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Eastern Environmental
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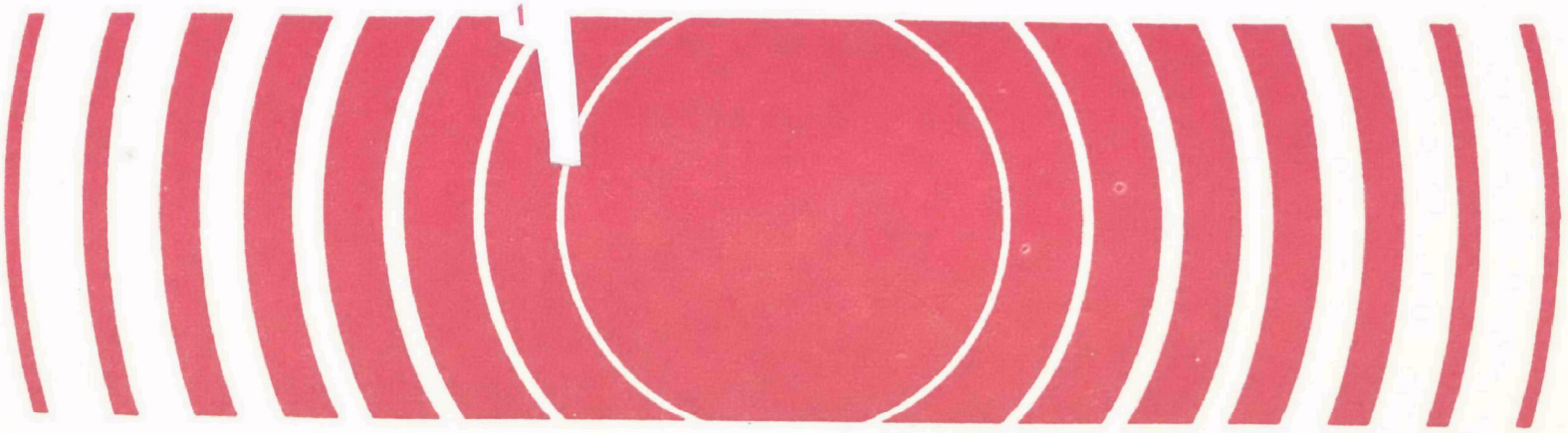

Radiological Survey of the Norfolk Naval Station, the Norfolk Naval Shipyard, and Newport News Shipbuilding

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Preface

The Office of Radiation Programs identifies and evaluates environmental public health impacts of both natural and man-made radiation sources. The Eastern Environmental Radiation Facility (EERF) is a fully integrated participant with other components of the Office in these efforts. The Facility provides comprehensive capability for evaluating radiation sources through planning and conducting environmental studies, nationwide surveillance, and laboratory analysis. The EERF also provides special analytical support for Environmental Protection Agency Regional Offices and other Federal government agencies, as requested, as well as technical assistance to the radiological health programs of State and local health departments.

This report presents results of the survey conducted by EERF personnel to assess levels of environmental radioactivity resulting from maintenance and operation of nuclear-powered warships at the Norfolk Naval Station, Norfolk Naval Shipyard and Newport News Shipbuilding. The purpose of the survey was to determine if activities related to nuclear-powered warships resulted in release of radionuclides which may contribute to significant population exposure or contamination of the environment.

Readers of our reports are encouraged to bring comments, omissions, or errors to our attention.

Charles R. Porter, Director
Eastern Environmental Radiation Facility

INTRODUCTION

Since 1963, the Eastern Environmental Radiation Facility (EERF), U.S. Environmental Protection Agency (USEPA), in cooperation with the U.S. Naval Sea Systems Command (NAVSEA) has surveyed facilities serving nuclear-powered warships on the Atlantic and Pacific coasts and the Gulf of Mexico. These surveys assess whether the operation of nuclear-powered warships, during construction, maintenance, overhaul, or refueling, have created elevated levels of radioactivity. The surveys emphasize sampling those areas and pathways that could expose the public.

