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Loss-of-Use Damages From U.S. Nuclear Testing in the Marshall Islands: Technical Analysis of the Nuclear Claims Tribunal's Methodology and Alternative Estimates

August 12, 2005

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Loss-of-Use Damages from U.S. Nuclear Testing in the Marshall Islands: Analysis of the Nuclear Claims Tribunal's Methodology and Alternative Estimates

Summary

Key oversight committees in the 109th Congress have held joint hearings on the Republic of the Marshall Islands (RMI) *Changed Circumstances Petition*, which requests \$522 million in additional compensation for loss-of-use of Enewetak and Bikini atolls due to U.S. nuclear testing. The \$522 million appears to be significantly overstated because the methodology — sample rent data, assumptions, and statistical procedures (i.e., the sampling technique and the use of the exponential regression model) — overestimates the per-acre rental rate for land on Enewetak and Bikini, the key variable in the loss-of-use calculation.

Rents on Enewetak and Bikini are overestimated because an exponential regression model was applied to rents established not in a competitive, free market for agricultural land on Enewetak and Bikini, but rather to government-established, and predominantly commercial, rents on the more urbanized and densely populated, Majuro and Kwajalein atolls. Most land in the RMI is leased at “the official government rate” established by the RMI cabinet. This rate, which was set by the RMI at \$2,500/acre on January 1, 1979 and increased to \$3,000/acre on October 1, 1989, serves as the benchmark for all lease transactions. The RMI government is not only the tenant in over 40% of the leases — a major source of the demand for RMI land — but RMI government officials were also effectively the landlords during the estimation period when rents were government-controlled. Applying this methodology to unrepresentative sample rent data leads to projected rent/acre of \$112,995/acre for the year 2027, which is equivalent to land asset value of nearly \$1,774,024/acre. The Nuclear Claims Tribunal's (NCT) methodology also assumes that vaporized islands were not vaporized, undervalues the rentals on alternative atoll habitation, and assumes that 100% of the rental proceeds would have been saved.

The NCT's estimated average rent/acre — e.g., \$4,105/acre in 1996 — also appears overstated when compared to average agricultural rents in the United States for similar periods: \$17.50/acre in Montana, \$115/acre in Oregon, \$210/acre in California, \$88/acre in New Mexico (1995 figures), and \$66.50/acre for the United States generally (1998 figures). Using an alternative economic methodology, and applying it to RMI's national income and product accounts data, the Congressional Research Service (CRS) has developed alternative estimates of agricultural land rents for Enewetak and Bikini for the period 1982-1990, which are more consistent with the underlying real rental value of the two atolls (and the RMI economy), as well as with agricultural rents observed in the United States and in regions in the Pacific. CRS estimated rent/acre at \$115/acre for the year 1982 rising to \$258/acre for 1990, as compared with the NCT's estimates of \$1,902 for 1982 rising to \$2,939 for 1990. Based on these rental rates, CRS estimates *gross* loss-of-use rentals for 1982-1990 (before adjustments and interest) of \$6.4 million, about 10% of the \$64 million estimated by the NCT. According to the NCT, the amount of loss-of-use compensation already paid by the United States over this period is \$36 million. This report will not be updated.

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Loss-of-Use Damages from U.S. Nuclear Testing in the Marshall Islands : Analysis of the Nuclear Claims Tribunal's Methodology and Alternative Estimates

Introduction and Background

The Republic of the Marshall Islands (RMI) is an archipelago of approximately 1,200 islets in 28 atolls and 5 separate islands (all coral) located in the Southwestern Pacific about 2,100 miles southwest of Hawaii and 1,700 miles Northeast of New Guinea (between 160° - 175°E longitude and 4°-12°N latitude). After evacuating the inhabitants, between June 30, 1946 and August 18, 1958 (i.e., over a period consisting of 4,432 days), the U.S. Government conducted an intensive program of nuclear testing on Bikini and Enewetak, two remote Northwesterly atolls in the RMI. Sixty-six underwater, surface, and atmospheric nuclear tests (atomic and thermonuclear) were conducted on these two atolls, which were considered to be “ideal” locations for such testing. The total yield of these weapons was 108,000 kilotons, the equivalent of more than 7,200 Hiroshima bombs — an average of over 1.6 Hiroshima-equivalent bombs daily during the testing period.

Damage from U.S. Nuclear Testing

U.S. nuclear testing on the Marshall Islands inflicted significant damage to property — lands, vegetation, lagoons, and surrounding ecosystems — as well as to people's health. Twenty-three nuclear devices were detonated on Bikini atoll.¹ The hydrogen bomb dropped on February 28, 1954 as part of the “Bravo Test,” which had the explosive power of 15,000 kilotons — the force equivalent of 1,000 Hiroshima-type bombs — was the most powerful nuclear weapon ever tested by the United States.² It completely vaporized five of the atoll's northern islands (a total of about 68 acres of land, or 4% of the pre-test lands). The underwater “Baker Test” of July 24, 1946, left 500,000 tons of radioactive mud in the atoll's lagoon. Bikini's southern islands were mostly covered by concrete and asphalt for the nuclear testing facilities. Bikini atoll was so devastated, nearly all of the atoll's vegetation was destroyed, and the islands sufficiently contaminated as to render them all uninhabitable through at least the year 2027.³

¹ An additional test was conducted (i.e., a bomb was detonated) 70 miles west of Bikini.

² For perspective, one might note that the bomb dropped on Hiroshima killed about 140,000 people; the bomb dropped on Nagasaki killed an additional 70,000.

³ At this writing, 10 people were reported living on Bikini. However, according to the
(continued...)

On the Enewetak atoll, 43 above-ground nuclear devices, ranging in size from 18 kilotons to 10,400 kilotons, were exploded from April 14, 1948, to October 18, 1958. The tests on Enewetak atoll pulverized four islands — about 10% of the land (nearly 200 acres) — and rendered about 60% of the remainder (about 1,120 acres) uninhabitable at least through the year 2026. The “Mike Test” of 1952 vaporized the islet of Elugelap, and left a crater in the atoll’s reef 200 feet deep and 1 mile in diameter. The northern half of the Enewetak atoll remains seriously contaminated by plutonium radiation, limiting habitation to the southern half of the atoll. The island of Runit contains 110,000 cubic yards of radioactive contaminants (e.g., plutonium 239) and remains a radioactive waste site. The atoll’s southern islands were mostly covered by concrete to support the weapons infrastructure so that nearly all of the vegetation there was destroyed also.⁴

In addition to rendering all of Bikini and most of Enewetak atolls dangerously irradiated and uninhabitable, radioactive fallout from nuclear testing on Bikini and Enewetak accidentally spread to other populated areas of the RMI. Fallout from the 1954 “Bravo Test” on Bikini, for example, unexpectedly fell on a total of 253 residents of the Rongelap (86 people) and Utrik atolls (167 people), 95 miles and 255 miles east of Bikini, respectively.⁵ Some experts argue that the nuclear tests on Bikini and Enewetak caused high incidences of birth defects, miscarriage, and weakened immune systems, and caused high rates of thyroid, cervical, and breast cancer throughout the Marshall Islands: They contend that more than a dozen Marshall Islands atolls, rather than only four, were seriously affected.⁶ Other analysts counter that the extent of radioactive fallout was limited to the four northern atolls, and that RMI experts overestimate the link between radiogenic illnesses in the Marshall Islands and the nuclear tests.

U.S. Government Compensation

The U.S. government has accepted responsibility for the injuries to the people of Bikini and Enewetak (and to other affected Marshall Island atolls), as well as the damage to their land, lagoons, and surrounding ecosystem. It has provided financial and program assistance, services, access to benefits in the United States, and trade and other economic incentives; and every recent budget has included money for the

³ (...continued)

NCT’s memorandum of decisions and order for Bikini, the date of safe return is estimated to be November 19, 2027.

⁴ Woodard, Colin. “Marshall Islands: Payback Time” *Bulletin of the Atomic Scientists*. March/April 2000. Pp.11-13.

⁵ As with other figures pertaining to RMI nuclear testing, the number of people on Rongelap and Utrik affected by the Bravo Test (the “down winders”) has been variously reported. For example, Weisgall reports that 236 inhabitants were irradiated by the Bravo Test. See Statement of Jonathan M. Weisgall on Behalf of the Peoples of Bikini, Enewetak, Rongelap, and Utrik Before the House Resources Committee. May 25, 2005.

⁶ Gary Lee, “Postwar Pacific Fallout Wider than Thought,” *Washington Post*, February 24, 1994.

RMI as compensation for the harm done by U.S. nuclear testing.⁷ According to the U.S. Department of State, over \$531 million (nearly \$840 million in 2003 dollars) has been spent since 1958 on nuclear-test related health care, medical surveillance, environmental monitoring and soil remediation, loss-of-use and resettlement, and surplus food assistance.⁸ About one-half of this assistance has been provided through congressional *ex-gratia* payments — payments not compelled by legal right or formal agreement. Including humanitarian causes, economic development, and other non-nuclear aid, the United States will spend, according to the U.S. Department of the Interior, nearly \$1 billion over the 15-year-period from 1987-2003.⁹

Class Action Lawsuits and the Nuclear Claims Fund

In the early 1980s, fourteen different groups of litigants representing approximately 5,000 inhabitants of the Marshall Islands (inhabitants of Enewetak, Bikini, Rongelap and Utrik) brought class-action cases in the United States Court of Claims against the United States to recover damages said to result from nuclear weapons testing.¹⁰ These lawsuits were dismissed because in 1986 an agreement, called the Compact of Free Association (the Compact of Free Association Act of 1985, P.L. 99-239), was reached between the Marshall Islands and the United States. This agreement, *inter alia*, provided for an alternative compensation system: a \$150 million Nuclear Claims Fund (NCF) funded by the United States. The agreement also established a Nuclear Claims Tribunal (NCT) to disburse money for nuclear test-related compensation from the fund. The NCF was to be the final and full settlement of all claims, past and future, arising out of the nuclear testing program; the RMI also agreed to espouse and dismiss any and all private damage claims that had been filed against the U.S. government in the Claims Court.¹¹

⁷ For instance, in 1988, P.L. 99-239 and P.L. 100-446 appropriated \$90 million to resettle Bikini claims and supplement the trust fund. In 2005, P.L. 108-188 appropriated \$5.3 million to rehabilitate and resettle Rongelap atoll. The proposed FY2006 budget proposes \$62 million in grants for the RMI. See Executive Office of the President. Office of Management and Budget. *Appendix, Budget Document of the United States, FY 2006*. P.648.

⁸ U. S. Department of State. *Report Evaluating the Request of the Government of the RMI Presented to the Congress of the United States of America*. November 2004.

⁹ U.S. Department of the Interior. Office of Insular Affairs. *The State of the Islands, 1999*. P.82

¹⁰ In 1981 and 1982 several suits were filed against the U.S. government by the residents of Enewetak, Bikini, and other RMI atolls that allegedly suffered damages by the nuclear testing. See *Peter v. United States* 6 Cl.Ct. 768 (1984), *Juda v. United States*, 6 Cl.Ct. 441 (1984), and *Nitol v. United States*, 7 Cl.Ct. 405 (1985).

¹¹ The Compact (99 Stat. 1770 as amended by P.L.108-188) was negotiated and agreed to by the governments of the United States and the Marshall Islands and approved by plebiscite in the Marshall Islands and by the U.S. Congress in 1985. It recognized the RMI as a sovereign nation with economic and security ties to the United States. From 1946-1986, the United States had administrative responsibility (i.e., full powers of administration, legislation, and jurisdiction) over the Marshall Islands in its role as Trustee for the United Nations Trust Territory of the Pacific Islands.

