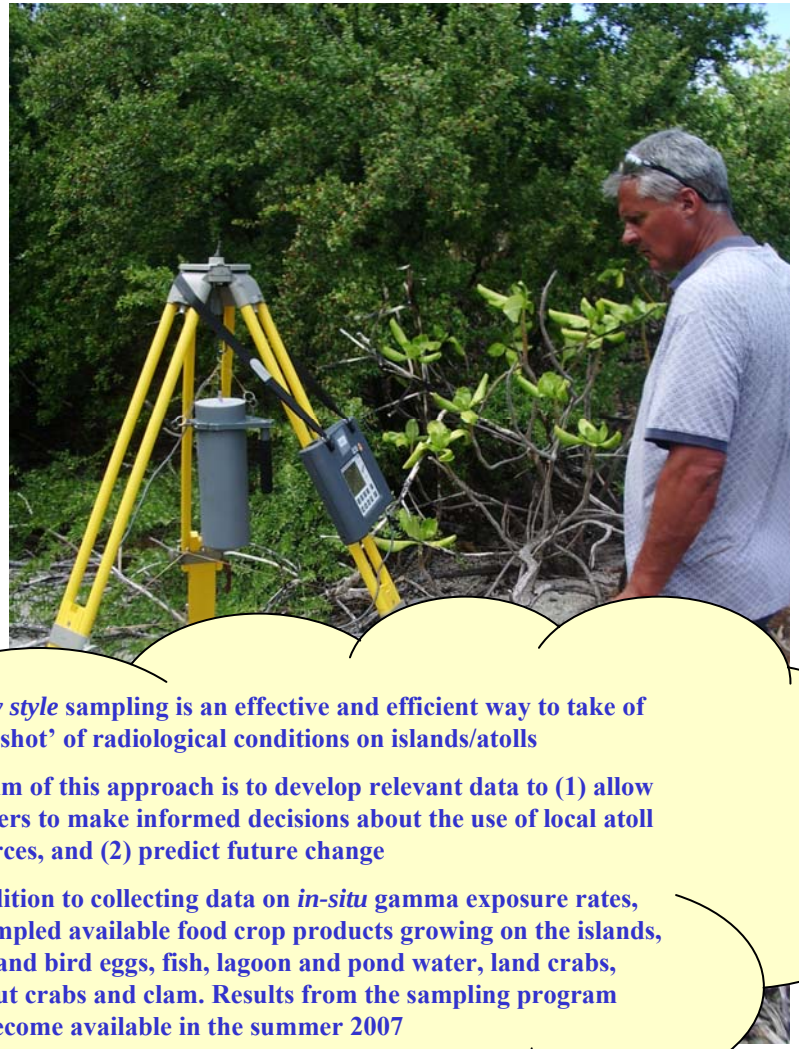
The Livermore/BN program team recently returned from a sampling mission to Bikini Atoll (March 2006).

Using an Army LCU we gained access to 10 small outer atoll islands [zone 1, 2, 3, 5 and 6] and collected water samples across the entire lagoon.

Even today, these islands are sometimes used by the community for food gathering.

Tentative plans are being made to complete the sampling program on zone 3 and 4 islands during the summer of 2006.

Pantry Style Sampling on Bikini Atoll, cont'd



Pantry style **sampling is an effective and efficient way to take of 'snap-shot' of radiological conditions on islands/atolls**

The aim of this approach is to develop relevant data to (1) allow islanders to make informed decisions about the use of local atoll resources, and (2) predict future change

In addition to collecting data on *in-situ* gamma exposure rates, we sampled available food crop products growing on the islands, birds and bird eggs, fish, lagoon and pond water, land crabs, coconut crabs and clam. Results from the sampling program will become available in the summer 2007

Preliminary Results of the *In-situ* Gamma Measurements to Assess External Gamma Exposure Rates on Bikini Outer Islands

