M298NC

GULF OF THE FARALLONES RADIOACTIVE WASTE DISPOSAL SITE

by

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INTRODUCTION - History of the site

* Ocean disposal of radioactive waste began on the continental slope seaward of the Farallon Islands in 1946.

* From 1946 to 1970 a total of 47,546 containers with a total "estimated" activity, at the time of packaging, of 14,515 Ci (Joseph, 1971).

* During the period of 1946 to 1958, an estimated 24,305 (51% of the total) containers, with an estimated activity of 14,061 Ci (97% of the total) were disposed.

* Atomic Energy Commission (AEC) began licensing disposal activity in 1959.

* AEC records show disposal of 24,263 containers with an activity of 587 Ci from 1959 to 1970 (Tetra Tech, 1992). Discrepancies exist between the estimated values reported before 1958 and the AEC records.

* Radioactive waste was generated and disposed by the military, or its contractors. Disposal records are non-existent, lost or destroyed (Tetra Tech, 1992), which leads to the discrepancy in numbers of containers and activity level of disposal prior to 1959.

* Disposal operations occurred in three general areas

Table 1. Location and summary of the Gulf of the Farallones Low-level Radioactive Waste Disposal Sites

Site/ Location	Depth (m)	Distance from shore(km)	Years Used	Estimated Number of 55-Gallon Barrels	Estimated Activity (Curies)*
1-37°37'N 123°00'W	90 (295 ft)	45 (28 mi)	1946	150	unknown
2-37°38'N 123°8.5'W	900 (2953 ft)	60 (37 mi)	1951-1953	3,600	1,100
3-37°37'N 123°17'W to 123°20'W	1700 (5578 ft)	77 (48 mi)	1946-1950 1954-1964	44,000	13,400

* One Curie= 37 billion disintegrations per second

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Location map of the Radioactive Waste Disposal areas

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Table 2. Monitoring activity within the Radioactive Waste Disposal Area

Cruise Date	Site Sampled	Funding Agency	Type of Samples	Radionuclides Measured	Primary Source
1957, Apr	900m, 1700m	AEC	S,W,B	Gamma Emmission	Faughn, et.al., 1958
1960, Mar 30-Apr 3	1700m	AEC	S,W,B	Gamma and Beta Emmission	Pneumodynamics, 1961
1960, Nov	1700m	AEC	S,W,B	Gamma and Beta Emmission	Pneumodynamics, 1961
1974, Aug	900m	US EPA Office of Radiation Programs	S	^{238}Pu, $^{239+240}$Pu, ^{137}Cs	Dyer, 1976,1980
1975, Aug	1700m	US EPA Office of Radiation Programs	S		
1977, Jan	900m, 1700m	US Energy Research and Development Commission	S,W,B	^{238}Pu, $^{239+240}$Pu	Noshkin, et.al., 1978
1977, Aug 28 - Sept 2	900m, 1700m	US EPA Office of Radiation Programs	S,W,B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs, ^{90}Sr	Schell and Sugai, 1980
1977, Oct 18-27	900m, 1700m	US EPA Office of Radiation Programs	S,W,B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs, ^{90}Sr	Schell and Sugai, 1980
1985	900m	US EPA Office of Radiation and Indoor Programs	B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs, ^{90}Sr, ^{241}Am	Curtis, unpub. Data
1986, Dec - Jan, 1987	900m	Calif. Dept. of Health Services	B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs	Suchanek and Lagunas-Solar, 1991
1987 May - June	900m	Calif. Dept. of Health Services	B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs	Suchanek and Lagunas-Solar, 1991
1987, Aug - Sept	900m	Calif. Dept. of Health Services	B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs	Suchanek and Lagunas-Solar, 1991
1990	900m	EPA/NOAA/USN	A		Karl, et. al,1990, 1992,1994
1991	Reference Site	NOAA	S,B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs, ^{90}Sr, ^{241}Am	Curl, unpub
1992	900m	NOAA	S,B	^{238}Pu, $^{239+240}$Pu, ^{137}Cs, ^{90}Sr, ^{241}Am	Curl, unpub

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Location of monitoring sites and disposal areas

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Table of sample collection sites. Exact location of the 6 cores collected by Pieces VI is unknown.