Despite the compensation and financial aid provided by the United States, including funds disbursed under the 1986 Compact agreement, the inhabitants of Enewetak and Bikini filed, in the early 1990s, another class action lawsuit. This suit was filed with the NCT, and claimed \$3,300 million in personal and property damages. The NCT awarded the judgments in 2000 and 2001, but with insufficient funds from which to pay the claim, the RMI filed a *Changed Circumstances Petition* in September 2000 with the U. S. Congress requesting \$3,300 million in additional nuclear testing compensation.¹² The \$3,300 million judgment includes unpaid property damages awards for Enewetak and Bikini totaling \$949 million, of which \$522 million is for the lost use of property (\$278,000,000 for Bikini and \$244,000,000 for Enewetak) from the date of evacuation in the 1940s to the date of return which is projected to be in 2026 (for Enewetak) and 2027 (for Bikini). This is above and beyond amounts already paid for loss-of-use, which, through the year 2000, the NCT has estimated to be about \$129 million. The remaining \$427 million (\$949 million less \$522 million) is for the remaining property damages: hardships, soil remediation, and land restoration.

The methodology used to estimate the \$522 million damages for loss-of-use of property, which is the same for both the Enewetak and Bikini claims, was developed by a consulting firm — a real estate appraisal firm — under contract for the NCT (as well as for counsel for claimants).¹³ No alternative methodologies were explored or used, and the NCT provided many of the estimation parameters and assumptions.¹⁴ The resulting estimates of the dollar value of loss-of-use were adjusted and awarded by the NCT as damages (or reparations) to the Enewetak and Bikini people, who are claimants in a class action suit against the U.S. government.¹⁵ The adjusted estimates are also the amounts requested in the *Changed Circumstances Petition* (CCP) submitted to the U.S. Congress by the government of the Republic of Marshall

¹² Additional claims are pending for Rongelap and Utrik, the other 2 Northwesterly atolls indirectly affected by nuclear testing on Enewetak and Bikini. These damages include personal injury, remediation, and hardship, but not loss-of-use, since the inhabitants of the two atolls were not evacuated except for very brief periods.

¹³ *Appraisal Report of the Loss in Value in Enewetak Atoll, Republic of Marshall Islands for the Nuclear Claims Tribunal*. The Hallstrom Group, Inc., and Raymond A. Leshner & Co., Ltd., May 17, 1996; *Appraisal Report of the Aggregate Loss in Use Value in the Bikini Atoll in the Republic of Marshall Islands*. Report written for Mr. Jonathan Weisgall, Chartered. The Hallstrom Group, Inc. November 19, 1997. Both the Hallstrom Group, Inc. and Raymond Leshner & Co. Ltd. are real estate appraisal firms.

¹⁴ For the Bikini claim, the NCT had access to a second set of independent estimates of loss-of-use from a report written by the New Zealand real estate consulting firm of Darroch Limited for the Defender of the Fund. That report used the same methodology as in the NCT report, but made fewer unrealistic assumptions. The Hallstrom estimates of past lost use are 60% greater than the Darroch report estimates; for future lost use, the Hallstrom report estimates are nearly 200% greater than the Darroch report estimates. Since the NCT did not use these estimates, but used the estimates of the Hallstrom Group to award damages instead, this second report is not discussed.

¹⁵ Nuclear testing occurred on Enewetak and Bikini, but claims are pending in the case of Rongelap, Utrik, Ailuk, and Likiep, which, though not directly bombed, experienced radioactive fallout.

Islands (RMI), which requests further compensation for damages resulting from U.S. nuclear testing on Marshall Islands atolls during the 1940s and 1950s.

Key oversight committees in the 109th Congress are the Senate Energy and Natural Resources Committee, the House Resources Committee, and the House International Relations Committee. On May 25, 2005, the House Committee on Resources and the Subcommittee on Asia and the Pacific of the House Committee on International Relations held a joint hearing on the *Changed Circumstances Petition*. The Senate Committee on Energy and Natural Resources held a hearing on July 19, 2005.

Purpose of the Report

This report examines the NCT loss-of-use methodology. It is a more detailed version of the loss-of-use discussion incorporated into CRS Report RL32811 *Republic of the Marshall Islands Changed Circumstances Petition to Congress*.¹⁶ It supplements that discussion by 1) comparing the NCT estimates of land rents for Enewetak and Bikini, with land rents in selected areas in the United States (e.g., California, Oregon, Montana, and New Mexico) and around the world, and 2) developing an economic model of agricultural land rents, which is then used to generate alternative estimates of land rents, which are also compared with the NCT estimates.

The next section describes the NCT's methodology in detail, including each of the steps that the appraisers took in estimating loss-of-use. The mathematical formulas used in the calculations, which are CRS derivations based on the appraisers' reports, appear in **Technical Appendices A and B**. The third section analyzes the methodology and explains why the NCT's methodology leads to significantly inflated rents, and consequently an overstatement of loss-of-use estimates. The fourth section presents empirical evidence — facts, comparisons, and additional arguments — that support the main conclusion that the NCT's loss-of-use estimates are significantly overstated. The fifth section applies standard neoclassical economic theory to develop a model of agricultural rents, which is applied to available data from RMI's national income and product accounts to generate alternative estimates of average rents/acre for the total loss-of-use rentals for the Enewetak and Bikini atolls.

This report discusses only the methodology as it relates to estimating damages for loss-of-use of property; the methodology applied to estimate land reclamation (or remediation) costs, and hardship costs — the other two components of property damages — or personal injury damages are not addressed here. Finally, the report is not a legal analysis of whether or not the loss-of-use claims are valid.

¹⁶ U.S. Library of Congress. Congressional Research Service. *Republic of the Marshall Islands Changed Circumstances Petition to Congress*. CRS Report RL32811, by David Bearden, Mark Holt, Salvatore Lazzari, Thomas Lum, and Kenneth Thomas. Updated June 24, 2005.

Description of the Methodology Used in the NCT Reports

On April 13, 2000, the NCT awarded the people of Enewetak loss-of-use damages — including past lost use, future lost use, and pre-judgment interest — of \$244,000,000. On March 5, 2001, the NCT awarded the people of Bikini loss-of-use damages — including past lost use, future lost use, and pre-judgment interest — of \$278,000,000. The total awards to both peoples sum to \$522,000,000 as shown in **Table 1**.

Loss-of-use includes not only the period when the United States tested the nuclear bombs (roughly the period from 1946 to 1958), but the period during which the islands have been, and will continue to be, unsafe due to dangerous levels of radiation contamination (roughly the period from 1958 to 2027).¹⁷

More specifically, the estimated loss-of-use is the sum of two components: past or retrospective loss-of-use, which is the present value of rents that should have been paid from the time of evacuation of the 312 residents (145 residents of Enewetak, and 167 residents of Bikini) to the date of the NCT reports' publication; and future or prospective loss-of-use, which is the present value of estimated rents from the reports' publication dates to that estimated date in the future (as described below) when the lands are sufficiently decontaminated and usable as to permit the return of RMI citizens. In addition, as part of the past loss-of-use estimates the NCT also awarded what it called a "pre-judgment interest," which is the interest income earned on the original judgments from the time they were determined to the time they were awarded.

Description of Past Loss-of-Use Methodology. For Enewetak, past loss-of-use consists of the estimated rents on the entire atoll (1,952.6 acres) from the time the entire Enewetak population of 145 people was evacuated (December 21, 1947) to their date of return on October 1, 1980. However, when the Enewetak people were allowed to return on October 1, 1980, they were allowed to safely use only 646.82 acres of the atoll — 1,305.78 acres continued to be off limits due to dangerous levels of radioactive contamination. Thus, past loss-of-use includes the estimated rents on this 1,305.78 acres from October 1, 1980, to May 16, 1996, which is the date of the Hallstrom Group's appraisal report. For Bikini, past loss-of-use is the estimated rental value of all the atoll (1,889.36 acres) from March 7, 1946, which is when the entire Bikinian population of 167 people was evacuated, to November 18, 1997, when the Bikini appraisal report is dated. The methodology assumes that the loss-of-use was continuous and uninterrupted — that the islanders never returned to the atoll.¹⁸

¹⁷ Memoranda of Decisions and Order for Enewetak and Bikini attached to the *Changed Circumstances Petition*.

¹⁸ Some of the Bikinians returned to the atoll in June 1969, but had to be re-evacuated in August 1978 due to continued high and dangerous levels of radioactivity from nuclear contamination. The islands of Enyu and Bikini were returned to, and inhabited by, the
(continued...)

Table 1. The NCT's Estimated Damages for Loss-of-Use, by Component
(\$ thousands)

Type of Loss	Enewetak		Bikini	
	Time Period	Amount (\$ thousands)	Time Period	Amount (\$ thousands)
Past Lost Use	12/21/47 to 5/16/96	\$149,000	3/3/46 to 11/18/97	\$163,731
Future Lost Use	5/17/96 to 5/17/2026	50,154	11/19/97 to 11/18/2027	68,420
Sub-Total		199,155		232,150
Pre-judgment Interest	1/97 to 4/2000	44,845	5/98 to 3/2001	45,849 ^a
Grand Total (rounded)	8/3/2000	\$244,000	3/5/2001	\$278,000

Source: Memoranda of Decisions and Order for Enewetak and Bikini attached to the *Changed Circumstances Petition*; and Bill Graham, Outline of the Prepared Remarks for Congressional Staff Briefing, *Operations of the Marshall Islands Nuclear Claims Tribunal Established Pursuant to U.S. Public Law 99-239*, Apr. 23, 2004.

Notes: a/ Pre-judgment interest on loss-of-use for Bikini is not reported separately, and thus, was estimated by the author based on the other available data. Note that these awards are only for loss-of-use of property; awards for other property damages (remediation costs and hardship) and for personal injury bring the total damages to \$3,300 million.

More specifically, the methodology used in the two appraisal reports for estimating the value of past lost use involves each of the following eight steps.

Step 1: Estimate Annual Rentals per Acre. The first step was to estimate the imputed annual rentals per acre of land that the islanders were unable to use. This is imputed because it represents what the land would hypothetically have rented for if the residents had been able to lease that land — there were no actual or explicit rentals or land sales during the estimation period. The estimate is based on public records of 174 transactions of actual leases primarily from the Majuro and Kwajalein atolls.¹⁹

¹⁸ (...continued)

Bikinians in 1985 and 1989, respectively. The appraisal reports assume, based on instructions from the NCT, that there was no return and that the loss-of-use was continuous and uninterrupted.

¹⁹ Majuro, RMI's capital, contains 72% of RMI's population and is 595 miles from Enewetak; Kwajalein, the next most populated atoll, contains 9% of RMI's population and (continued...)

The records spanned a period of 50 years from 1944 to 1996, but there was only one lease transaction in 1947, none from 1948 to 1964, and one in 1965.²⁰ Between 1965 and 1996 the number of lease transactions in the Majuro and Kwajalein atolls increases but there are still missing observations for some years. This problem is addressed by first taking a five-year moving average to fill in the missing years (in effect, fabricating rents for those missing years) and estimating two regression models on the resulting data. The average of the fitted (or predicted) values calculated from each of these two regression equations was used as the estimated rents on the affected atolls.²¹ The first model (model A) used the fitted or predicted values of the regression throughout the forecast period, 1947-1996; the second model (model B) used the fitted values from the regression for the period 1947-1978, and the official rents set by the government for the period 1979-1996. The official government rental rates per acre were \$2,500/acre for the years 1979-1989, and \$3,000/acre for the years 1990-1997.

Step 2: Determine the Quantity of Land and the Period of Denied Use. Having estimated average rents per acre for each of the loss-of-use years, the next step was to determine how much of their atolls the owners/inhabitants were prevented from using, i.e., the quantity of acreage lost to use, and the corresponding period of lost use. The latter included both temporary loss (temporary because of the return of the inhabitants and their descendants) and permanent loss due to complete destruction of the some parts of the atolls. As discussed, the period of lost use has two components: past loss and future loss.²² The assumed values for these variables are in **Table 2**.

Note that the vaporized (or pulverized) portions of the atoll's islands — 201.62 acres in the case of Enewetak, and 69.67 acres in the case of Bikini — were included in the acreage of denied use, which means the estimates assume that the acreage was not vaporized. The vaporized portions continue to generate rents for the loss-of-use estimates both in the past and into the future even though no return to these portions

¹⁹ (...continued)

is 354 miles from Enewetak. Bikini is approximately 440 miles from Majuro and 217 miles from Kwajalein.

