HYDROLOGIC RADIOLOGICAL BASELINE PROGRAM AT WIPP

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ABSTRACT

The Waste Isolation Pilot Plant (WIPP) is a Department of Energy (DOE) facility designed for demonstrating the safe disposal of defense-generated transuranic wastes. The Radiological Baseline Program (RBP) supplies pre-operational radiological data for the WIPP site. A subset of the Radiological Baseline is the Hydrologic Radiological Baseline Program (HRBP), which provides data from surface and ground water systems in the vicinity of the WIPP site.

Baseline data from one sweep of ground water and two sweeps of surface water sites in the vicinity of WIPP is presented. The ten surface water sites include: the only through-going river, several engineered catchments, and two lakes covering an extensive area in the vicinity of the WIPP site. The ground water program, part of the Water Quality Sampling Program, consists of sampling twenty wells from four water-bearing units at the WIPP site. One water-bearing zone, the Culebra Dolomite Member of the Rustler Formation, has been the subject of the most extensive sampling and analyses efforts as it is considered the most feasible transport conduit in the event of a breach of the repository. Data reported to date indicates low levels of uranium, radium and radon are present in the ground water. This report represents the first of several sampling suites for the pre-operational baseline characterization at the WIPP site.

INTRODUCTION

The HRBP at WIPP is a subset of the RBP. The HRBP program includes sampling of surface and ground waters at and near the WIPP site in order to establish baseline values for radionuclides currently present at the WIPP. The surface water program is carried out under the direction of the Guidance Manual for Surface and Sediment Sampling for the Environmental Monitoring Program at WIPP(1). The ground water portion of the HRBP is conducted under the guidance of the Water Quality Sampling Program (WQSP)(2). Both programs involve sampling of waters for both radiological and nonradiological parameters. This presentation will focus primarily on general water quality parameters and the radiological aspects of the programs. Ten surface water sites and 23 ground water sites have been sampled and analyzed. Several rounds of data consisting of samples from each location will be collected as the data base for the baseline values.

The ten surface water sampling locations are presented in Fig 1. These locations represent four sampling locations along the only through-going stream in the vicinity of the WIPP site, the Pecos River. Five locations represent near-site engineered catchments for stock watering, and the last site is a large ephemeral salt lake whose volume fluctuates with rainfall and mining activity in the area. All ten locations were sampled for the suite of radionuclide analyses given in Table I. In addition, bottom sediments were collected from five locations for the

TABLE I

Analytes in the Radiological Surface Water and Sediment Sampling Program

FIELD PARAMETERS*	LABORATORY PARAMETERS
pH	General
Density	
Temperature	Total Suspended Solids*
Specific Conductance	Moisture Content**
	Radionuclides
	Plutonium-238
	Plutonium-239, 240
	Plutonium-241
	Uranium-233
	Uranium-234
	Uranium-238
	Americium-241
	Neptunium-237
	Curium-244
	Radium-226
	Cesium-137
	Strontium-90
	Tritium*
	Thorium-230
	Thorium-232
	Thorium-228

*Analyzed in water samples only.
**Analyzed in sediment samples only.