Station	Latitude	Longitude	Depth(m)	239,240Pu mCi/km2// pCi/kg dry
Dyer 13A	37 38.0'	123 08.0'	920	
15	37 36.0'	123 06.0'	929	
6	37 36.0'	123 05.0'	945	
Noshkin N-1	37 38.5'N	123 18.0'W	2000	W/S 1.78/40
N-2	37 38.0'N	123 08.0'W	920	1.40/35.7
N-3	37 36.0'N	123 06.0'W	750	1.21/NA
N-4				NA/26.3
N-5	37 39.0'N	123 08.0'W	650	1.23/NA
N-6	37 38.5'N	122 58.0'W	99	0.41/29.0
N-7	37 42.6'N	122 44.0'W	Surface	0.19/NA
N-8	37 49'12"	122 28'37"	Surface	0.25/NA
N-9	37 31.0'N	123 8.5'W	Surface	0.38/NA
N-10	37 31.0'N	123 18.5'W	Surface	0.11/NA
Shell&Sugai2A	37 38.8'N	123 07.1'W	878	7.0
13A	37 38.1'N	123 08.0'W	1043	4.3
39	37 38.0'N	123 17.0'W	1469	1.3
47	37 38.3'N	123 14.0'W	1400	0.9
48	37 36.6'N	123 12.7'W	1216	2.2 2.1 (2 sub-cores analyzed separately)
Pisces Submersible 1				11.0
2				7.5
3				8.4
4				4.1

Station	Latitude	Longitude	Depth(m)	239,240Pu mCi/km2// pCi/kg dry
6				20.6
9				5.0
NOAA 1991	37.10833	122.80000		
NOAA 1992 2	37 38.453'	123 07.461'	560	
4	37 37.95'	123 07.43'	415	
5	37 38.93'	123 08.35'	480	
6	37 37.40'	123 06.70'	420	
9	37 38.40'	123 07.30'	342	
11	37 36.971'	123 06.009'	404	
12	37 37.620'	123 05.633'	415	

Table 3. Waste Container Sightings (Tetra Tech, 1992)

Lat	Long	Date	Number of Containers	Depth (m)	Vessel/Investigator	Document Reference
Between 37° 38.90' & 37° 38.82'	Between 123° 20.30' & 123° 19.63'	April, 1960	2 drums, not verified as radioactive waste	2,550	O/S Decatur Pneumodynamics/ AEC	00092, 00099
Station 13A 37° 37.95'	123° 8.01'	August, 1974	28 drums in 30mx60m area, 100 drums in 130mx250m area	913	CURV III IEC/EPA	00300, 00029
Station 13B 37° 38.04'	123° 7.548'	Aug, 1974	Unspecified number in area of 30mx30m	839	CURV III IEC/EPA	00300, 00029
37° 38.0'	123° 18.0'	Nov, 1975	Unspecified number	1,700	CURV III IEC/EPA	00300, 00029
37° 38.1'	123° 07.6'	Oct. 1977	1 drum recovered	900	Pisces III IEC/EPA	00100, 00187
		1977	Approx 40 drums and blocks	18-50	Divers/Project Tekite	R023
37°37.903'	123° 08.25'	June, 1985	1 drum identified	1,032	Avalon USN/EPA/CFG	00254
37° 37.33' 37° 37.38' 37° 39.94' 37° 41.33' 37° 40.53' 37° 39.14' 37° 38.31'	123° 07.18' 123° 08.24' 123° 12.56' 123° 14.24' 123° 12.35' 123° 11.40' 123° 11.52'	July, 1990 " " " " " "	Cluster, unspecified number; " " " " " "	900 1,000 1,300 1,100 1,000 1,100 1,100	R/V Farnella NOAA/USGS/EPA/ USN	00252
37° 28.40'	123° 07.6'	July, 1990	USS Independence, or a scuttled drydock	900	R/V Farnella NOAA/USGS/EPA/ USN	Karl, USGS
37° 30.30'	123° 00.3'	July, 1990	T/V SS Puerto Rican	370	R/V Farnella NOAA/USGS/EPA/ USN	Karl, USGS
			Pers. Comm.	unknown		Ueber & Van Peters

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Locations of radioactive waste disposal areas and waste container sightings (Tetra Tech, 1992).