²⁰ The public records were documents from the Majuro Court House and the RMI's Attorney General's Office.

²¹ Regression analysis is a statistical technique that links cause and effect between variables that are functionally related, as determined by a theoretical analysis, and whose covariations are related in some significant way (either negatively or positively); it is used to test theories about the importance of variables suggested by theories, in making predictions, as well as in policy analysis. In this application, the regression model hypothesizes that rents per acre increase over time (are a function only of time) at an exponential rate, with the rate of increase per year determined by the results of the model estimation. The available raw rent data are first converted to a 5-year moving average and the regression of this average is estimated as a function of the time variable.

²² In the case of Enewetak, there are some differences in the acreage of lost use assumed in the appraisal report and those that appear in the NCT's memorandum of decision and order. CRS reports only the former as they are the values assumed in the estimation procedures.

is possible.²³ A more appropriate approach, as discussed later, would compensate landowners for the value of the vaporized portions at the time of vaporization, plus interest.

Step 3: Compute Total Rental Value for Each Year. The total annual rental for all the lost land is the product of the estimated average rents/acre for each year (from step 1) and the affected acreage for that year (from step 2). For Enewetak this begins in 1947 and runs through the 50-year period through 1996; for Bikini this begins in 1946 and runs for 52 years through 1997. Each of these annual rentals is the estimated amount that the U.S. government should have paid the landowners for the use of their land in that year that the land was appropriated and *actually used* by the U.S. Government, and, therefore, lost to the use of the islanders *as a result of* the U.S. Government's nuclear testing.

Step 4: Subtract the Value of Alternative Habitation (Land) Used. Next the appraisers subtracted the estimated annual rental value of the land to which the islanders were relocated, which in the case of Enewetak was to Ujelang (429 acres) and in the case of Bikini, was four different locations: Majuro's Ejit island, Kili atoll (230 acres), Rongerik atoll (416 acres), and Kwajalein atoll (4,051.2 acres).²⁴ The average rentals/acre of these alternative atolls were not estimated separately but were assumed to be a fraction of the base values. In the case of Enewetak, Ujelang was valued at 58% of Enewetak's rentals. In the case of Bikini, alternative atolls were valued as follows: Kili's at either 58% or 75% depending on the time period of alternative use, and Rongerik and Ejit, at 100%.²⁵ Note that except for Kwajalein, the replacement atolls are each significantly smaller than Bikini.

²³ Bikini's land area differs in the two appraisal reports. The Hallstrom report assumed the total acreage is 1,889.63; the Darroch report assumed it is 1,848.34. One survey reported 1,438 acres. The NCT used the highest figures and assumes that there was no vaporization. See Hallstrom Group, Inc., and Darroch, Lmt., op. cit.

²⁴ CRS was unable to determine Ejit island's land area.

²⁵ This adjustment is more difficult for Bikini because of the relocation to four different atolls, Rongerik, Kili, Kwajalein, and Ejit for different time periods. On a per acre basis, the stay on Rongerik and Ejit is valued at 100% of the Enewetak rents, but this was for slightly more than 2 years from Mar. 7, 1946, to Mar. 14, 1948, for Rongerik and from Sept. 1, 1978 to Nov. 2027.

Table 2. Quantity of Land and Duration of Denied Use, by Type of Loss

Type of Loss	Acreage of Denied Use	Period of Denied Use	Notes
Enewetak			
Past Loss-of-Use	1,952.60	12/21/47 to 9/30/80	On 12/21/47, 145 Enewetak residents were evacuated.
Past Loss-of-Use	1,305.78	10/1/80 to 5/16/96	646.82 acres returned to use on 10/1/80.
Future Loss-of-Use	1,104.16 ^a	5/17/96 to 5/16/2026	On 5/16/2026, 1,104.16 acres are to be sufficiently decontaminated for use.
Bikini			
Past Loss-of-Use	1,889.36	3/7/46 to 11/18/97	On 3/7/46, 167 residents were evacuated. They returned on June 1969 and inhabited the atoll through July 1978, but due to dangerous contamination, NCT estimates assume no return.
Future Loss-of-Use	1,889.36	11/19/97 to 11/18/2027	The entire (unvaporized) atoll will likely be contaminated until 11/19/2027.

Source: Memoranda of Decisions and Order for Enewetak and Bikini attached to the *Changed Circumstances Petition*.

Notes: a/ Per agreement between the parties, the original acreage of 1,305.78 in the future loss-of-use calculation was reduced to 1,104.16, but no explanation was given.

Step 5: Adjust Annual Rentals for Prior Rentals Paid. Then the appraisers subtracted any amount paid by the U.S. government in that year as compensation for loss-of-use. While it is difficult to determine precisely how much of the total nuclear compensation was for loss-of-use, **Table 3** shows the totals assumed by the NCT: from 1956-1997, about \$38.5 million for the lost use of Enewetak, and about \$65.7 million for the lost use of Bikini has already been paid. Through 2000, a total of \$128.9 million has already been paid for loss-of-use, according to the NCT. Beginning in 1987, these amounts represent allocations for loss-of-use from the \$150 million Nuclear Claims Fund, which was established as

part of the Compact of Free Association.²⁶ Note that the NCT's past loss-of-use estimates ended in 1996 for Enewetak and 1997 for Bikini. Through these years, the total compensation for lost use assumed by the NCT as paid by the U.S. Government was \$100.9 million.²⁷

Step 6. Multiply Each Year's Rentals by a Compound Interest Factor. Each year's estimated (adjusted) total rental value (the values determined at step 5) was compounded (multiplied) by an interest factor to adjust for the time value of money — reflecting the foregone interest that could have been earned had the rents been paid in the year the atolls' use was actually lost. The interest rate used in this calculation, which varies by year, was the effective yield on 30-year U.S. Treasury bonds.

Step 7: Add the Investment Income on the Proceeds of Foregone Rental Income. The appraisers calculated the foregone investment income the islanders could have earned had the rental proceeds from 1946 to 1967 been invested in 30-year U.S. Treasury bonds. This step, which is different from, and in addition to the interest calculation in step 6, assumes that the residents/proprietors would have saved 100% of the rental proceeds, and invested them in long-term U.S. Treasury securities.²⁸

Step 8: Sum Each Year's Rental Over the Period of Denied Use. The eighth step was to sum, for each year, the terms from steps 6 and steps 7.

²⁶ Note that loss-of-use compensation has been provided after 1997. The "Compact of Free Association" law, P.L. 99-239, authorized annual payments from 1987 through 2003, when the original economic assistance package expired. The Compact of Free Association Amendments Act of 2003, P.L. 108-188, continues financial assistance to the RMI through FY2023. However, for purposes of **Table 3**, since the rentals are only calculated through 2000, the loss-of-use compensation in later years is excluded.

²⁷ The Hallstrom Group's initial loss-of-use estimates generated for the NCT did not take these amounts under consideration. Subsequent estimates by the Hallstrom Group did account for this compensation.

²⁸ In other words, the interest adjustment in step 6 reimburses residents for delayed nature of the compensation "owed" by the U.S. government; the interest adjustment in step 7 assumes that if the rentals had been paid when due, the residents/proprietors could have invested the money in interest-bearing assets.

Table 3. Prior Compensation for Loss-of-Use: Figures Used by the NCT
(\$ thousands)

Enewetak		Bikini	
Date/Time Period	Amount	Date/Time Period	Amount
11/19/56	\$175	11/22/56	\$325
8/19/69	\$1,020	1957-1976	None
9/30/76	\$750		
1977	None	2/14/77	\$3,000
12/18/78	\$750	11/15/78	\$3,000
1979-1986	None	2/1/80	\$1,400
		9/10/82	\$3,000
		1982-1986	None
1987	\$3,250	1987	\$5,000
1988	\$3,250	1988	\$5,000
1989	\$3,250	1989	\$5,000
1990	\$3,250	1990	\$5,000
1991	\$3,250	1991	\$5,000
1992	\$3,250	1992	\$5,000
1993	\$3,250	1993	\$5,000
1994	\$3,250	1994	\$5,000
1995	\$3,250	1995	\$5,000
1996	\$3,250	1996	\$5,000
1997	\$3,250	1997	\$5,000
1998	\$3,250	1998	\$5,000
1999	\$3,250	1999	\$5,000
2000	\$3,250	2000	\$5,000
Totals	\$48,195		\$80,725

Source: Memoranda of Decisions and Order for Enewetak and Bikini attached to the *Changed Circumstances Petition*; and Administration evaluation of RMI *Changed Circumstances Petition*, Nov. 2004. CRS Report RL32811, *Republic of the Marshall Islands Changed Circumstances Petition to Congress*.

Step 9: Determine the Cumulative Sum. Then, for each year, from the time of evacuation to the valuation date, the appraisers took the cumulative sum of the annual terms determined in step 8. This is the total of estimated past loss-of-use, as reported in **Table 1**. (The formulas for the computations in each of these steps appear in **Technical Appendix A**.)

Pre-Judgment Interest Methodology. The grand total past loss-of-use estimate includes pre-judgment interest, which is the interest that accumulates on the original award (\$199,154,811 for Enewetak; \$232,150,821 for Bikini) compounded (at 7%) from the original date of estimation to the time the awards were granted. For Enewetak this is the 40-month period from January 1997 to April 2000; for Bikini this is the 33-month period from May 1998 to March 2001.²⁹ In effect, this pre-judgment interest assumes that the loss-of-use awards should have been paid when the claims were heard as compared to when either the estimates were generated and reported to the NCT, when the claims were actually awarded, or when the claims will be paid, if ever.

Description of Future-Loss-of-Use Methodology

Future loss-of-use begins on the day after the damage estimates were reported (May 17, 1996, for Enewetak; November 19, 1997, for Bikini) and continues until such time as the claimants are allowed to return to a safe homeland (May 16, 2026, for Enewetak; November 18, 2027, for Bikini). The value of future loss-of-use was calculated as the present discounted value of the estimated annual rents over this time period.

More specifically, for Enewetak future loss-of-use is the value of projected foregone rental income on the 1,104.16 acres from the period from May 17, 1996, to May 16, 2026, (which is the date that the 1,104.16 acres of the Enewetak atoll are to be sufficiently decontaminated to permit its safe use); for Bikini future loss-of-use is from November 19, 1997 to November 18, 2027 (which is the estimated date that the Bikini islanders are to have full use of their atoll once again). These dates of return were determined by the NCT. Each year's projected rentals — again the product of *estimated* average rents per acre and the projected (or assumed) lost acreage — was discounted at the assumed uniform nominal interest rate of 8%. Average rents per acre were assumed to start at \$4,105 for Enewetak, and \$4,167 for Bikini, and to remain constant for each year throughout the forecast period. (These rates are the fitted values for the final years determined from the past loss-of-use estimation procedure.)

The formulas for this computation appear in **Technical Appendix B**.

²⁹ The relevant dates are as follows: for Enewetak the Hallstrom loss-of-use estimates report is dated May 16, 1996; the report was transmitted to counsel and the NCT in October 1996; the claims hearings were conducted in January 1997; and the award was granted on April 13, 2000. For Bikini, the Hallstrom loss-of-use estimates report is dated Nov. 19, 1997; the report was transmitted to the NCT and filed in Apr. 1998; the claims hearings were conducted in May 1998; and the award was granted on Mar. 5, 2001.

Assessment of the Methodology

The Loss-of-use Concept

The NCT's loss-of-use methodology is based on sound economic concepts: 1) that the uncompensated loss-of-use of an asset that has economic value should be compensated, and 2) that compensation should be based on the rental value of that asset, as established by the marketplace.³⁰

Individuals receive a stream or flow of benefits or income from an asset over time. In a market economy, the value of those streams of income are measured by the asset's rental. Further, since individuals may also purchase (rather than simply use or rent) an asset, the rental value of an asset is, at least in theory, also equal to the present discounted value of the projected stream of future net rental payments — the value of the streams of net income or benefits earned — over the expected life of the asset.³¹ In the case of land (or other real estate) the market-determined price of land would be computed as (and in fact would tend to equal) the present discounted rental values of that land — the fair market value of the annual rents that a willing tenant would pay a willing landlord in an arms-length transaction over the life of the asset (in perpetuity in the case of land).