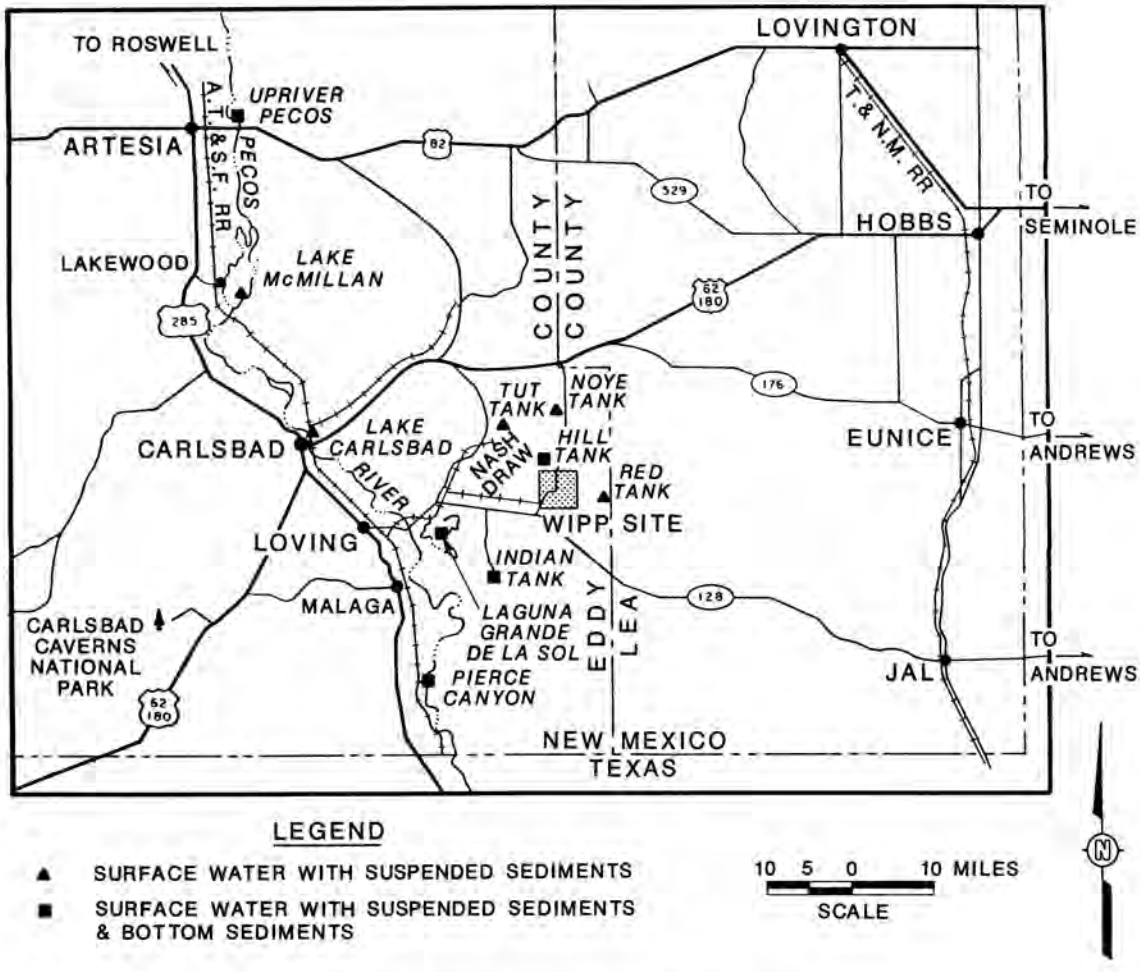
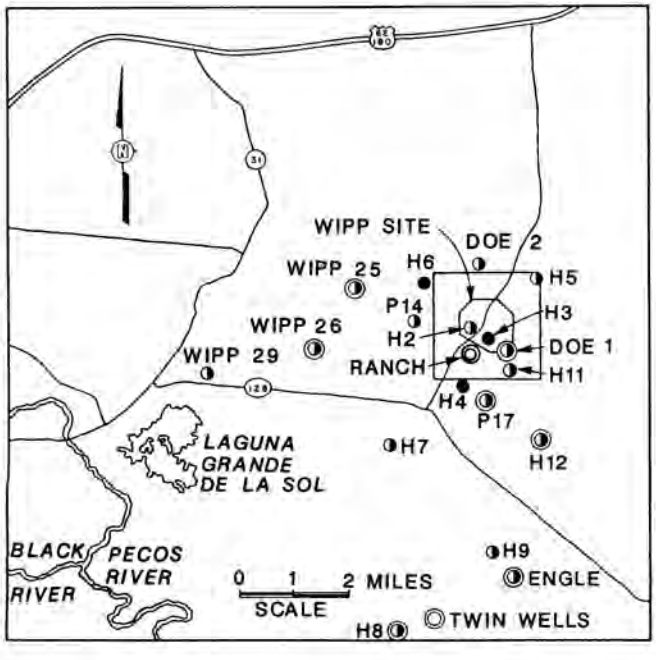


Fig. 1. Surface Water Sampling Locations.