In 1984, NAVSEA requested that EPA survey all active facilities servicing nuclear-powered warships over the next three years. This report contains the results of surveys conducted at Norfolk Naval Shipyard, Norfolk Naval Station and Newport News Shipbuilding during the period July 28 to August 1, 1986. Some of these same areas were previously surveyed by EERF personnel (at that time U.S. Public Health Service) in January 1968. Results of that survey are shown in (Ha68).

Characteristics of the Harbor and Sampling Areas

Three separate nuclear ship building or servicing harbors located in the Hampton Roads, Virginia area were surveyed. These included the U.S. Navy Shipyard at Portsmouth, the U.S. Naval Station at Norfolk and Newport News Shipbuilding at Newport News. All these facilities are located in the southeast corner of Virginia on either the James River or the Elizabeth River as they lead to the Chesapeake Bay.

The Hampton Roads area has more than 200 piers and wharves along more than 30 miles of improved waterfront. These facilities are heavily used by both conventional and nuclear powered vessels. A map of the general site locations for these surveys is shown in Figure 1.

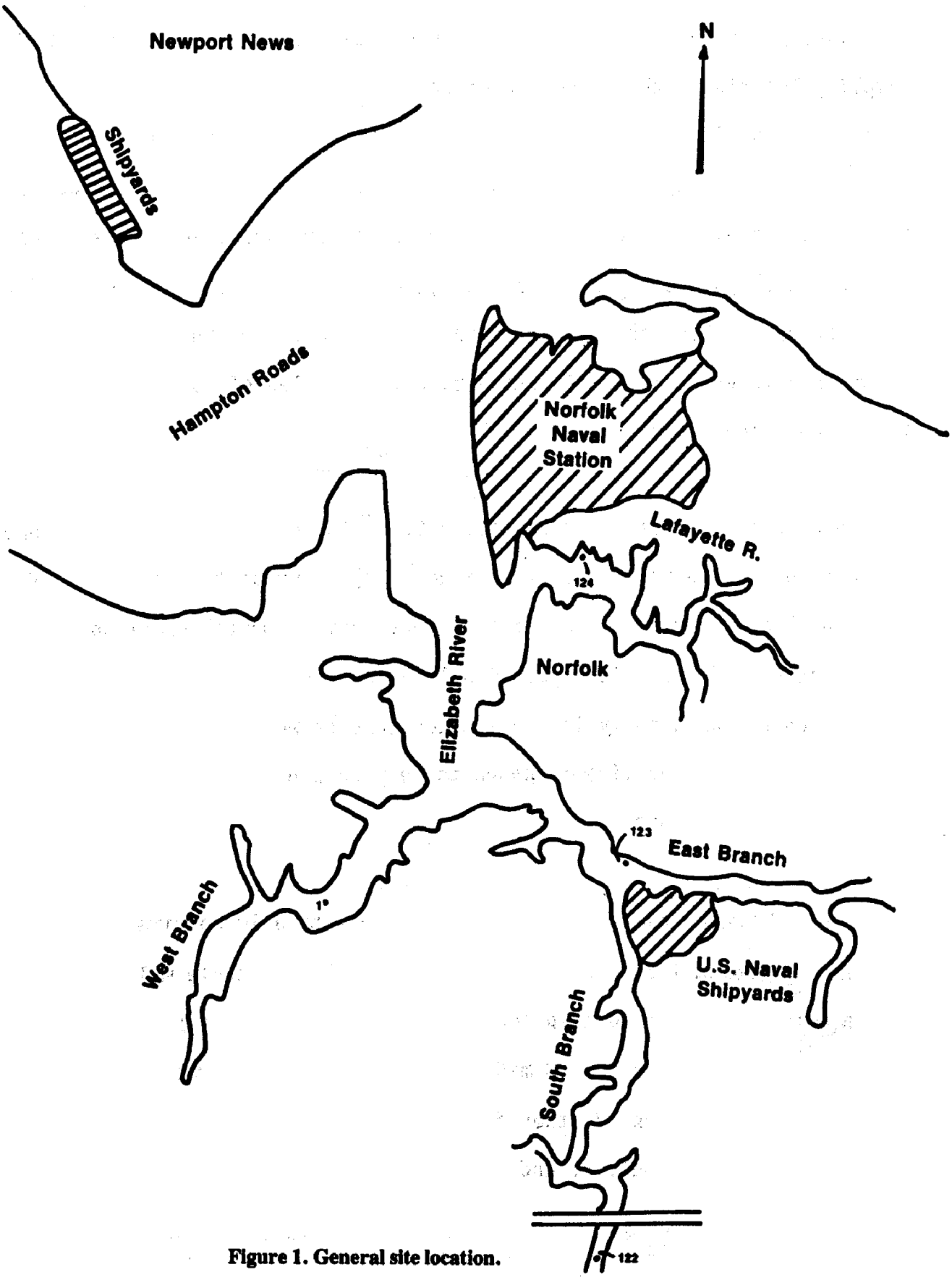

Figure 1. General site location.

Survey and Analytical Methods

Navy personnel helped the EERF survey team identify the most probable sampling locations, those where radioactivity associated with Naval nuclear propulsion plants, if it were present, would most likely be detected. The study did not include extensive surveys on land surfaces, but rather it emphasized measurements near the dry docks and piers where nuclear warships are or have been serviced. Sampling sites at the Norfolk Naval Shipyard, Norfolk Naval Station, and Newport News Shipbuilding are shown in Figures 2, 3, and 4, respectively. Samples of bottom sediment, water, and algae were taken.

According to past surveys, cobalt-60 is the predominant radioisotope found in environmental media if radioactivity is present as a result of Naval nuclear propulsion plants; therefore, environmental sampling focused on detecting this radioisotope. Cobalt-60 content in all samples was determined by gamma analysis. All water samples were also analyzed for tritium since this nuclide is known to be produced in the coolant of light water nuclear reactors.

An underwater gamma scintillation probe with a 10 centimeter by 10 centimeter sodium iodide detector was used with a portable multichannel pulse height analyzer to help locate areas of radioactivity. All probe measurements were made for 10 minutes. The underwater probe has been useful in past surveys of other facilities to select areas for dredge sampling of bottom sediment and to delineate areas of radioactivity.