Location	N	Cesium-137 External Gamma Dose Rate (mrem per year)	
		range	average
Nam (B1)	8	28 – 228	108
Lomilik (B-4)[#]	10	1.0 – 18	6.4
Aomen (B-5)	2	0.6 – 1.5	1.1
Enidrik (B-17)	6	<0.5 – 8.0	3.8
Lukoj (B-18)	5	11 – 345	198
Jelete (B-19)	7	<0.5 – 490	134
Adrikan (B-20)	5	24 – 30	26
Oroken (B-21)	5	9.8 – 27	16
Bokaetoktok (B-22)	4	0.7 – 9.9	4.2
Borkdrlul (B-23)	3	16 – 26	22
Beaches	9	>0.5 – 1.4	0.6

[#]excludes one point (188 mrem per year)

Part 3. Resettlement Support on Rongelap Island

In support of resettlement, RALGOV and the U.S. Department of Energy adopted a number of shared provisions in support of resettlement and environmental cleanup

1) **Shared vision to monitor the resettlement workers and ultimately the resettled population**

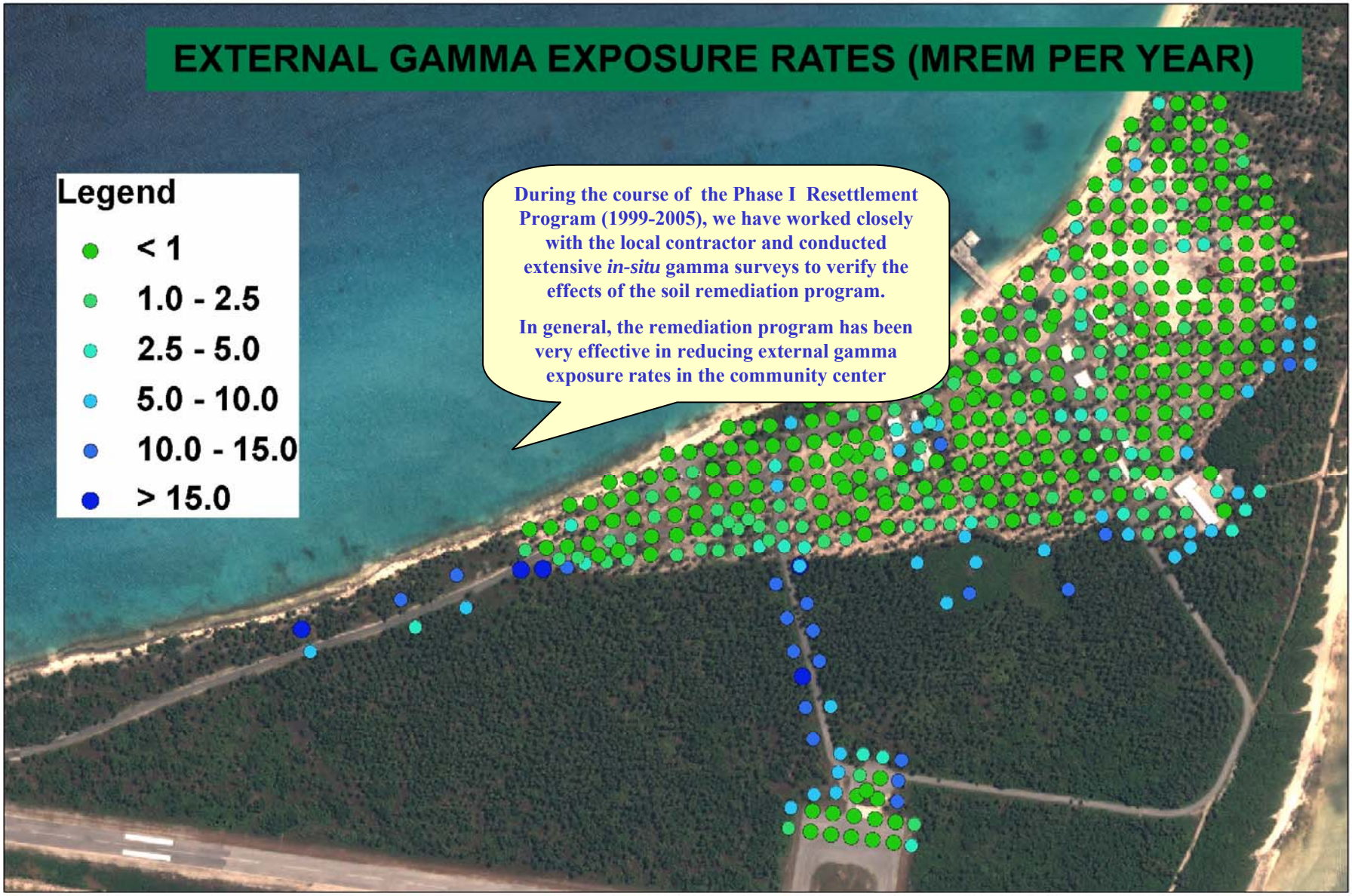
2) **Implemented the '*combined option*' as a cleanup technique developed by Livermore scientists to reduce exposure to residual fallout contamination in the environment**