LEGEND

A. LOCATIONS TO BE SAMPLED AT LEAST TWICE FOR ACTINIDES AND FISSION PRODUCTS

◑ WATER FROM CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION

◐ WATER FROM MAGENTA DOLOMITE MEMBER OF THE RUSTLER FORMATION

● WATER FROM BOTH MEMBERS

B. LOCATIONS TO BE SAMPLED AT LEAST ONCE AND COUNTED FOR GROSS AND

◑ WATER FROM CULEBRA DOLOMITE MEMBER OF THE RUSTLER FORMATION

◐ WATER FROM MAGENTA DOLOMITE MEMBER OF THE RUSTLER FORMATION

◎ WATER FROM UNITS IN THE DEWEY LAKE REDBEDS

Fig. 2. Ground Water Sampling Locations.

suite of radionuclides. Water and sediment samples for the EPA's Hazardous Substance List were collected from five locations.

The ground water locations represent water from four water bearing zones, three of which overlay the repository horizon. Fig. 2 presents locations of the ground water sampling locations while Fig. 3 shows the general stratigraphy of the WIPP site with the facility horizon being noted. The four water-bearing zones, in descending stratigraphic order, are: the Dewey Lake Red Beds, the Magenta and Culebra Dolomite Members of the Rustler Formation, and the Bell Canyon formation.

Sampling Methodology

Surface water samples are collected biannually. At six locations, single samples were collected. Composite samples were collected from the remaining locations. Composite samples are generally collected when a single sample cannot adequately represent the sampling area. Table II summarizes the pertinent information with respect to surface water sampling. At the time samples are collected, field measurements are made of pH, water temperature, conductivity, wind speed, and air temperature.

Ground water samples are being collected annually from three locations. Samples are collected and analyzed either for gross alpha/beta or the specific suite of radionuclide analyses. Ground water samples are also collected for a variety of other analyses supporting other research and monitoring programs at WIPP. Table III lists the pertinent information relevant to the ground water program. The primary goal of the Water Quality Sampling Program is to obtain representative and repeatable ground water quality data from selected wells under rigorous pumping and analytical chemistry protocol. At each sample site, the water-bearing zone of interest was pumped as continuously as possible, and the water serially analyzed for selected field parameters. When values for those parameters indicate that chemical stabilization had been reached, final samples for analysis were collected.

RESULTS AND DISCUSSION

General Water Quality: Surface Water

Surface water quality as indicated by the field parameters, shows the various points on the river and catchments to be fairly fresh. The salinity of the Pecos River increases as it moves southward. The catchments drain rather large areas of land and runoff can be quite extensive depending on rainfall. Laguna Grande de la Sal is a large salt lake whose bottom is dredged frequently for salt. This lake is saturated with respect to sodium chloride. Recently, samples were collected from selected locations for EPA's Hazardous Substance list; however, the results have