Thus, in theory, had the Enewetak and Bikini economies operated on a market-based system, with private property rights, and a competitive real estate market with many potential landowners and lessees, these competitively determined explicit rents would have been what the U.S. government would have paid and what the islanders would have charged. With a competitive rental market, the people of Enewetak and Bikini, as landlords, could have leased the land to tenant-operators who would have paid rents to the landlord over an agreed upon period of time.³² If the U.S.

³⁰ Obviously, the whole question of compensation, from a legal perspective, hinges on whether the lost use of the atolls was coerced or whether it was part of a voluntary, and legally binding written contract or agreement. It is CRS's understanding that there was only an oral agreement between the U.S. military governor of the Marshall islands and the resident/proprietors to evacuate for a "brief" (though unspecified) period due to nuclear testing, and to provide alternative habitation. The military governor gave the impression (based on this oral agreement) that the resident/proprietors would be able to return soon after the "brief" testing period ended. As noted in the text, however, the residents/proprietors of the Bikini atoll have been forbidden to return (except for a brief period) due to continued nuclear contamination, and the residents of Enewetak were allowed to return to only a portion (33%) of the land. Whether the oral agreement constitutes a legally binding and enforceable contract is a legal issue beyond the scope of this report. See Guyer, Ruth Levy. "Radioactivity and Rights: Clashes at Bikini Atoll" *The American Journal of Public Health*. Sept. 2001, vol. 91, pp. 1371-1377.

³¹ In this context, the economic concept of rent is similar to the popular notion of rent — the price one pays for the right to use an asset such as a house, or car, for a specified period of time.

³² A third type of arrangement common in more sophisticated (developed) capitalistic economies is the sale lease-back arrangement. Under this type of exchange, the original
(continued...)

government had permanently taken Enewetak and Bikini atolls without adequate compensation, any restitution would be based on the value of those assets at the time of the taking. But the assumption is that, rather than a permanent taking, there was only a temporary use by the U.S. Government (and equivalently, temporary loss-of-use to the resident/proprietors of the atolls). Therefore, any restitution would be based on the value of this use to the U.S. government, (or equivalently, the value of the lost use to the rightful owners of the two atolls). This value would be the fair market average rents per acre times the relevant acreage — the lands consisting of the two atolls (and including the environmental assets or habitat and any residences) — for the length of time that it was rendered unuseable as a result of U.S. government activities. Note that as long as the market is competitive, the U.S. government would not pay more than the fair market rental, based on the land's return as agricultural and residential property.³³

Explicit and Implicit Rentals

There has never been a competitive real estate market, nor even a market economy generally, in either Enewetak or Bikini atoll. Indeed, until recently there has never been any type of real estate market nor a market economy in the RMI generally. The islanders did not employ a concept of market value; land was held communally rather than privately, and was not exchanged for money as in a capitalistic real estate market. The Enewetak and Bikini landowners did not lease their land — there were no tenants paying rent to the landlords — but used it themselves. Thus, there are no actual real estate transactions, competitive or otherwise, in either Enewetak or Bikini, from which to obtain explicit rentals for agricultural land.

With no real estate market (competitive or otherwise) from which to obtain explicit rents, the equivalent implicit (accrued) rents must be estimated before loss-of-use damages may be estimated. Implicit rents would have accrued to the people of Enewetak and Bikini, as property owners and operators of the lands, if they had continued to live and produce on their lands even if an explicit real estate market did not exist. In other words, when the people of Enewetak and Bikini lost the use of their assets, they lost the implicit rentals that would have accrued to them. Regardless of the type of leasing and the tenure system, there is, at least in theory and assuming a competitive market with private property and no transactions costs, an equivalency between the implicit rentals that would accrue to a landlord and any explicit rentals paid by tenants.³⁴ These foregone *implicit* rentals are what the NCT

³² (...continued)

owner of an asset (typically a non-taxable entity) sells the asset to a taxable entity who then leases it back to the original owner. This type of deal is frequently a tax-motivated one — it is undertaken to take advantage of tax breaks that would otherwise be lost to the non-taxable entity.

³³ In theory there is an equivalency between the rentals (either explicit or implicit) and the asset value: Value is equal to the present discounted value of the future, projected stream of returns (or rents) over the income producing life of the asset.

³⁴ With transactions costs, the implicit and explicit rents would diverge. Explicit rentals would be larger than implicit rentals by the amount of such costs. Also, the assumption of (continued...)

methodology attempted to determine. According to this line of reasoning, these rents are the amounts that the U.S. government should have paid the owners of the land for their use of it at the time of the use.

The Methodology in General

In general, the methodology used by the NCT's estimators to estimate these implicit (accrued) rentals is rooted in sound economic and financial theory; it is (at least when the competitive rent data are available) standard methodology used by economists, as well as by the courts, in solving similar problems.³⁵ This is because, in general, if the assumptions and conditions of the theory were met, the real estate market rents obtained from comparable (i.e., agricultural and residential) properties — to the extent they existed — would represent the implicit rentals on agricultural and residential properties on the islands of Enewetak and Bikini.

Further, the NCT's methodology attempted to adjust each year's estimated rentals owed — the gross rentals — for 1) any rentals previously paid by the U.S. government for loss-of-use, and 2) the value of alternative land provided as domiciles by the U.S. government. The NCT's appraisers adjusted the annual net rentals for interest on unpaid prior rents. This is also viewed as appropriate because rents should have been paid at the time of the U.S. government's use, and at the time of the consequential loss-of-use to the islanders. Since such rents, if any, should be paid retroactively, they would have to be compounded, on a year-by-year basis, for the interest income the islanders would have earned had they been paid on time. In estimating past loss-of-use, hundreds of actual lease transactions from RMI atolls were sampled to estimate average rents per acre for each year — a critical variable upon which both past and future loss-of-use estimates depend. In estimating future loss-of-use, the methodology appropriately attempted to estimate the value of such loss-of-use as the present discounted value of projected rentals up to the date of return.

Although, in general, the methodology could be appropriate, the conditions under which it should be applied to generate reliable estimates of past implicit rentals for loss-of-use were not present in either Enewetak and Bikini. Moreover, the NCT's specific application of the methodology — much of the critical data used, some of the assumptions, and certain statistical procedures applied (i.e., the sampling technique and, specifically, the exponential regression model) — produced estimated rentals that appear to be overstated, particularly in comparison with rents in the United States and elsewhere around the world, and in comparison to rents calculated based on RMI's national income and product accounts. If the rental value of

³⁴ (...continued)

private property rights is crucial. If private property has value, then a share of a resource that is privately held has more value than a proportionate share of a communally owned resource.

³⁵ In *Yuba Natural Resources, Inc. v. United States* 904 F.2d 1577, 1581 (Fed. Cir. 1990) the Federal Circuit court argued that the usual measure of just compensation for a temporary taking of property is its fair rental value for the period of the taking, based on the "minimum" amount of rents under a lease agreement. This is the value for the use of the property during the taking — the amount which the owner lost as a result of the taking.

Enewetak and Bikini land (average rents/acre) is overestimated, this leads to overstated past and future loss-of-use estimates, and excessive total loss-of-use damages claimed and awarded by the NCT. The main shortcoming is with the past loss-of-use estimates, but since future loss-of-use calculations rely on past loss-of-use rent estimates, these estimates appear to be inflated as well.

Overestimation of Past Loss-of-Use

This section of the report demonstrates that past loss-of-use damages appear to be overstated. First, the methodology overestimated or inflated average rents per acre for land on Enewetak and Bikini. Second, the quantities of land that were denied use were overstated by, for example, including the use of vaporized portions of islands (although these would, alternatively, be compensated as assets at the time of their vaporization, as already explained). Third, the value of alternative atolls provided by the U.S. government as domiciles may be understated.

Overestimation of Average Rents Per Acre. The NCT's methodology — sample rent data, assumptions, and statistical procedures (i.e., the sampling technique and the use of the exponential regression model) — overestimated the per-acre rental rate for land on Enewetak and Bikini, the key variable in the loss-of-use calculation.

The NCT's methodology examined all lease transactions in the RMI from 1944 through November 1997 (the valuation date) — nearly 500 of them in total — and used 196 transactions as the basic statistical sample from which to estimate average rents/acre for each year from 1946-1996. The lease transactions were primarily commercial leases from the urbanized, and densely populated, atolls of Majuro, the capital of RMI, and Kwajalein, where the U.S. missile test site is located. These transactions do not reflect the value of the more isolated, rural, and agricultural lands of Enewetak and Bikini.³⁶ In the NCT's statistical rent sample, 176 of the 196 leases are for land on Majuro, which is 595 miles from Enewetak and 439 miles from Bikini (Kwajalein is 354 miles from Enewetak and 217 miles from Bikini). There are no surveys of leases on any of the affected atolls because property was (and is) communally owned and little land or property was bought and sold or rented until the late 1970s, when the RMI real estate market became more developed.

These problems raise the question of the validity of the sample to determine land rents in the affected islands. It is true that there have not been actual lease transactions on either Enewetak or Bikini, even at this writing. However, because the land on Majuro and other Southeastern atolls, from which sample data are obtained, are not representative or comparable to land on Enewetak and Bikini, the NCT arguably should have explored use of an alternative methodology.

³⁶ The 29 RMI atolls and five islands are spread over about 750,000 square miles of ocean. About 70% of the population live on two atolls: Majuro (50%), and Kwajalein (20%). The population densities on Majuro and Kwajalein are 5,244 persons/sq.mile and 1,471 persons/sq.mile, respectively. On Enewetak and Bikini, population densities are 316 and 4, respectively.

Economic theory suggests, and the evidence supports, that rents decline the further the land is from the central business district; and that the more distant land will be used for agricultural purposes, and generally at the lowest rents.³⁷ Although one would expect to find higher rentals in these two atolls than in either Enewetak or Bikini, the applicability of these rentals to distant, more agrarian, less populated, and less productive atolls is questionable. In theory, sample rents would be taken as a random sample from a population of comparable properties sold or rented in a competitive real estate market, the same market to which a rental value is being estimated. In the event that such data are unavailable, then an attempt would be made to estimate the implicit rentals by an alternative method. (The fifth section of this report develops such an alternative methodology.)

A more serious methodological problem is that the rents/acre obtained from the sample data are not competitive, free-market rents — they are not the equilibrium result of the interplay of supply and demand, and, therefore, do not represent the real underlying productivity of land as a factor of production. There are essentially three reasons for this: First, most lease transactions in the RMI place take place at what is called “the official government rate,” which is established by law by the RMI cabinet, which, under the parliamentary system of government is appointed by the President, who is also the Prime Minister. The RMI cabinet established the official rental at \$2,500/acre on October 1, 1979, and increased it to \$3,000/acre on October 1, 1989. This rate has been the price at which land and other property is rented throughout the RMI; it is also the benchmark for most other lease transactions in the RMI including land leased by the United States government — virtually all land transactions since 1979 have been conducted at this rate. For example, the United States rents the Kwajalein missile test range at the official rate of \$3,000/acre.³⁸ This makes the United States (which values the RMI lands as a strategic asset) the single biggest lessee (tenant) for RMI land.

Not only does the RMI government determine the land (and other property) rental rate, but it is also the source of much of the demand for land, at least during the period from 1979-1997 (the loss-of-use valuation period). The lessors (tenants) in many of the nearly 500 lease transactions are either the RMI Government, Government of the Trust Territory of the Pacific Islands, the Ministry of Interior & Outer Island Affairs, or other RMI government agencies (such as the National Telecommunications Authority). According to the Hallstrom appraisal report:

The federal and national governments have been active participants in the market with over 180 transactions or 40% of the data involving them primarily as lessees. The national government of the Marshall Islands continues to lease land for a variety of purposes, but has actually played an important role in establishing

³⁷ Randall, Alan and Emery N. Castle. Land Resources and Land Markets. *Handbook of Natural Resource and Energy Economics, vol II*, edited by A.V. Kneese and J.L. Sweeney. Elsevier Publishers, 1985. pp 571-620.