"The combined option involves soil remediation in the housing and community areas, and the addition of potassium fertilizer to agricultural areas (largely coconut groves)"

Verification Monitoring of Cleanup of Rongelap Island

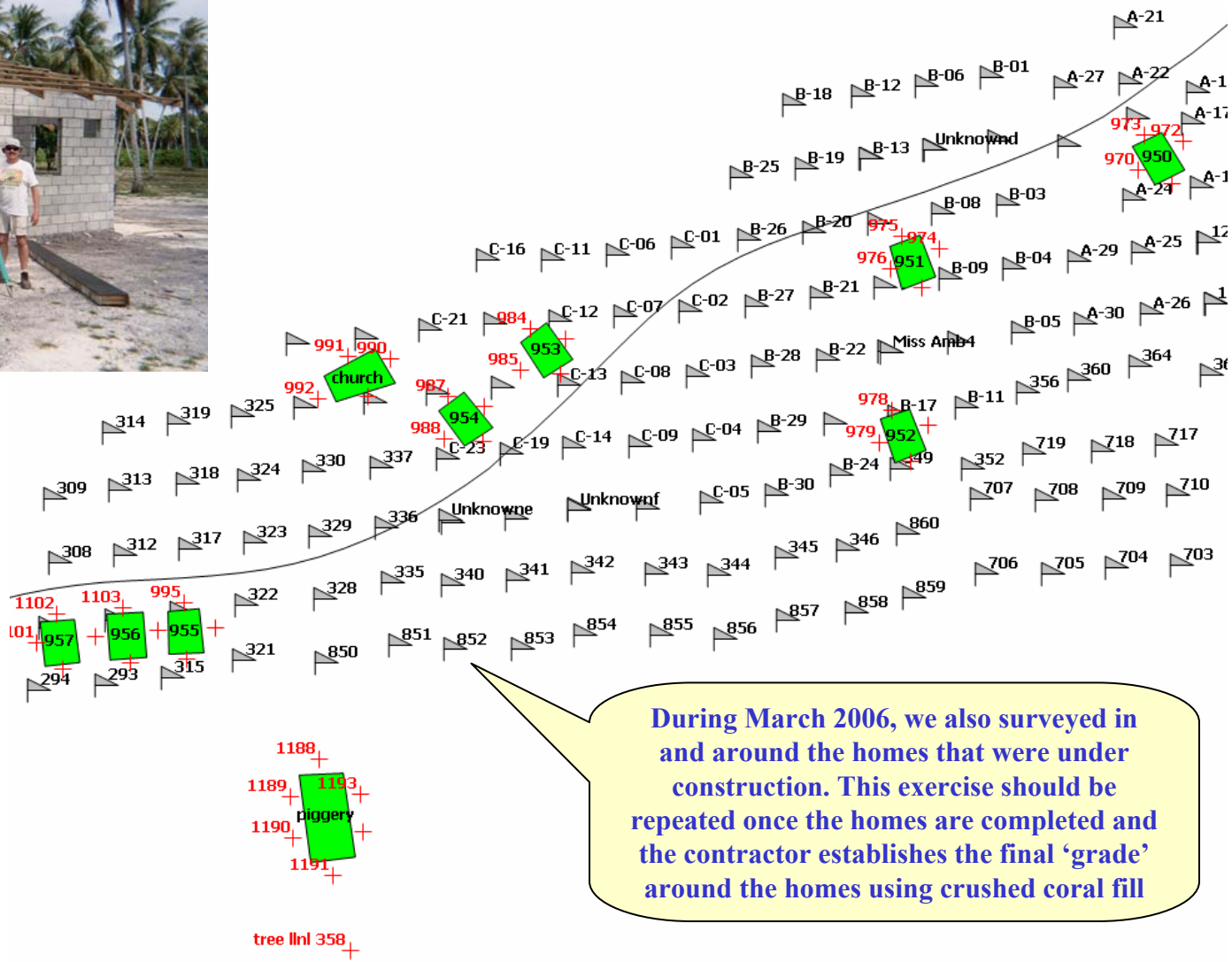
Lawrence Livermore National Laboratory

Projection: Geographic WGS84; Satellite Imagery was collected by Digital Globe May 28, 2003



The Initial sampling period occurred during 1999. The 'Post' sampling occurred