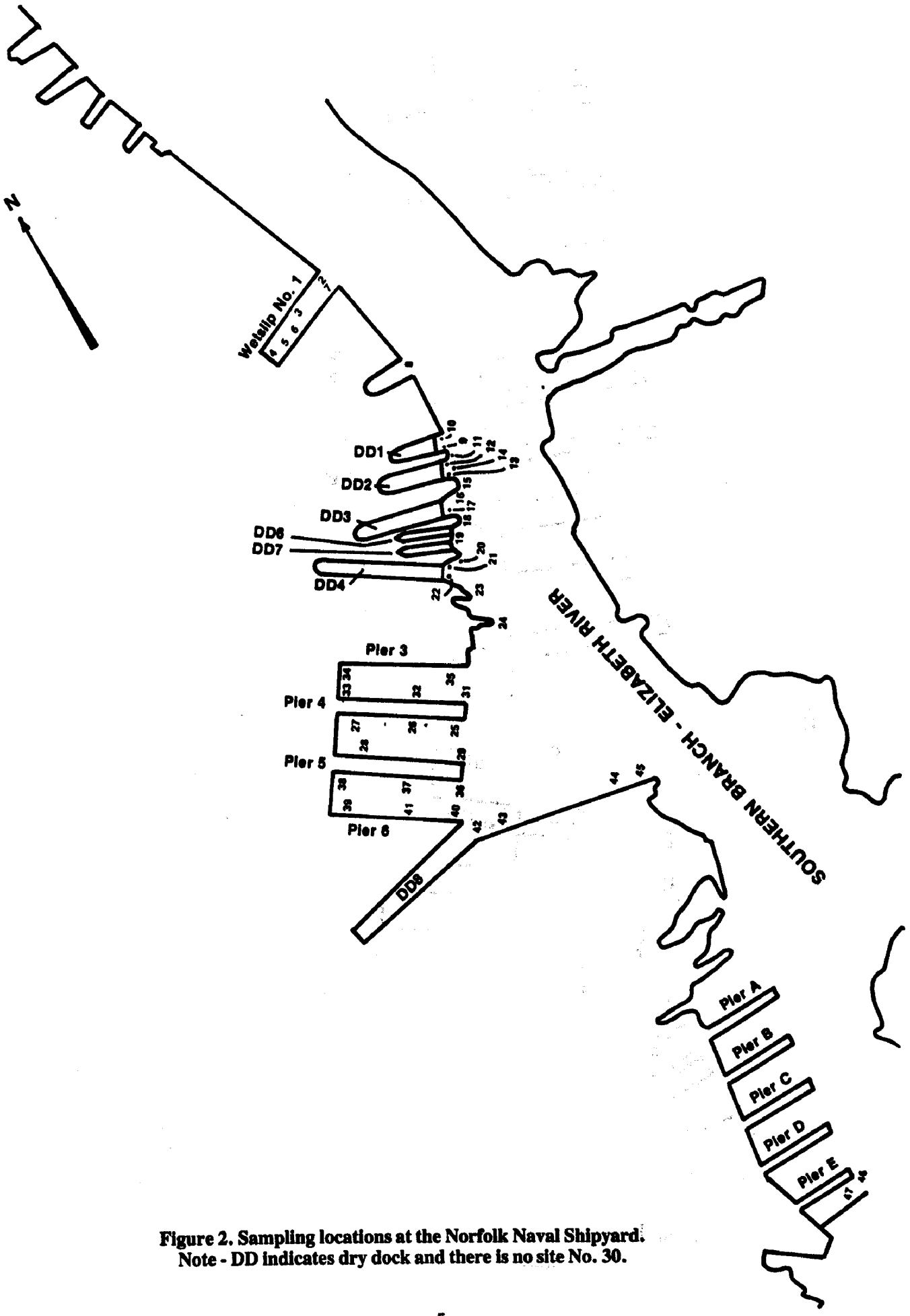

Figure 2. Sampling locations at the Norfolk Naval Shipyard. Note - DD indicates dry dock and there is no site No. 30.