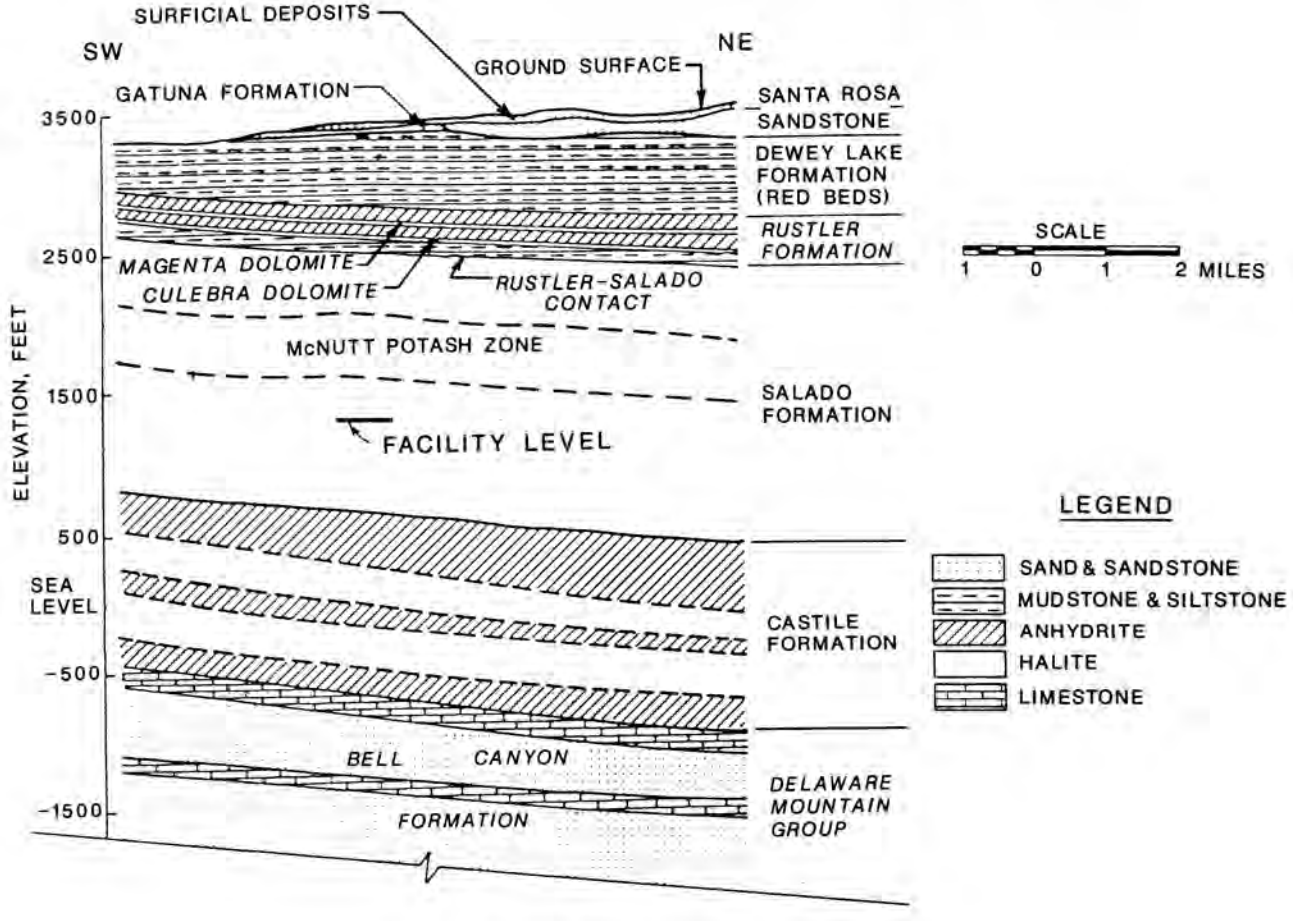


Fig. 3. General Stratigraphy of the WIPP Site.

TABLE II

Radiological and Non-Radiological Monitoring

STATION	RADIOLOGICAL		NON-RADIOLOGICAL	
	SURFACE WATER	SEDIMENT	SURFACE WATER	SEDIMENT
Upriver Pecos	X	X	---	---
Lake McMillan	X(1)	---	---	---
Lake Carlsbad	X(1)	---	---	---
Pecos River, Pierce Canyon	X	X	---	---
Laguna Grande de la Sal - Laguna Tres	X(1)	X	X(1)	X
Red Tank	X	---	X	X
Hill Tank	X	X	X	X
Tut Tanks	X(1)	---	---	---
Indian Tank	X	X	X	X
Noye Tank	X	---	---	---
TOTAL	10	5	4	4

X = Sample scheduled to be taken.
--- = No sample scheduled to be collected.
(1) = Composite of subsamples.