³⁸ According to the Bank of Hawaii, the United States spent about \$180 million for land rent on Kwajalein over the 15-year-period from 1986 to 2001, \$12 million per year. There are 4,051.2 acres of dry land in Kwajalein. Assuming the entire island was rented by the U.S. government, the exact rental per acre is \$2,962. See *Republic of the Marshall Islands Economic Report*. Bank of Hawaii. April 2001

a more active market. Prior to the establishment of the “government rate,” relatively little activity is observed in the Marshall Islands. However, upon providing businesses and private individuals a basis of land value, a marked increase in transactions ensues — over 70 percent of the database involves transactions from 1980 to current. Further discussed below, the market has tracked the government rate with each adjustment.... This is further supported in many cases by leases that adopt the then government rate as a standard or basis for ground rent renegotiation. Since the 1980s, most leases have been written with a provision for a five-year review and comparison with the official government rental rate.³⁹

Finally, top RMI government officials were also effectively landowners of much of the land rented to the RMI government agencies — they were a source of the supply of land — which raises the possibility of a conflict of interest. Under the system of landownership in the RMI, the King or paramount chief (called the “Iroijlaplap” in the RMI’s native language) effectively owns one-third of all the land, which means that he receives one third of the rent or any other income from the land, whether in-kind or in currency (dollars). Many of the leases in the sample of 500 lease transactions, and many of the leases in the sample of 196 lease transactions used in the NCT’s estimation methodology, list the paramount chief (or King) Amata Kabua as one of the landowners.⁴⁰

The practical effect of this system of land ownership, land pricing, and rent determination is that the RMI government (the primary lessee or tenant) rents much of the land from itself (as the landlord) at above market prices also determined by the RMI government. To illustrate, on May 1, 1979, the citizens of the Marshall Islands approved a constitution and elected its King, Amata Kabua, as its first President. On October 1, 1979, the RMI cabinet, which was appointed by President Kabua, established by law the official government rental rate. The RMI government has leased substantial quantities of land at the official government rate, and has influenced the leasing of other non-government land. And since by tradition the King owns a one-third share of all rents, President Kabua received one-third of the government established rental rate. Rents obtained from these types of non-arms-length and non-market transactions, do not yield rent estimates that would realistically reflect implicit agricultural and residential rentals (i.e., the real agricultural productivity of the land) on either Enewetak and Bikini.

Finally, the NCT’s methodology also assumed that all of the islands of the two atolls were equally valuable; that the land in these islands was potentially rentable at the same average rate as for the RMI as a whole, based, again on lease transactions on Kwajalein and Majuro atolls. However, at the time of their relocation on March 7, 1946, the Bikinians all resided on Bikini island. Three other islands — of the atoll’s original 29 islands — could have supported permanent populations: Enyu,

³⁹ *Appraisal Report of the Loss in Value in Enewetak Atoll, Republic of Marshall Islands for the Nuclear Claims Tribunal*. The Hallstrom Group, Inc., and Raymond A. Leshner & Co., Ltd., May 17, 1996, pp. 19,21.

⁴⁰ *Appraisal Report of the Loss in Value in Enewetak Atoll, Republic of Marshall Islands for the Nuclear Claims Tribunal*, Hallstrom Group, Inc. and Raymond A. Leshner & Co., Ltd., May 17, 1996, Exhibit VI.

Namu, and Eniirikku. This may suggest that the other 25 islands had little use value, even to the Bikinians, and to value them equally with the usable islands is questionable.

The Exponential Model of Rent Growth. CRS research demonstrates that the NCT also overestimated average rents per acre on Enewetak and Bikini due to the use of an exponential regression model to extrapolate rental rates for years in which observations are not available. The model estimated by the NCT is: $R_t = e^{2.8967 + .0993 t}$ — that the trend of average rentals in the RMI grows every year at an exponential rate as determined by this equation. Applied to overstated non-market sample rents, this model predicts implausibly high average rents/acre of \$5,745 for 1997, and \$112,995/acre for the year 2027, which is equivalent to land value of nearly \$2,000,000/acre (compounded at 8% for 30 years the precise figure is \$1,774,024/acre).⁴¹ When this model is fitted to data calculated using the more recent observations from inflated government-controlled rental rates, it produces very high slope estimates — an estimate of implied changes in rentals each year. This method further compounds the upward bias in the estimated average rents/acre and overestimates past loss-of-use. In theory, and according to much empirical evidence, real estate rents reflect real estate values, which, when they fluctuate — as they invariably do — do so depending primarily on economic conditions, and generally do not increase at exponential rates.

The Quantity of Land Affected. Another source of overstated loss-of-use estimates is the assumption that more land on Enewetak and Bikini was lost to use than is actually the case.⁴² For example, though some portions of the affected atolls were completely destroyed or pulverized by the nuclear testing — 182.46 acres of Enewetak (9.34% of the atoll's land acreage) and 69.67 acres of Bikini (3.69% of the land acreage) — the NCT's methodology assumed that they were not. The result is that the U.S. government owes rentals for loss-of-use on land that no longer exists, and which continues to earn inflated rents at compound interest through 2026 for Enewetak and 2027 for Bikini.

The NCT's justification for making this assumption was twofold. First, it argued that Enewetak and Bikini are “part of the environmental whole” and should not be separated into islets. However, this assumption results in an inconsistency: Enewetak and Bikini atolls are treated as individual land masses for purposes of 1) calculating the annual rental values on unvaporized portions of the atolls, 2) adjusting for alternative habitation, and 3) adjusting for prior loss-of-use compensation already paid by the U.S. government. But, Enewetak and Bikini atolls are treated as

⁴¹ However, the NCT's methodology for future loss-of-use does not use these estimates, probably because they are so inflated as to be not plausible. Rather, the appraisers take averages of the predicted rents for 1996 (Enewetak) and 1997 (Bikini) from two different models (one of which is the exponential model) and holds the future rents/acre through 2026 (Enewetak) and 2027 (Bikini) constant at these levels.

⁴² Note that for both Enewetak and Bikini, the two appraisers use different quantities of land lost-to-use, and different quantities of vaporized acreage. For example, for Bikini, the Hallstrom report assumes the total acreage is 1,889.63; the Darroch report assumes it is 1,848.34. The NCT employs the highest of the various acreage estimates.

collective land masses for the purposes of excluding the vaporized portions of the atolls.

The second reason given for including the vaporized land portions in the loss-of-use calculation was that there are problems in determining the value of the vaporized and otherwise unusable portions of Enewetak and Bikini. But, there are no more problems in valuing vaporized land as there are problems in valuing unvaporized land. Given the equivalency between the value of land and the rentals earned on that land, an appropriate methodology would consider the vaporized land areas as being tantamount to a permanent taking of property, and estimate the capitalized land value based on the projected streams of rentals, using the estimated rentals at the time of pulverization. In this way, past loss-of-use estimates would include the rental value of the vaporized portions up to the time of pulverization, and thereafter based on the capitalized value of these portions of the land as assets, with interest. This is the same as calculating future rents foregone, but it does so at the time of the destruction of the land, whether from vaporization or any other cause.⁴³

Finally, the NCT methodology also made some assumptions regarding the timing of denied use, in the case of Bikini atoll, that raise the loss-of-use damage estimates. In particular, it assumed that the Bikinians' loss-of-use was continuous and there was no return. On March 7, 1946, 167 Bikini islanders (the inhabitant proprietors) were evacuated, but the Bikinians returned to two islands of the atoll (Bikini and Eneu islands) from June 1, 1969, to July 31, 1978. While it is true that they returned to a contaminated island, the time they spent on the atoll after their return should not be counted as a loss-of-use. The implication for the loss-of-use estimation is that the rentals on these two occupied islands of the atoll would be lower owing to this contamination and that the corresponding value of their stay on alternative atolls should not be deducted from the overall rental.

The Value of Alternative Habitation. The estimating assumption that the rents/acre of alternative homeland provided by the U.S. government is only a fraction of the rental value of the original homeland also resulted in overstated loss-of-use damages. The NCT's methodology valued Ujelang generally at only 58% of the average rents on Enewetak; Rongerik, Kili, and others were valued at either 75% or 58% of the value, per acre, of Bikini.⁴⁴ The assumption is based on an assertion that the economic value of copra (dried coconut meat) production and other agricultural commodities (cassava, sweet potatoes, etc.), which were produced on the contaminated and vaporized islands before U.S. testing and population evacuation, was less on these alternative residences than on either Enewetak and Bikini.

⁴³ Another illustration is the case of Runit Island of Enewetak atoll. This island has been indefinitely quarantined because it is used to store nuclear waste, and should thus be compensated based on its value at the time it was rendered unusable (plus interest).

⁴⁴ This adjustment is more involved for Bikini because of the relocation to four different atolls, Rongerik, Kili, Ejit, and Majuro, for different time periods. On a per-acre basis, the stay on Rongerik and Ejit is valued at 100% of the Enewetak rents, but this was for slightly more than 2 years from Mar. 7, 1946, to Mar. 14, 1948, for Rongerik. For more detail see the Memoranda of Decisions and Order for Enewetak and Bikini attached to the *Changed Circumstances Petition*.

While deducting the value of alternative habitation provided by the U.S. Government is viewed as fair and appropriate, the assumption that rent/acre on these alternative habitats are lower than on either Enewetak and Bikini because the value of the economic output on these alternatives is less than on either Enewetak and Bikini is inconsistent with the rest of the methodology. The methodology developed for the NCT — based on instructions given to the appraisal firm by claimant's counsel and the NCT — assumed that rents on Enewetak and Bikini, should not be based on economic value of land in agricultural production, such as production of copra, or potential for nuclear storage.⁴⁵ Thus, for purposes of adjusting for alternative habitation (i.e., calculating variables for a term in the formula that is subtracted from gross rentals), the NCT did take into account differences in economic value. But, for purposes of calculating gross rentals on Enewetak and Bikini, differences in average rents/acre due to differences in economic output were not taken into account by the NCT. The value of the produce from the land, its output potential or productivity of the islands in producing copra or fish, was not considered. The assumption is also inconsistent with the capitalization model that the value of an asset is equal to the present discounted flow of income streams (returns).

Reinvestment of Rental Proceeds. Finally, the NCT methodology assumed that all of the rental proceeds earned during the first 20 years of payments — the estimated amounts of past loss-of-use rental owed by the U.S. government for the period 1946-1966 — would have been invested in 30-year U.S. Treasury bonds. This step in the procedure, which seems like double counting, effectively assumes that none of the proceeds would have been distributed to the residents of the affected atolls and consumed. This is equivalent to assuming that savings rates would have been 100%. A more appropriate way to adjust for this would be based on the assumption that a large portion of the proceeds would have been expended on consumer goods and the remainder saved in a savings account at some interest rate. The amount saved should be based on a realistic savings rate.⁴⁶

Overestimates of Future Loss-of-Use

With respect to future loss-of-use, the present discounted value methodology is generally appropriate, but the estimated dollar amounts also appear to be inflated or overstated. The primary reason that future loss-of-use is overstated is that the procedure carries over into the calculation of projected future rents the inflated estimates of average rents per acre from the past loss-of-use. Thus, for Enewetak, rents for 1997-2026 are projected to be the same as for 1996 (\$4,105/acre); for Bikini, rents for 1998-2027 are the same as for 1997 (\$4,167/acre). The assumption that the Enewetakians and Bikinians could return to use the vaporized islands also contributes to this overestimate.

⁴⁵ Memorandum from Jonathan M. Weisgall to Philip A. Okney, Defender of the Fund, Feb. 23, 1998.

⁴⁶ Another possible source of overstatement is in the adjustment for prior loss-of-use compensation. The George W. Bush Administration argues that the extent of such prior compensation used in the methodology is greater than is shown in the NCT reports. CRS was unable to independently verify this, but if so, this also would contribute to inflated past lost use values.