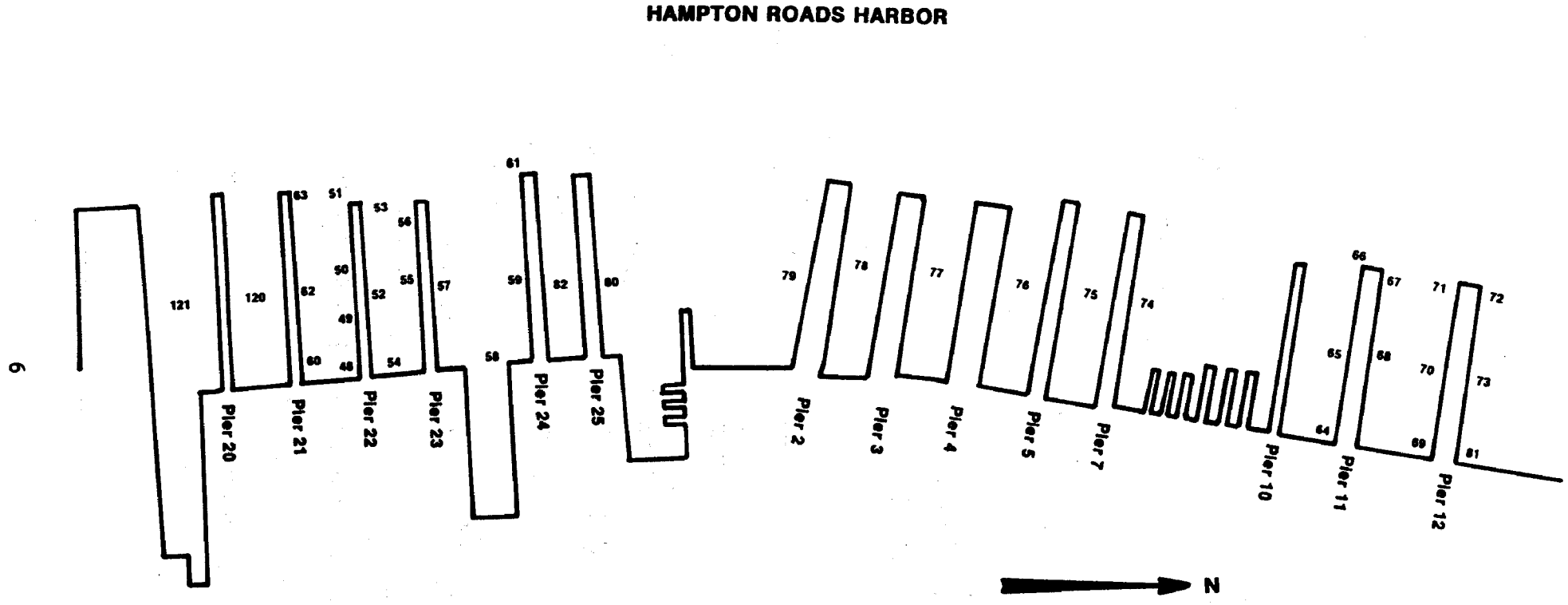

Figure 3. Sampling locations at the Norfolk Naval Station.