TABLE III

Ground water Sampling Information

Well Name	Zone*	Hydrologic Testing	Type of Samples**				Long-Term Schedule***		
			SNL	RBP	WQM		85-88	89-93	94-2013
H-2a	C		X	X	X		X	X	
H-3b3	C		X	X	X		X	X	X
H-3b1	M		X	X	X		X	X	
H-4c	M		X	X	X		X	X	X
H-4b	C		X	X	X		X	X	X
H-5b	C		X	X	X		X	X	X
H-6b	C		X	X	X		X	X	X
H-6c	M		X	X	X		X	X	
H-7b1	C	X	X	X	X		X		
H-8b	C	X	X		X	X	X		
H-9b	C	X	X	X	X		X		
H-11b3	C	X	X	X	X		X	X	X
H-12	C		X		X	X			
P-14	C		X	X	X		X	X	X
P-17	C		X		X	X		X	
DOE-1	C		X		X	X	X	X	
DOE-2	C	X	X	X	X				
DOE-2	BC	X	X	X	X				
WIPP-25	C		X		X	X	X		
WIPP-26	C		X		X	X	X		
WIPP-29	C		X	X	X		X		
ENGLE	C		X		X	X			
RANCH	DL	X	X		X	X	X		
TWIN	DL		X		X	X			

*C - Culebra, M - Magenta, DL - Dewey Lake, BC - Bell Canyon
**SNL - Sandia Site Characterization Sampling
RBP - MOC Radiological Baseline Program Sampling
WQM - MOC Water Quality Monitoring Samples (Baseline Parameters)
- MOC Scan only
***As currently planned, one sample per year per well will be collected from 1985-1993, and one sample every two years from 1994-2013.

not as yet been reported. More detailed information regarding surface water sampling and analysis has been published in Reith (3).

General Water Quality: Ground Water

An extensive ground water program is ongoing at the site, supporting site characterization activities as well as long term monitoring programs. A complete set of one round of water quality data is presented in Uhland (4). The ground water at and near the WIPP site shows great variability in total dissolved solids. Concentrations of sodium chloride range from 30 to over 230,000 mg/L. Values for the organic portion of the EPA Hazardous Substance list has, in general, been below detectable values for all wells analyzed to date. The ground water near the site is not used for drinking water purposes and can be shown not to be of drinking water quality.

Radiological Considerations

Table IV presents radiological results reported to date for two rounds of surface water collections. Results indicate trace concentrations of ^{226}Ra and ^{234}U from some sampling locations; typically, radionuclide concentrations are at or below the detection limit for each analysis. Table V presents radiological results reported to date for ten ground water locations. (See next two pages for Tables IV and V.)

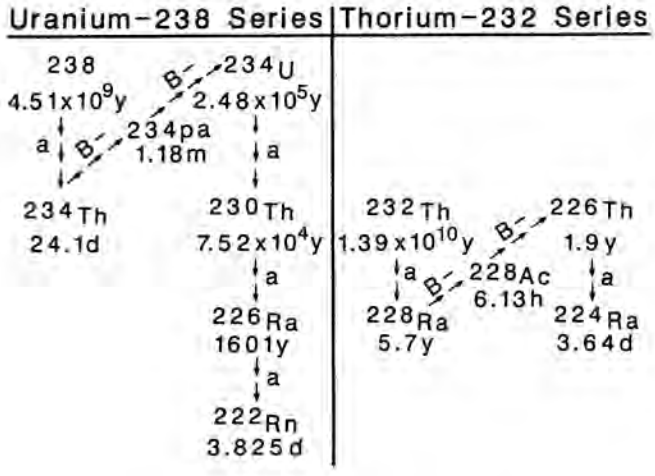


Fig. 4. Nuclide Decay Structure.

Ground water results indicate the presence of isotopes of uranium, radium and radon. Fig. 4 depicts portions of two decay schemes from naturally occurring nuclides representing the results reported in the ground water samples. Values for ^{234}U are in secular disequilibrium with its great-grandparent ^{238}U. Three possible mechanisms have been proposed to account for the observed ^{234}U excess in natural waters(5).

a) The recoil energy of the ^{238}U alpha decay ejects the daughter ^{234}Th from the solid phase into the solution. The released thorium remains in solution long enough to decay to ^{234}U.

b) The alpha-recoil from ^{238}U decay disrupts the mineral lattice allowing preferential leaching of ^{234} (or perhaps ^{234}Th). This is commonly called the "hot atom" effect.

c) The ^{234}U produced from decay is initially in the +6 oxidation state and has more mobility than the +4 ^{238}U.