Empirical Evidence

The main conclusion of the discussion so far — that loss-of-use estimates appear overstated or inflated — is based on an examination and economic analysis of the strengths and weaknesses of the NCT’s methodology. This section of the report presents empirical evidence — facts, comparisons, and additional arguments — that support this conclusion.

- From 1970-1978, before the establishment of the RMI’s “official government rental rate” of \$2,500/acre on January 1, 1979, annual rents on all RMI lease transactions (which were primarily commercial leases on business properties and residential leases, rather than agricultural land) averaged \$511/acre according to the Hallstrom report and \$597/acre according to the Darroch report. In contrast, average rents in 1979 — after the official government rental rate was enacted in October 1, 1979 — averaged \$2,575/acre, 404% above the Hallstrom average, and 331% above the Darroch average. The economic conditions for rent increases of this magnitude — essentially the demand for land would have had to increase by that same percentage, given that the supply is essentially fixed — while not inconceivable, do not appear to have existed in the RMI generally, and the Enewetak and Bikini atolls particularly.
- Estimated average rents per acre in the NCT report for Enewetak and Bikini (and the rest of the RMI) — \$4,105/acre in 1996 and \$4,167 in 1997 — appear high in comparison with agricultural rents in the continental United States, Hawaii, and various other parts of the world.⁴⁷ For example, rents for continental U.S. cropland in 1996 ranged from \$17.50/acre in Montana, \$115/acre in Oregon, to \$210/acre in California, which has the highest agricultural rents anywhere in the continental United States primarily because it produces a greater quantity of more valuable specialty crops than anywhere else (reflecting primarily the marginal productivity of California agricultural land). For New Mexico crop-land rents in 1995 averaged \$88/acre. Average rents for continental U.S. cropland in 1998 (the first year average figures for the U.S. became available) were \$66.50/acre.
- The NCT-estimated rents also appear high when they are converted to farmland (or asset) prices and compared to average land prices for comparable properties in selected areas around the world. The NCT’s estimated 1997 rental of \$4,167/acre, discounted at 8% for 30 years, is equivalent to land valued at \$46,911/acre, which is nearly 2,000% greater than the \$2,405/acre average price for Hawaiian land, and 5,000% more than the \$926/acre *average price*

⁴⁷ See U.S. Department of Agriculture, *Agricultural Land Values and Cash Rents: Final Estimates 1999-2003*, National Agricultural Statistics Service, Statistical Bulletin # 993.

of farmland in the continental United States generally.⁴⁸ **Figure 1** shows average land prices for the continental United States from 1982-2004.

- Although official rent and land value data from places around the world are unavailable, anecdotal evidence also suggests that the NCT's estimates of rents are significantly overstated. For example, in 1997 the U.S. Fish and Wildlife Service purchased 5,300 acres of land in the South Kona district of the Hawaiian Islands at a total cost of \$7.78 million, or \$1,468/acre, which translates into an estimated annual rent per acre of \$130.⁴⁹ In June 2002, the average price of cropland in Brazil was reported at \$355/acre.⁵⁰ In April 2005, 100,725 acres of New Zealand forest land went on sale for \$42/acre in New Zealand dollars (which, at the April exchange rate, converts to about \$30/acre in U.S. dollars).⁵¹ On February 2005, a 1,300 acre New Zealand commercial farm, with residential structures, was on the market for \$3,846/acre.⁵² Again, when compared to these prices, the \$46,911 price for RMI land estimated by the NCT in 1997 seems substantially overstated.
- Finally, a comparison based on national income and product accounts and the relative income shares of various factors of production — shares earned by labor, capital, land, and profits — also suggests that the NCT's methodology significantly overstated rents. For example, the NCT's loss-of-use calculations for 1990 resulted in a total rental value of \$9,155,949 (\$3,837,687 for Enewetak and \$5,318,262 for Bikini), which is 13% of RMI's aggregate GDP (gross domestic product) of \$68,691,000.⁵³ For 1995

⁴⁸ Based on the average asset value (price) of agricultural land in Hawaii, the estimated rent per acre would be \$213.63, as compared with an average estimated rent of \$4,167 in the NCT reports. For the value of Hawaiian agricultural land see U.S. Department of Agriculture. *2002 Census of Agriculture: State Data*. p.31.

⁴⁹ "Ranchers Press Federal Government to Pay To Move Junk, Wild Cattle off Refuge Land." *Environment Hawaii*, vol.14, Nov. 2003. Available at [<http://www.environment-hawaii.org/1103ranchers.htm>].

⁵⁰ Kenneth. M. Chomitz and Timothy Thomas, "Determinants of Land Use in Amazonia: A Fine Scale Spatial Analysis." *American Journal of Agricultural Economics*, Nov, 2003, vol. 85, pp. 1016-1029.

⁵¹ Available at [<http://www.nzforestland.co.nz>].

⁵² *Wall Street Journal*, Feb. 18, 2005, p. W11.

⁵³ GDP is the value of all final goods and services produced by the productive factors inside a country during a given year. It equals GNP (gross national product) less overseas remittances. GDP may be measured either as the sum of expenditures by consumers and governments, gross investment spending, and total merchandise exports less imports or as the sum of all factor incomes earned by all of the economic agents in the economy. In terms of national income and product accounts, $GDP = W + I + R + \pi$, where W are wages (continued...)

the total estimate of \$11,890,496 (\$5,039,009 for Enewetak and \$6,851,487 for Bikini), is 11.3% of RMI's 1995 GDP.⁵⁴ Such implicit rentals for just two atolls, whose combined land area comprises 8.7% of RMI's total land area, are high in and of themselves, but they also do not account for the implicit and explicit rents on RMI's other 27 remaining atolls and 5 islands. Applying the estimated 1995 per-acre rental rates of \$3,859/acre to the entire area of the RMI would yield a total implicit rental of \$170.5 million, 62% more than the 1995 RMI's GDP of \$105.2 million.⁵⁵

Alternative Methodology

This section of the report develops a model of agricultural rents, which is applied to available data from RMI's national income and product accounts to generate alternative estimates of average rents/acre for the total loss-of-use rentals for the Enewetak and Bikini atolls. The model is founded on the same neoclassical microeconomic theory underlying the NCT loss-of-use methodology. However, in addition to making the model explicit, it avoids shortcomings of the NCT methodology, by using available data from RMI's national income and product accounts that is consistent with the underlying theory. The model is deterministic — there is no uncertainty — and assumes that land values, and therefore land rents, derive primarily from agricultural productivity, but also from proximity to the major urban areas (Majuro).⁵⁶ The value of agricultural land, and equivalently, the rental price of that land, reflects the value of the crops produced.

The RMI Economy

Table 4 is a brief statistical profile of the RMI economy. The RMI is a small, developing island country, and, like other Western Pacific island nations, its economy is based primarily on services. These are largely government services

⁵³ (...continued)

or labor's income, I is the return to capital or interest income, R is rental income (the return to land), and π are profits (the return to entrepreneurial ability and management efficiency).

⁵⁴ For every country, the relative income shares, e.g., R/GDP vary, but only within certain parameters which follow the laws of economics. For example, rental income in the United States over the last 75 years has declined from about 7.5% of GDP in the early 1930s to under 2% in 2002. See David Barker and Jay Wa-Aadu, "Is Real Estate Becoming Important Again? A Neo Ricardian Model of Land Rent." *Real Estate Economics*, Spring, 2004, pp. 33-54.

⁵⁵ Using 640 acres/sq. mile x 69 sq. miles gives 44,185 acres x \$3,859 = \$170,512,230. Note that there are some minor differences in the reported land area of the RMI. Darroch reports 70.05 sq. miles; Hallstrom reports 69.04 sq. miles.

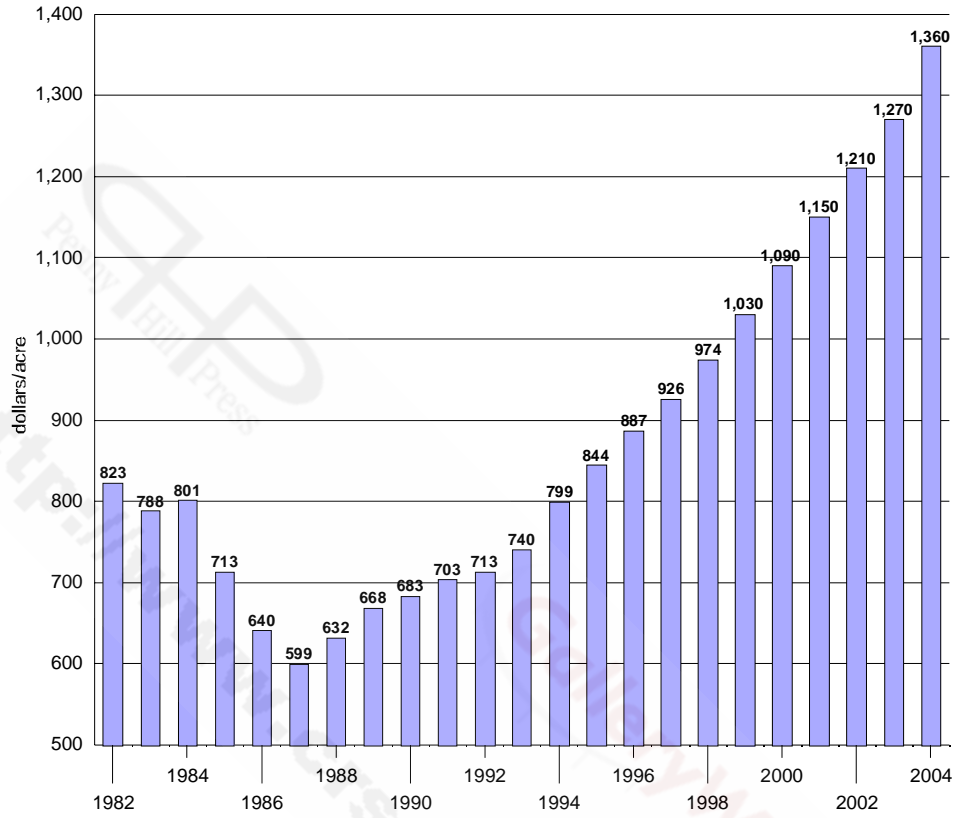
⁵⁶ Uncertainty would make many of the determining variables in the model random, which, although it would add realism, it would also add an unnecessary level of complication and, in any event, is beyond the scope of this memorandum.

mostly funded, either directly or indirectly, by U. S. Government assistance under the Compact of Free Association. Much, if not most, of RMI's growth has depended on these external resources (grants) provided by the U.S. government. According to column (7) of **Table 4**, U.S. grants to the RMI from 1992-1997 have averaged 44% of GDP.⁵⁷ However, with grant flows declining in real terms in the 1990s, economic growth in the RMI has weakened, and real per-capita income fell below the pre-independence level.

Production capabilities of the RMI, such as manufacturing, are quite limited as the country is geographically isolated and dispersed, has limited access to world markets, and is susceptible to natural disasters. The RMI, in general, possesses few natural resources other than the Pacific Ocean, which is exploited for fishing. The labor force is very small and unskilled; there is also relatively little capital and infrastructure, although investment in capital and infrastructure has been growing of late. Much of the population has historically been involved in subsistence agriculture and fishing, including livestock farming.

⁵⁷ In addition to U.S. grants (which are both mostly "Compact grants," but also include other types of grants) the RMI receives assistance grants and loans from other foreign governments. See International Monetary Fund. *IMF Concludes 2003 Article IV Consultation with the Republic of the Marshall Islands*, Feb. 13, 2004; and International Monetary Fund, IMF Staff Report, *Marshall Islands: Recent Economic Developments*.

**Figure 1. U.S. Average Farm Real Estate Value
Dollar Per Acre, 1982-2004**



Source: USDA - NASS, Aug.2004.