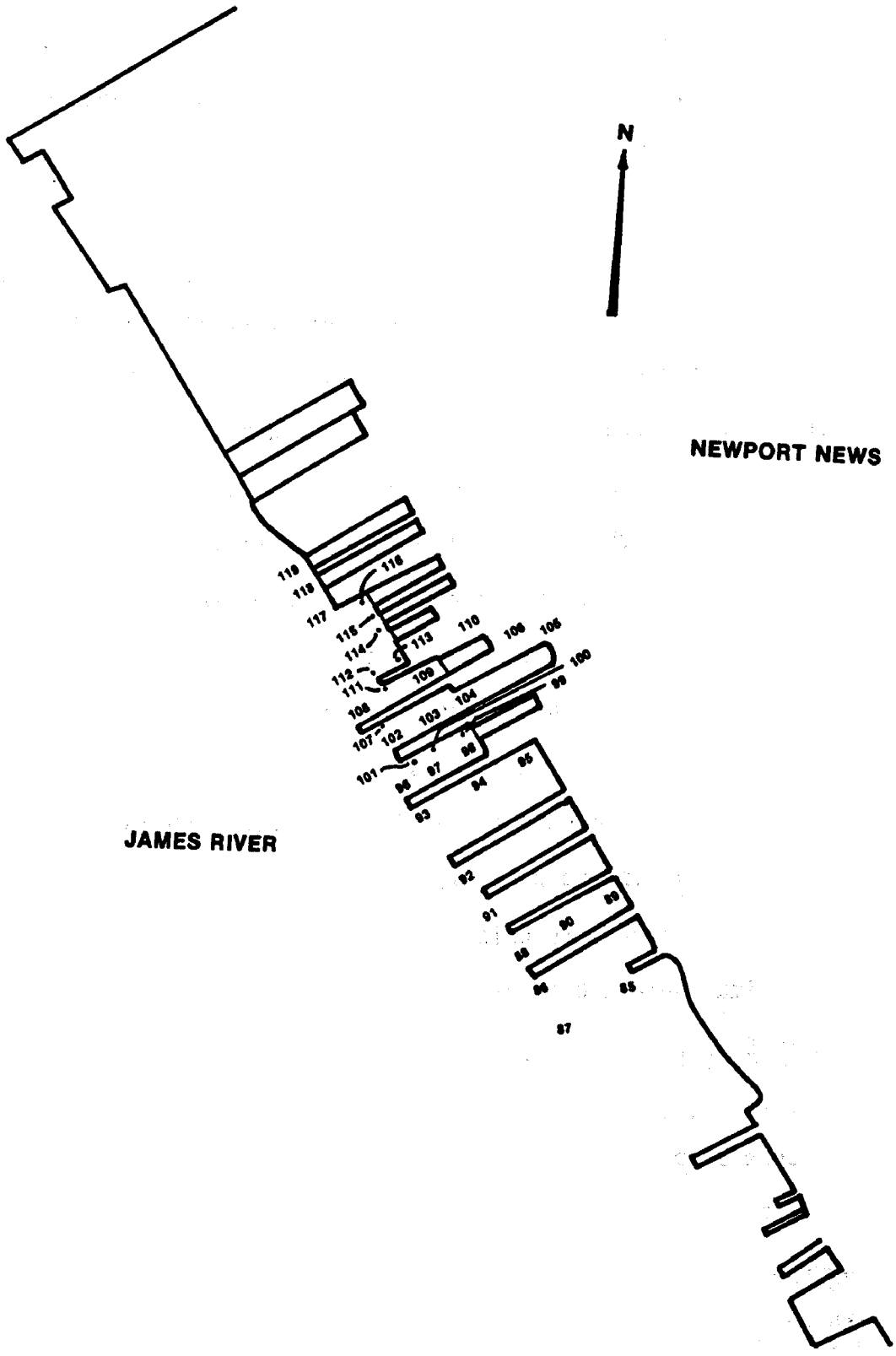

Figure 4. Sampling locations at the Newport News Shipbuilding.

However, due to the relatively low sensitivity (as compared to laboratory measurements) of the probe, sediment samples were collected for laboratory analysis at all locations of probe measurements. Probe measurements and sampling were duplicated for quality assurance purposes at approximately 5 percent of the sites.

A standard Peterson dredge was used to sample approximately the top 10 centimeters of sediment. These sediment samples were collected at all locations identified in Figures 2, 3, and 4. In addition, a sediment sample was collected in a background location (No. 1) in the West Branch of the Elizabeth River at the Churchland Bridge across from the city park, and at three locations with access to the public; a recreational area in Deep Creek Canal (No. 122), downstream of the Navy Yard near the tourist ferry boat landing (No. 123), and in the Lafayette River at the Norfolk Yacht Club and the Lafayette Marina (No. 124). Locations of these latter sampling sites are shown in Figure 1. At the laboratory these samples were dried, ground to a fine powder, placed in a 400 cm^3 sample counting container and counted on an intrinsic germanium detector for 1000 minutes. The minimum detectable activity for cobalt-60 in this geometry is approximately 0.01 picocuries per gram (pCi/g).

Sediment core samples are useful in determining the vertical distribution of radioactivity in harbor bottom sediment. If radioactive materials were present from past operations which were subsequently covered with sediment, it might be observed in the core samples. Core samples were taken with a 3.8 centimeter diameter by 61 centimeter long

plastic tube. A diver pushed the tube into the sediment as far as possible and capped the ends. Core samples were collected at locations 4, 9, 13, 17, 20, 42, and 43 at the Norfolk Naval Shipyard, 52 and 70 at the Norfolk Naval Station, and 85 at Newport News Shipbuilding. At the laboratory the cores were frozen and cut into 2.5 cm sections. The individual sections were freeze-dried and counted on an intrinsic germanium detector to determine gamma emitting radioisotopes. The minimum detectable activity for cobalt-60 in this geometry is approximately 0.1 pCi/g.