Chloride complexation has been considered to be a factor in the solubility of both uranium and radium, but no clear trend can be discerned from available data.

SUMMARY AND CONCLUSIONS

As more data is collected and sampling sweeps are repeated, a statistical treatment of the data can be accomplished. A more complete set of data will also lend itself to explain some of the initial observations of uranium disequilibrium. Correlations may then be made regarding water chemistry and radionuclide concentrations. The HRBP is an ongoing project that will be reporting its results in the form of DOE annual reports and site documents.

REFERENCES

1. S. D. PRILL and G. R. BUCKLE, "Guidance Manual: Surface Water and Sediment Sampling for the Environmental Monitoring Programs," Waste Isolation Pilot Plant, Carlsbad, New Mexico, (December 1986).

2. I. D. COLTON and J. G. MORSE, "Water Quality Sampling Plan," WIPP-DOE-215, Waste Isolation Pilot Plant, Carlsbad, New Mexico (1985).

3. C. C. REITH et al., "Annual Site Environmental Monitoring Report for the Waste Isolation Pilot Plant," DOE-WIPP 86-002 (1986).

4. D. W. UHLAND and W. S. RANDALL, "Annual Water Quality Data Report for the Waste Isolation Pilot Plant," DOE-WIPP-86-006, Carlsbad, New Mexico (1986).

5. H. J. SIMPSON et al., "Mobility of Radionuclides in High Chloride Environments," Nureg/CR-4237, (1983).

TABLE IV

Radiological Results Reported for Two Rounds of Surface Water Collections

	Sample Location							
	Indian Tank	Laguna Grande De La Sal	Upriver Pecos	Lake McMillan	Tut Tanks	Red Tank	Pierce Canyon	Lake Carlsbad
Date	12/18/85	12/16/85	12/17/85	12/17/85	12/16/85	12/16/85	12/17/85	12/17/85
Ra-226	$2.2\pm0.31 \times 10^{-8}$	LD	LD	LD	LD	LD	LD	LD
Th-228	$1.3\pm1.2 \times 10^{-8}$	$3.2\pm1.8 \times 10^{-9}$	LD	LD	LD	LD	LD	LD
K-40	LD	$2.1\pm0.052 \times 10^{-5}$	LD	LD	LD	LD	LD	LD
Ra-228	LD	LD	$2.9\pm2.6 \times 10^{-8}$	LD	LD	LD	LD	LD
U-233	LD	LD	LD	LD	LD	LD	LD	LD
U-234	$1.0\pm0.63 \times 10^{-9}$	$2.1\pm0.27 \times 10^{-8}$	$8.2\pm1.0 \times 10^{-9}$	$2.8\pm0.71 \times 10^{-10}$	$2.4\pm0.65 \times 10^{-9}$	LD	$6.5\pm0.63 \times 10^{-9}$	$3.0\pm0.57 \times 10^{-9}$
U-235	LD	$7.0\pm5.6 \times 10^{-10}$	LD	$4.4\pm3.1 \times 10^{-10}$	LD	LD	$2.0\pm1.4 \times 10^{-10}$	LD
U-238	LD	$1.1\pm0.19 \times 10^{-8}$	LD	$1.9\pm0.53 \times 10^{-10}$	$4.6\pm3.0 \times 10^{-10}$	LD	$2.7\pm0.42 \times 10^{-9}$	$1.5\pm0.40 \times 10^{-9}$
Pu-241	LD	LD	LD	$2.8\pm1.5 \times 10^{-8}$	$3.8\pm1.2 \times 10^{-8}$	LD	LD	LD
Date	04/17/86	04/17/86	04/17/86	04/17/86	04/17/86	04/17/86	04/17/86	04/17/86
Ra-226	$8.0\pm1.3 \times 10^{-9}$	$5.6\pm4.2 \times 10^{-9}$	LD	LD	LD	LD	$7.7\pm0.54 \times 10^{-9}$	LD
Th-228	LD	LD	LD	LD	LD	LD	$3.5\pm2.4 \times 10^{-9}$	LD
K-40	LD	$3.1\pm0.055 \times 10^{-5}$	LD	1.4×10^{-7}	$7.4\pm4.3 \times 10^{-7}$	LD	LD	LD
U-233				LD		LD		
U-234				$2.6\pm0.51 \times 10^{-9}$		LD		
U-235				$1.2\pm1.1 \times 10^{-10}$		LD		
U-238				$1.4\pm0.36 \times 10^{-9}$		$3.4\pm2.2 \times 10^{-10}$		
Pu-241	LD	LD	LD	LD	LD	LD	LD	$8.9\pm5.5 \times 10^{-8}$