Table 4. Descriptive Statistics on the RMI Economy, 1981-2001
(\$ thousands)

Year	Total GDP	GDP in Agriculture, Forestry, and Fishing	Agriculture, Forestry, and Fishing, as % of GDP	Population	Total Employment	GDP Per-Capita	U.S. Grants Under the Compact
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1981	\$27,152	\$3,469	12.75%	32,942	—	\$824	N.A.
1982	\$30,584	\$3,900	12.75%	34,299	4,980	\$892	N.A.
1983	\$36,543	\$4,659	12.75%	35,711	—	\$1,023	N.A.
1984	\$39,513	\$5,038	12.75%	37,182	—	\$1,063	N.A.
1985	\$38,406	\$4,897	12.75%	36,702	5,487	\$1,046	N.A.
1986	\$49,907	\$6,363	12.75%	38,044	6,971	\$1,312	N.A.
1987	\$55,130	\$7,029	12.75%	39,449	7,139	\$1,398	N.A.
1988	\$61,874	\$7,889	12.75%	42,692	6,761	\$1,449	N.A.
1989	\$63,721	\$8,124	12.75%	43,332	6,224	\$1,471	N.A.
1990	\$68,691	\$8,758	12.75%	43,982	6,839	\$1,562	N.A.
1991	\$72,219	\$10,015	13.86%	44,642	7,277	\$1,618	N.A.
1992	\$79,709	\$10,739	13.47%	45,312	7,896	\$1,876	\$50,400
1993	\$87,059	\$11,476	13.18%	45,991	7,625	\$1,893	\$49,300
1994	\$94,596	\$15,068	15.92%	46,681	8,727	\$2,026	\$50,600
1995	\$105,239	\$15,874	15.08%	47,381	8,810	\$2,221	\$50,200
1996	\$97,036	\$13,589	14.00%	48,092	9,181	\$2,018	\$46,200
1997	\$92,184	\$12,963	14.06%	48,814	7,293	\$1,888	N.A.
1998	\$95,223	\$11,403	11.97%	49,546	6,889	\$1,931	N.A.
1999	\$97,352	\$8,274	8.49%	50,840	6,681	\$1,914	\$40,100
2000	\$98,961	\$9,715	9.81%	52,671	—	\$1,821	\$50,400
2001	\$99,174	\$10,296	10.38%	54,584	—	\$1,817	\$58,700

Sources: Columns (1) and (6): [<http://www.spc.int/prism/country/mh/stats>] and *Republic of the Marshall Islands Economic Report*. Bank of Hawaii. April 2001. Columns (2), (4) and (5): *Republic of the Marshall Islands Economic Report*. Bank of Hawaii. Apr. 2001. Column (7): International Monetary Fund. IMF Staff Report. *Marshall Islands: Recent Economic Developments Appraisal Report of the Loss in Value in Enewetak* Column (3): Author's calculation, as indicated.

Life on both Enewetak and Bikini was traditionally agrarian with generally adequate food — at least, before the nuclear testing — and an abundance of fish. This lifestyle included the growing and gathering of food crops, fishing on the adjoining lagoon, and gathering seafood from the reefs. The soil on Enewetak and Bikini is basically coral rock and coralline sands with limited water and fertility retention. Annual rainfall averages 50-60 inches. Few products are convertible into cash crops other than copra, products from the processing of coconut oil, pearl farming, and fishing. In addition to copra some of the islands produce pandanus, breadfruit, bananas, limes, taro, and arrowroot, but in relatively small quantities. Handicrafts are made for export, but this is also a very small industry. Tourism is insignificant primarily due to RMI's remoteness from major population areas, which makes travel costs high. Thus, the economic potential of the RMI economy in general, and the agricultural sector in particular, is extremely limited, which implies that rents would not be expected to be very high. Based on the theory that rentals of agricultural land in capitalistic or mixed economies reflect primarily the net earnings capacity of the land (the value of the land's marginal productivity), the rents for agricultural land values estimated by the NCT appear to be overstated.⁵⁸

Theoretical Framework of Rent Determination

As discussed above, land is a marketable capital asset, a productive factor, that produces a flow of goods and services over time.⁵⁹ The exchange value of land is its fair market price: what a willing buyer would pay a willing seller in an arms-length transaction in a free, competitive marketplace. The exchange value of the goods and services produced by the land are its rents — what a willing lessee would be willing to pay a willing lessor for the use of the land over an agreed-upon period of time in an arm's-length transaction. Economic theory suggests that the exchange value of the land itself, the price of the land, is equal to the present discounted value, discounted at the opportunity cost of capital, of the streams of annual returns (or income) generated by employing the asset in its best and highest use and over its economic life plus any salvage value of the asset at the end of its economic life.⁶⁰

In the case of agricultural land, that stream of returns — the annual ground rents per acre — would reflect the fertility (or productivity) of that land as a productive factor as well as its location, topography, the value of any natural resources (and environmental amenities), any speculative potential value, and cultural value. Agricultural land prices would then be closely related to the present and expected

⁵⁸ As the German colonists developed the Marshall Islands' copra production and trade, later continued by Japanese traders, land became commercially important and its rental value increased. This point is noted in the Darroch Ltd. appraisal report p.15.

⁵⁹ Land has many uses such as a store of minerals, wildlife habitat, park land, urban land (residential, industrial, etc.), and as a speculative asset. We adopt the NCT assumption that the Enewetak and Bikini lands were valued primarily as agricultural land and, to a lesser extent, as residential land.

⁶⁰ This general rule applies to all capital asset stocks, real estate, business machines, and other income earning assets.

earnings of that land — as in fact they have been historically — and those earnings would be the price for which the land would rent: they would be its cash-rent.⁶¹

Assume households have an endowment of labor L , capital K , and the effective quantity of land $A(S)$, which are used in combinations to produce marketable commodities, Q , satisfying the following agricultural production function $F[(K, L, A(S))]$, where

$$(1) \quad Q = F[K, L, A(S)]$$

Q = output of copra and other agricultural commodities, and fish caught in the lagoons and surrounding waters,

K = capital, including residential structures and farm buildings

L = labor

A = land

S = soil fertility or quality

In this formulation the effective quantity of land reflects not just the acreage of land but soil fertility and nutrients, which are assumed to be a function of environmental amenities or the ecosystem. For example, one possible specification of $A(S)$ is $A(S) = q(I, t) \cdot A$ where $q(I)$ is some quality index, which is itself a function of soil improvement investments and time, with $\delta q / \delta I > 0$ (the greater the level of investment, the more fertile is the soil, and $\delta q / \delta t > 0$ (soil fertility improves with time). Soil fertility is then a choice variable — the agricultural firm/household can choose the level of investment to increase soil fertility, which would increase the return to land. To illustrate, 2 different parcels of land A_1 and A_2 could differ in effective land if one is more fertile and productive than the other. Thus $q_1 = 1$ and $q_2 = 1.05$ would make parcel 2 five-percent more productive than parcel 1 — this would be equivalent to having 5% more land area.

Assume that $F[K, L, A(S)]$ is homogeneous of degree one (constant returns to scale) satisfying $\delta F / \delta K > 0$, $\delta F / \delta L > 0$, $\delta^2 F / \delta K^2 < 0$, and $\delta^2 F / \delta L^2 < 0$. Assume also that land is a factor of production allocated to its highest and best use, which is primarily for agricultural uses (as the NCT assumes) and that the household-farmer, who owns his land, chooses combinations of L , K , together with a fixed quantity of land A so as to maximize profit π defined as

$$(2) \quad \pi = P \cdot F[K, L, A(S)] - wL - (i + \delta)K - rA(S)$$

⁶¹ Agricultural land can also rent for a crop rent, which means that the rental is paid as a share of the crop produced.

where

P = the competitively determined output price

w = wage rate

i = the interest rate

r = the land rental

δ = building depreciation rate

Output price P is exogenous, as are w, and i.

Economic theory suggests rents are the intra-marginal residual returns — the surplus income — accruing to each acre of land after paying the variable factors of production the value of their marginal products. They are the difference between revenues and the opportunity costs of inputs. In equilibrium, pure economic profits (net of the return to capital) will be zero and the implicit rental r per acre accruing to land in any given point in time is

$$(3) \quad r[K^*, L^*, A(S)] = [P \cdot F[K^*, L^*, A(S)] - wL^* - (i + \delta)K^*] / A(S)$$

where the asterisks indicate equilibrium, profit maximizing levels of inputs and supply.

That is, after the household-farmer pays all the costs of production, including implicit labor costs equal to the opportunity cost of employing his labor services in the next best alternative, and capital, rents per acre are equal to the net revenue minus labor and capital costs at the zero profit equilibrium point. K^* and L^* are the solutions to the first order conditions. At this profit maximizing point, the marginal return to land, i.e., the value of land's marginal productivity, will also be equal to its rental price.

Equation (3) is used to estimate rents per acre and total rents which is then compared with the NCT's estimates. $r(K^*, L^*, A)A$ is the total land rental which is estimated and compared with the NCT's estimates. The data used to calculate rents per acre as defined by equation (3) are in **Table 5**. These data, in particular the data in column (2) for 1982-1990, are the starting point for the calculation of $r[K^*, L^*, A(S)]$ in equation (3) above. Column (1) replicates column (2) in Table 4. Column (2) estimates labor costs for the agricultural, fishing, and forestry sector. The estimates are based on available data on employment in that sector and average wages for private sector employment. Column (3) estimates capital costs for that same sector, based on depreciation deductions data from the NIPA. The discount rate is assumed to be 6%, and the capital depreciation rate is straight line with a recovery period of 20 years (a weighted average of residential and non-residential business capital). Column (4) shows the estimates of "gross" rents per acre before any adjustments, such as for the economic effects of nuclear testing, which is addressed next.

Adjusting for the Economic Effects of Nuclear Testing

Before equation (3) can be applied to measure rents, an adjustment has to be made to account for the adverse effects of nuclear testing on the RMI economy. It can

be reasonably assumed that RMI's total economic output (the production function $F[K^*, L^*, A(S)]$) would have been higher had there been no nuclear testing.⁶²

Table 5. Data Used to Estimate Unadjusted Rents per Acre from Equation (3)

Year	$pF[K^*, L^*, A(S)]$ (1)	wL^* (2)	$(i + \delta)K^*$ (3)	$r[K^*, L^*, A(S)]$ (4)
1982	\$3,900,000	\$589,140	\$428,890	\$77/acre
1983	\$4,659,000	\$648,576	\$512,490	\$102/acre
1984	\$5,038,000	\$658,822	\$554,180	\$103/acre
1985	\$4,897,000	\$802,332	\$538,670	\$96/acre
1986	\$6,363,000	\$1,165,605	\$699,930	\$121/acre
1987	\$7,029,000	\$1,475,711	\$773,190	\$128/acre
1988	\$7,889,000	\$1,856,166	\$867,790	\$139/acre
1989	\$8,124,000	\$1,836,126	\$893,640	\$145/acre
1990	\$8,758,000	\$1,607,808	\$963,380	\$166/acre

Source: CRS estimates based on RMI's National Income and Product Accounts data available from various reports cited elsewhere in this report.