Surface water samples were collected at the background location (No. 1, Fig. 1) and at two locations at the Norfolk Naval Shipyard (12 and 37), one location at the Norfolk Naval Station (48), and at three locations at Newport News Shipbuilding (91, 105, and 115). In addition, surface water samples were collected at the Deep Creek Canal recreational area (No. 122, Fig. 1) and from the Lafayette River near the Norfolk Yacht Club (No. 124, Fig. 1). Public drinking water supplies were sampled at two McDonald's Restaurants (No. 126, Fig. 3 and near the Portsmouth Holiday Inn), and from the pier near site 105 in Newport News. These samples were analyzed for gamma emitters (especially Co-60) and tritium. The minimum detectable activities for tritium and cobalt-60 in water are 200 pCi/L and 5 pCi/L, respectively.

Algae was collected from location 10 at the Norfolk Naval Shipyard and a vegetation (grass) sample was collected from the Deep Creek Canal recreational area (No. 122, Fig. 1). The algae was packed into a

400 cm^3 container and counted wet on an intrinsic germanium detector for 1,000 minutes to determine the concentrations of gamma emitting radioisotopes. The vegetation sample was treated in an identical manner, except it was dried prior to counting.

Gamma radiation surveys were made using pressurized ionization chambers (PIC) or portable scintillation survey instruments that were periodically calibrated with a pressurized ionization chamber. All measurements were made 1 meter above the ground or water surface. Surveys were conducted within the exclusion areas of the Newport News Shipbuilding and the Norfolk Naval Shipyards, in the dock and pier areas where sediment (dredge) samples were collected, and along the portside and waterfront shorelines down river from the Norfolk Naval Shipyard that are frequented by the public.

A summary of all samples collected from the harbor at the three facilities is presented in Table 1.

Table 1. Summary of Samples Collected from the Harbor

Facility	Sampling Sites	Number of Samples			
		Water	Sediment	Cores	Algae
Norfolk Naval Shipyard[a]	46	2	46	7	1
Norfolk Naval Station[b]	37	1	37	2	0
Newport News Shipbuilding[c]	35	3	35	1	0
Public Areas	3	2	3	0	0

[a] Samples collected: 7/28-29/86
[b] Samples collected: 7/29/86
[c] Samples collected: 7/30/86

Results and Discussion

Samples From Controlled Areas

A summary of the radionuclide concentrations measured in samples of sediment collected during an extensive survey of the Hampton Roads Harbor is presented in Table 2. Nearly all of the radioactivity associated with these samples is associated with naturally occurring radionuclides. The underwater gamma-ray scintillation probe did not detect any areas of radioactivity above background. Small and relatively uniform levels of Cs-137 were observed in samples from all areas of the harbor that approximate the background concentration due to fallout from previous nuclear weapons testing. Cobalt-60 is the only radionuclide measured in the sediment that can be attributed to the operations of Naval nuclear-powered warships. Trace amounts of Co-60 were observed in most of the sediment samples obtained from the three regions of the harbor. Concentrations ranged from less than detectable amounts (0.01 pCi/g to 0.12 pCi/g), and in most cases were greater than that in the background sample (0.02 pCi/g). However, in all cases the Co-60 concentration was a small fraction of the total background radioactivity concentration (see Table 2).