LD = Less than detectable.
The following were analyzed and found to be less than detectable:

Am-214	Np-237	Ra-228
Cm-244	Pu-238	Th-230
Co-60	Pu-239/240	Th-232
Cs-137	Sr-90	

TABLE V

Radiological Results Reported for Ten Ground Water Locations

	Sample Location									
	H-09b	H-06b	H-03b1	H-04b	H-11b3	DOE-2	H-03b3	WIPP-29	H-05b	H-12
Date	11/14/85	09/15/85	07/01/85	07/20/85	06/03/85	03/12/85	02/04/85	12/14/85	08/27/85	08/05/85
Ra-226	1.0±0.13 x 10^{-8}	LD	2.4±1.2 x 10^{-8}	6.9±2.2 x 10^{-8}	1.2±0.25 x 10^{-7}	1.6±0.3 x 10^{-7}	1.3±0.27 x 10^{-7}	1.1±0.85 x 10^{-8}	2.9±0.65 x 10^{-7}	2.39 x10^{-7}
Th-228	LD	LD	LD	3.1±2.5 x 10^{-9}	8.4±6.9 x 10^{-9}	1.0±0.63 x 10^{-8}	8.5±7.5 x 10^{-9}	LD	1.2±0.11 x 10^{-8}	LD
K-40	LD	3.0±0.81 x 10^{-7}	LD	1.9±1.2 x 10^{-7}	LD	LD	LD	2.1±0.045 x 10^{-5}	9.2±5.6 x 10^{-7}	--
Ra-228	LD	LD	LD	2.4±0.5 x 10^{-8}	4.0±0.84 x 10^{-8}	1.8±0.59 x 10^{-8}	3.0±1.9 x 10^{-8}	LD	4.6±0.84 x 10^{-8}	2.45 x10^{-8}
U-234	2.1±0.11 x 10^{-8}	7.2±0.73 x 10^{-9}	LD	1.7±0.10 x 10^{-8}	1.3±0.098 x 10^{-8}	2.9±0.23 x 10^{-8}	1.5±0.11 x 10^{-8}	1.8±0.25 x 10^{-8}	LD	2.2 x10^{-9}
U-235	5.6±2.3 x 10^{-10}	LD	5.0±0.97 x 10^{-10}	1.4±1.2 x 10^{-10}	1.6±1.3 x 10^{-10}	3.5±2.9 x 10^{-10}	LD	LD	LD	--
U-238	1.0±0.079 x 10^{-8}	2.3±0.39 x 10^{-9}	LD	2.5±0.4 x 10^{-9}	2.5±0.43 x 10^{-9}	4.6±0.91 x 10^{-9}	2.4±0.42 x 10^{-9}	6.9±1.5 x 10^{-9}	LD	1.39 x10^{-9}
Rn-222	6.05 x 10^{-7}	7.45 x 10^{-7}	1.57 x 10^{-7}	3.94 x 10^{-7}	6.40 x 10^{-7}	8.95 x 10^{-7}	5.1 x 10^{-7}	2.1 x 10^{-7}	6.45 x 10^{-7}	5.23 x 10^{-7}
Pu-241	LD	LD	LD	LD	1.2±0.67 x 10^{-7}	LD	LD	1.7±1.6 x 10^{-7}	5.5±3.4 x 10^{-8}	

LD = Less than detectable.
All values are reported in ci/ml.
The following were analyzed and found to be less than detectable:

Am-214	Np-237	Ra-228
Cm-244	Pu-238	Th-230
Co-60	Pu-239/240	Th-232
Cs-137	Sr-90	