during 2000, after soil removal. The 'Final' sampling occurred during 2001, 2003 and 2005. The 2001 and 2003 values have been adjusted for decay.

Rongelap External Dose Rate Measurements - 2006



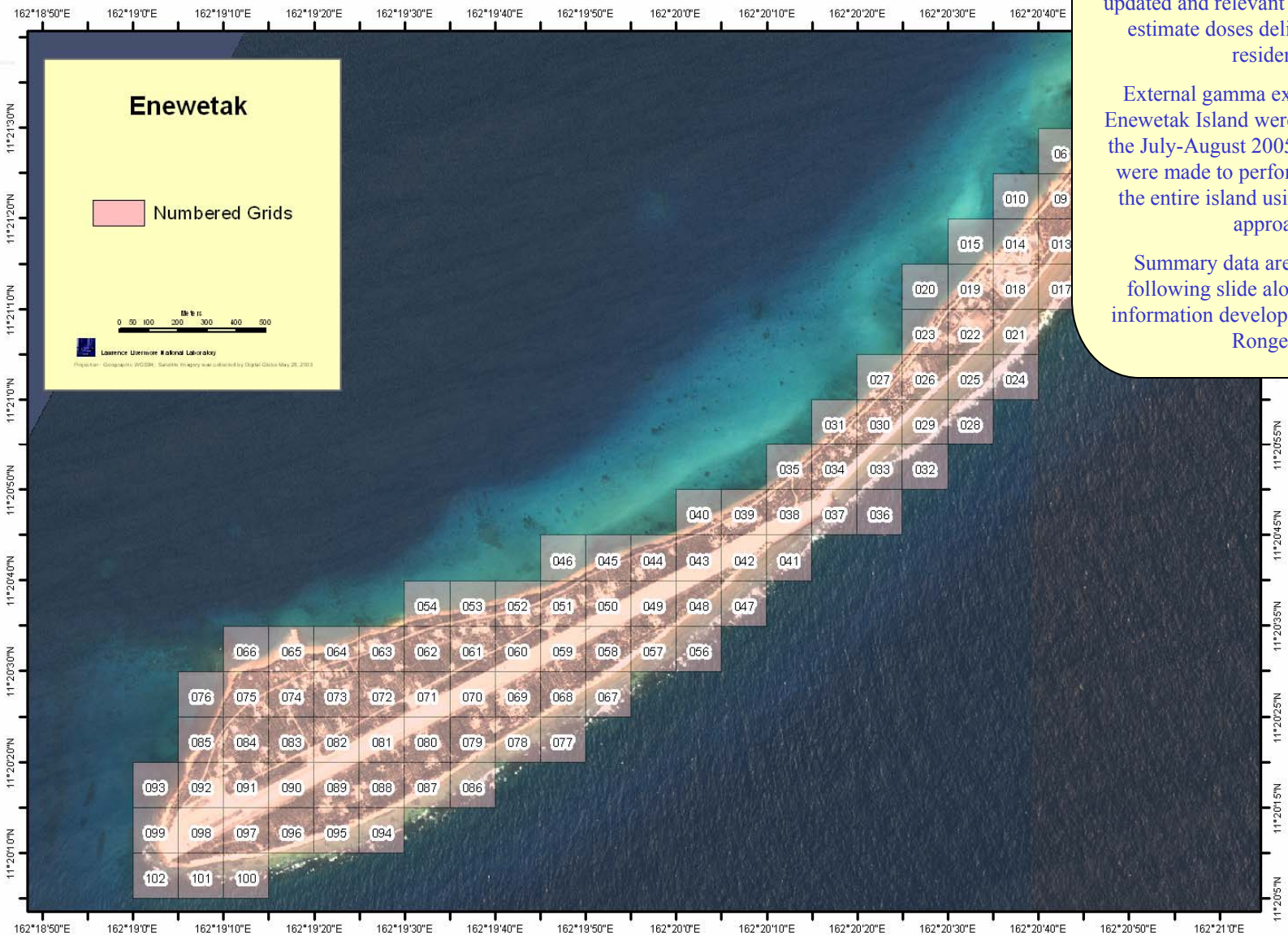
During March 2006, we also surveyed in and around the homes that were under construction. This exercise should be repeated once the homes are completed and the contractor establishes the final 'grade' around the homes using crushed coral fill