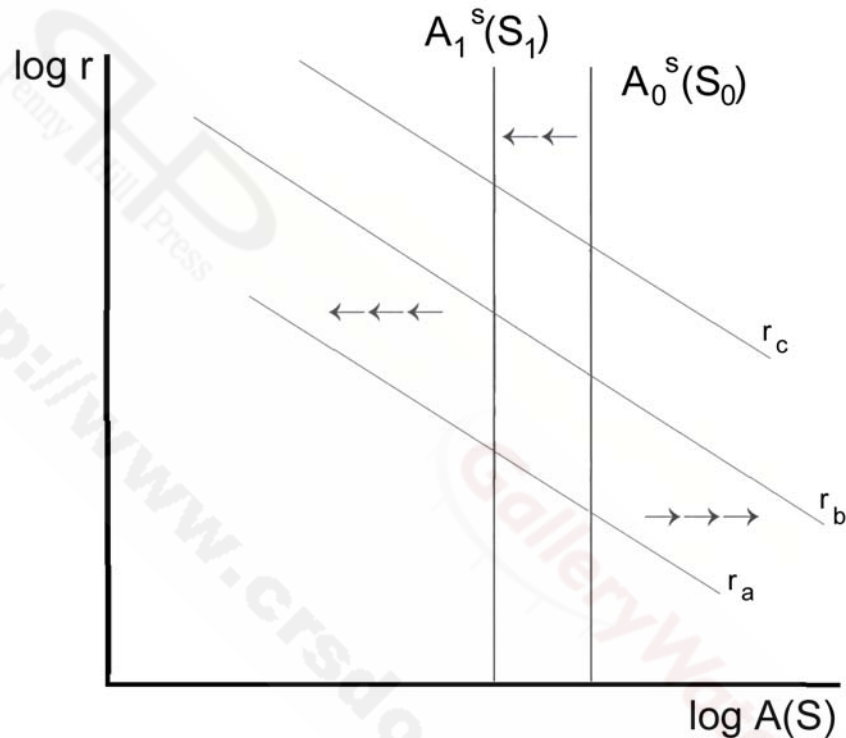
As discussed, nuclear testing reduced the total quantity of land, vaporizing about 13% of Enewetak's and Bikini's land area. But such testing also reduced soil fertility — the quality of the land on Enewetak and Bikini as a factor of production.⁶³ In addition, nuclear testing led to the contamination of the remainder of the two atolls for many years. According to **Table 2**, the entire atoll land areas (3,842 acres) are sufficiently contaminated to prevent their full use until at least 2026 (Enewetak) and 2027 (Bikini). Indeed, some parts of the two atolls may never be usable at all because they can never be completely sufficiently decontaminated as to be safe for human

⁶² This is merely an assumption to facilitate computation of equation (3). One could also argue that had nuclear testing not occurred, there would have been less U.S. assistance, and RMI's level of economic development, would have been much less, and therefore rents would have been smaller.

⁶³ In addition, nuclear testing has reduced rents from what they would otherwise be due to its adverse effects on the productivity of the labor force (the L in equation (3)). Labor productivity would be lower than had there been no testing because of radiation exposure to the residents of Enewetak, Bikini, and other atolls, primarily Rongelap and Utrik. Such exposure results in a variety of adverse biological effects and diseases. Some experts believe that nuclear testing caused high birth defects and weakened immune systems, as well as high thyroid, cervical, and breast cancers in the RMI population. Many other diseases may also be linked to exposure to ionizing radiation, which would have reduced labor productivity, output supply, and land rents.

habitation. Also, two other atolls, Rongelap and Utrik, were contaminated by fallout from the tests on Enewetak and Bikini.⁶⁴ This contamination of the lands of the four atolls reduced the fertility of the soil — the marginal productivity of the land — and therefore the rents. These effects are shown in **Figure 2**.

Figure 2. The Supply of and Demand for Land After Nuclear Testing



$r_b [K, * L, * A(S)]$ is the demand for land before nuclear testing. The supply of land is fixed at $A^s(S)$. The effects of nuclear testing are shown by an leftward shift of the demand curve to $r_a [K, * L, * A(S)]$, and a leftward shift of land supply curve to $A_1^s(S_1)$. In order to adjust for these effects, CRS determined the average output per acre for RMI lands other than Enewetak and Bikini. These lands and surrounding ecosystems are assumed not to be affected adversely by nuclear testing during the 1940s and 1950s. That figure is then multiplied by the unusable acreage (the vaporized and contaminated land area) on Enewetak and Bikini. This figure is then added back in to the total agricultural output of the RMI generally to which equation (3) is applied to determine rents per acre. The net result is a procedure which brings the demand for land, hence land rents, back to the pre-nuclear testing position $r_b [K, * L, * A(S)]$.

⁶⁴ There is much disagreement on the extent of contamination of the rest of the RMI. Some experts contend that 8 additional atolls were contaminated in addition to the four mentioned in the text.

Estimation Results

The results of calculating adjusted equation (3) appear in **Table 6** column (1), which is essentially the figures from column (4), **Table 5** with the aforementioned adjustments for the economic effects of nuclear testing. The corresponding total “gross” annual rental — gross because it represents the value of the loss-of-use before adjustments for interest, alternative habitation, and prior compensation — is shown in column (3). Note that, due to lack of data, estimates could be generated only for years 1982-1990.

The results support the conclusions in the first section of the report, as well as the empirical evidence presented in the second section, that the rents and loss-of-use damages estimated by the NCT are apparently significantly overstated. More specifically, summing up the values for the nine-year period 1982-1990 shows an apparent overstatement of rents by a factor of 10. Note that this does not include the cultural or environmental value of the land to the Enewetak and Bikini peoples as discussed in the next section.

The Value of Environmental Amenities

The final adjustment in estimated rents/acre is for the value of environmental amenities. Equation (3) does not fully reflect the value of the services provided by the Enewetak and Bikini ecosystem as natural capital. Environmental amenities generate utility, and thus, have value to the community of the RMI in addition to their value as factors of production to landowners. Environmental amenities are part of the ecosystem; they are public goods that are not traded in the marketplace and thus their value cannot be easily measured in dollars as for most tradeable commodities.⁶⁵ These lands, and the environmental amenities (the shores, lagoons, reefs, vegetation and the entire ecosystem) support the culture and sustain the lives of the inhabitants and thus have a value in use beyond market or exchange (tradeable) value.

Table 6. Comparison of CRS-Estimated Rents With NCT Estimated Rents, 1982-1990

Year	Rents/Acre		Total “Gross” Annual Rental for Enewetak and Bikini	
	CRS Estimates (1)	NCT Estimates (2)	CRS Estimates (3)	NCT Estimates (4)
1982	\$115	\$1,902	\$441,830	\$5,991,541
1983	\$137	\$1,970	\$526,354	\$6,198,558

⁶⁵ Public goods such as national defense and other common property resources are commodities whose consumption and use is non-rival, equally available to all, who cannot be excluded from their enjoyment and use, and which are non-divisible (the commodity cannot be parceled out or divided).

	Rents/Acre		Total “Gross” Annual Rental for Enewetak and Bikini	
1984	\$148	\$2,045	\$568,616	\$6,425,800
1985	\$144	\$2,128	\$553,248	\$6,678,266
1986	\$187	\$2,219	\$718,854	\$6,954,109
1987	\$207	\$2,320	\$795,294	\$7,257,788
1988	\$232	\$2,431	\$891,344	\$7,592,997
1989	\$239	\$2,553	\$918,238	\$7,961,042
1990	\$258	\$2,939	\$991,236	\$9,155,949
Totals	— -	— -	\$6,405,011	\$64,216,046

Source: CRS estimates based on data provided by the NCT in the two appraisal reports. NCT estimates are obtained from the two appraisal reports.

The people of Enewetak and Bikini have always maintained deep emotional ties to their land, which traditionally could not be sold, is “owned or used” as a matter of birthright, and bequeathed to one’s progenitors only. Because there are no markets for such goods, alternative estimation procedures must be used to assess value. In terms of **Figure 2**, the value of environmental amenities would raise rents from $r_b [K, * L, * A(S)]$ to $r_c [K, * L, * A(S)]$.

While economists have developed methodologies for estimating such non-market values, the data for the RMI are not available to permit estimation. Such estimates as are available suggest values ranging from \$23-61/acre for the amenity value of South Carolina farmland, to \$1,205-\$1,597/acre for the value of wetlands in different locations (all values are in 2000 dollars).⁶⁶

Conclusions

In conclusion, based on 1) an analysis of the NCT’s loss-of-use methodology, 2) empirical evidence of agricultural land rents in the continental United States, Hawaii, and selected areas of the Pacific, and 3) alternative estimates based on a neoclassical economic model of land rents in the RMI — estimates that are consistent with the real underlying productivity of agricultural lands on Enewetak and Bikini — the \$522 million figure for loss-of-use of Enewetak and Bikini atolls appears to be significantly overstated.

⁶⁶ See McConnell, Virginia and Margaret Walls. *The Value of Open-Space: Evidence from Studies of Nonmarket Benefits*. Resources for the Future, Jan. 2005, Table 2, pp. 56-57.

Technical Appendix A: The NCT's Formulas for Estimating Past Loss-of-Use

The formula used by the NCT for estimating retrospective (past) loss-of-use is

$$(1) \quad \sum_{t=1}^n (R_t A_t - R_t^c A_t^c - C_t)(1+r_t)^{n-t} + \sum_{t=1}^{n-m} (R_t A_t - R_t^c A_t^c - C_t)(1+r_{t+m-1})^{n-t}$$

where

- R_t = average rents per acre on Enewetak and Bikini in year t
- A_t = acreage of Enewetak and Bikini lost to use in year t
- R_t^c = average rents per acre on alternative habitation
- A_t^c = acreage of alternative habitation
- C_t = loss-of-use compensation previously provided by the U.S.
- $n = 50$ (52 for Bikini), $m = 30$,
- $t = 1$ represents 1947 for Enewetak, 1946 for Bikini
- r_t = discount rate in year t (the rate on 30-year U.S. Treasury bonds)

But,

$$(2) \quad R_t = (R_t^{Ma} + R_t^{Mb}) / 2$$

And, for Enewetak

$$(3) \quad R_t^c = .58 [(R_t^{Ma} + R_t^{Mb}) / 2]$$

Thus, for Enewetak

$$(4) \quad \sum_{t=1}^n [.42 (R_t^{Ma} + R_t^{Mb}) / 2 (A_t - A_t^c) - (C_t)] (1+r_t)^{n-t} \\ + \sum_{t=1}^{n-m} [.42 (R_t^{Ma} + R_t^{Mb}) / 2 (A_t - A_t^c) - (C_t)] (1+r_{t+m-1})^{n-t}$$

where

$$(5) \quad R_t^{Ma} = e^{(\alpha + \beta t)}$$

are the fitted values of the regression $R_t^M = e^{(\alpha + \beta t + u)}$ for years 1940-1996, where R_t^M is the 5-year moving average of rents/acre in time t, and u is a log-normally distributed random disturbance term, and

$$(6) R_t^b = \begin{cases} e^{(a+bt)} & \text{for years } t = 1940 - 1978 \\ \$2,500 / \text{acre} & \text{for years } t = 1979 - 1989 \\ \$3,000 / \text{acre} & \text{for years } t = 1990 - 1996 \end{cases}$$

and $e \approx 2.718281828$.⁶⁷

⁶⁷ The \$2,500 and \$3,000 figures are the official government rental rate, as explained in the text. See *Appraisal Report of the Aggregate Loss in Use Value in the Bikini Atoll in the Republic of Marshall Islands*. Report written for Mr. Jonathan Weisgall, Chartered, Hallstrom Group, Inc., Nov. 19, 1997. pp. 32-33.

Technical Appendix B: The NCT's Formulas for Estimating Future Loss-of-Use

The future loss-of-use value is estimated as the present value, at the time of the valuation (1996 for Enewetak; 1997 for Bikini) of the projected future stream of annual rents over thirty years, discounted at 8%, assuming that rents begin at those estimated in the past loss-of-use model, and adjusting for alternative habitation provided,

$$(1) \quad PV = \sum_{t=1}^n (R_t A_t - R_t^c A_t^c) (1 + r_t)^{-n}$$

which, for Enewetak would be

$$(2) \quad PV = \sum_{t=1}^n .42 (R_{1996}^a + R_{1996}^b) / 2 (A_{1996} - A_{1996}^c) (1 + r_t)^{-n}$$

With the assumed constant annual rentals over the thirty year period through 2026, the formula reduces to

$$(3) \quad PV = .42 (R_{1996}^a + R_{1996}^b) / 2 (A_{1996} - A_{1996}^c) [(1/r_t) - (1/r_t) (1 + r_t)^{-n}]$$

where

$$(4) \quad (R_{1996}^a + R_{1996}^b) / 2 = \$4,105 \quad \text{for Enewetak}$$

$$(5) \quad (R_{1997}^a + R_{1997}^b) / 2 = \$4,167 \quad \text{for Bikini}$$

$$r_t = .08$$

$$n = 30$$