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Locations of monitoring sites and waste container sightings.

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History of Congressional Funding

* In 1991 $900K was allocated to study Radioactive Waste disposal in the Gulf of Farallones

* Then-Congressman Doug Bosco gave $500K funding to NOAA

* Then-Congresswoman Barbara Boxer gave $400k to the EPA

Results of the Tetra Tech Report

* Significant uncertainty in the model because of the inaccuracy of disposal locations

* It is expected that clusters of containers are distributed in a random fashion over the sea floor.

* Tetra Tech was only able to collect information identifying 31,784 containers with a total activity of 702 Ci.

* Very little information on the specific radionuclides disposed of in any one event or overall.

* Eleven studies have examined radionuclide concentrations in sediments, water, or biota

    - 4 studies in the vicinity of the 900m site
    - 3 studies in the vicinity of the 1700m site
    - 4 studies at the 900m and 1700m site

Table 4. Maximum observed concentrations of radionuclides in water column, sediments and biota in the vicinity of the Gulf of the Farallones (Tetra Tech, 1992)

Medium	Units	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}Pu$	^{241}Am
Water Column	pCi/m^3	10	4.0	1.8	18	ND
Sediments	pCi/g-dry	0.23	0.137	0.027	0.946	0.184
Sablefish	pCi/g-wet	0.19	0.031	0.010	0.001	0.054
Shortspine Thornyhead	pCi/g-wet	0.005	0.006	0.017	0.002	0.004
Longspine Thornyhead	pCi/g-wet		0.003	0.017	0.002	0.004
Dover Sole	pCi/g-wet	0.0014	0.072	0.069	0.025	0.181
Tanner Crab	pCi/g-wet	ND		0.00025	.000078	ND
Sea Cucumbers	pCi/g-wet	0.00014	0.040	0.00028	0.0075	ND
Polychaetes	pCi/g-wet	ND	ND	ND	0.00090	ND

The Tetra Tech model calculated the Hazard Quotient for the following three scenarios

* Observed Conditions
* Worst Case
* Release and Dispersion

The following components of uncertainty were addressed in the development of the three scenarios

* Source characterization
* Radionuclide release from the waste forms
* Dispersion of radionuclides
* Rates of biological uptake of radionuclides
* Dose calculations

Table 5. Maximum Hazard Quotients for each receptor species under the three exposure scenarios. An Hazard Quotient (HQ) greater than 1 indicates the potential for risk to receptors (Tetra Tech, 1992).

Species	Observed Conditions	Worst Case	Release and Dispersion
Sablefish	$7.6*10^{-5}$	$1.2*10^{-1}$	$4.6*10^{-5}$
Shortspine Thornyhead	$4.0*10^{-5}$	$1.2*10^{-1}$	$8.1*10^{-5}$
Longspine Thornyhead	$2.3*10^{-5}$	$1.2*10^{-1}$	$8.1*10^{-5}$
Dover Sole	$1.1*10^{-4}$	$1.2*10^{-1}$	$1.1*10^{-4}$
Tanner Crab	$2.2*10^{-8}$	$8.5*10^{-5}$	$3.3*10^{-6}$
Sea Cucumbers	$2.5*10^{-7}$	$8.4*10^{-4}$	$3.3*10^{-6}$
Polychaetes	$2.6*10^{-5}$	$4.7*10^{-2}$	$3.9*10^{-3}$

^{241}AM not included in generating HQ.

HQ = calculated dose (mSv/h) / reference toxicity value (mSv/h)

Conclusions

* The Tetra Tech model doesn't answer the spatial relationship question of where the highest concentration of radionuclides occur.

* Distribution of the barrels still needs to be determined. The work by the USGS/BGS is a major step towards this goal.

* Determine the spatial distribution gamma emitters within the Radioactive Waste Disposal area. Work we will do with the help of BGS.

* Sablefish, Dover Sole and Tanner crab were selected as Receptors because of their market value in completing a Human Health Risk Assessment. At present results from these studies indicate there is not a problem.

* Market place monitoring program is difficult because most of the fish go to foreign markets

* Data from the Deep Ocean Disposal Site (DODS) studies indicate no problems.