External Gamma Dose Rates on Rongelap Island

Location	N	Cesium-137 External Gamma Dose Rate (mrem per year)	
		range	average
Inside Houses	17	<0.5 – 1.1	0.7
Around Houses	81	<0.5 – 3.3	1.1
Lagoon[#]	63	<0.5 – 28	8.5

[#]excludes one point (53 mrem per year)

Livermore researchers were recently invited by the Rongelap Atoll Local Government to participate in a series of community meetings to explain the current radiological situation on Rongelap Island
With implementation of proposed cleanup measures, Livermore and RMI consulting scientists were agreed that Rongelap Island was safe to resettle



We are using a common strategy across each of the atolls to develop updated and relevant data to accurately estimate doses delivered to island residents.

External gamma exposure rates on Enewetak Island were surveyed during the July-August 2005 mission. Efforts were made to perform counts across the entire island using a grid survey approach

Summary data are shown on the following slide along with similar information developed for Bikini and Rongelap

Preliminary External Gamma Exposure Rate Estimates for Islands/Atolls

Location	N	Cesium-137 External Gamma Dose	
		range	average
BIKINI ATOLL			
Bikini Island	(External Dose Rate = 53 mrem per year)		
Grove	20	92 - 260	160
Central village area	35	<0.5 – 35	10
Beaches	3	>0.5 – 1.5	1
Eneu Island	(External Dose Rate = 2.4 mrem per year)		
Grove	7	<0.5 - 8.4	4.7
Airport Terminal/Dock	16	<0.5 - 7.9	1.6
Beaches	1	<0.5	<0.5
RONGELAP ATOLL			
Rongelap Island	(External Dose Rate = 4.2 mrem rem per year)		
Grove	198	>0.5 – 53	9.5
Central village and other easily assessible areas including roads and the airport terminal	391	<0.5 – 44	2.1
ENEWETAK ATOLL			
Enewetak Island	(External Dose Rate = <0.5 mrem per year)		
Village & Grove	93	<0.5 – 0.9	<0.5

Hypothetical external gamma dose rates based on preliminary results from our in-situ gamma surveys (2005-06)

"Based on a worse case example for a resident field worker who spends 7 hours per day working in the field (interior of the island)

Conclusions

"I am going to end where I started by asking the question …,"

How do we measure dose? and protect human health now and into the future?

DOSE = EXTERNAL + INTERNAL

(environ. monitoring) **(whole body counting & plutonium bioassay)**

measurements

Committed Effective Dose Equivalent (CEDE)

Predictive dose assessments

On-going environmental characterization and monitoring studies

However, our continuing environmental characterization program is still considered critically important in providing data on all potential exposure pathways, especially in relation to:

- **Establishing the need for and verifying the effects of cleanup;**
- **Being able to predict future change in radiological conditions (and any potential long-term impacts on human health)**
- **Developing predicting scenarios on the future use of food gathering islands or atolls**

Our whole body counting program and high-quality urinalysis tests are providing a unprecedented level of radiation protection monitoring for resettled and resettling populations in the Marshall Islands

"Whole body counting provides a more direct measure of the doses delivered by internally deposited radionuclides such as cesium-137 rather than relying on model dietary assumptions used in predictive dose assessments"

End