The presence of Co-60 in sediments from these areas of the harbor was initially detected during a similar survey conducted in January 1968 (Ha68). Concentrations of Co-60 in the sediments are much less today than in 1968. The average concentrations of Co-60 measured in the sediment samples collected during the two harbor surveys are compared in Table 3. Because of radioactive decay, only about 8.3 percent of the Co-60 present in January

1968 would exist in August 1986 (considering an elapsed time of 18.7 years and a half-life for Co-60 of 5.2 years). Listed in the last column of Table 3 are the concentrations measured in 1968 corrected for radioactive decay to August 1986. The decay corrected concentrations of 1968 agree reasonably well with those obtained in 1986 considering that different numbers of samples were obtained during the two surveys, samples were not obtained at the exact same location, and particularly, that nearly 19 years of sedimentation had occurred between the two surveys which would tend to dilute the Co-60 and bury it further beneath the sediment surface.

Table 2. Summary of Radionuclide Concentrations in Harbor Sediment Samples

Radionuclide	Norfolk Naval Shipyard	Norfolk Naval Station	Newport News Shipbuilding	Background
Samples	46	37	35	1
Be-7	0.23(0.07-0.58)	0.36(0.13-0.62)	0.26(0.09-0.41)	NA
K-40	15(9-18)	15(10-19)	15(8-17)	16.0 ± 0.5
Co-60	0.02(<0.01-0.04)	0.06(0.02-0.10)	0.07(<0.01-0.12)	0.018 ± 0.012
Cs-137	0.26(0.10-0.43)	0.24(0.10-0.33)	0.27(0.07-0.38)	0.24 ± 0.02
Pb-214	0.72(0.53-1.38)	0.54(0.35-0.65)	0.63(0.39-0.78)	0.62 ± 0.03
Bi-214	0.66(0.51-1.28)	0.50(0.32-0.60)	0.59(0.40-0.73)	0.59 ± 0.04
Ra-226	1.8(1.2-2.8)	1.3(0.8-1.5)	1.4(1.0-1.8)	NA
Th-232	0.72(0.48-0.94)	0.61(0.39-0.75)	0.61(0.42-0.74)	0.63 ± 0.06
U-238	2.2(1.2-3.5)	1.8(0.94-3.1)	1.7(0.95-3.0)	2.5 ± 1.6

Notes:

1) Concentrations are pCi/gm dry weight.
2) Mean concentrations are given with the range shown in parenthesis.
3) NA-Not Analyzed
4) ± values are 2σ counting error. In general, the 2σ counting errors were approximately: Be-7 (40 percent); K-40 (3 percent); Co-60 (65 percent); Cs-137 (7 percent); Pb-214 (5 percent); Bi-214 (6 percent); Ra-226 (15 percent); Th-232 (9 percent); U-238 (90 percent).

Table 3. A Comparison of the Average Co-60 Concentrations in Sediment Samples Collected in 1968 and 1986

Facility	Co-60 Concentration, pCi/g dry wt. 1986	1968	1968 decayed[c]
Norfolk Naval Shipyard	0.02 (46)[a]	1.4 (23)[b]	0.12
Norfolk Naval Station	0.06 (37)	0.17 (15)	0.014
Newport News Shipbuilding	0.07 (35)	3.1 (10)	0.26

[a]Values in parenthesis are the number of samples collected.
[b]Two samples containing 105 and 18 pCi/gm were not included in the 1968 average because they were not considered representative of the typical concentration of Co-60 in the sediment at that time.
[c]The 1968 concentration adjusted for radioactive decay to 1986.

The results obtained by analyzing successive 1-inch increments of the core samples from the harbor floor tend to confirm the above conclusion. These results are summarized in Table 4. As in the sediment samples, Cs-137 concentrations are relatively uniform between cores taken from different sites and no regular variation in concentration was observed with depth. However, Co-60, detected in three of the 10 core samples, was located only at the 5-6 inch depth and at no other level. Because the core sample measurements are ten times less sensitive than the sediment measurements (40 gm vs 400 gm sample size), Co-60 was not detected below a concentration of 0.1 pCi/gm. Thus, these data indicate that approximately 5 inches of sediment have been added to the harbor floor and that no measurable quantities of Co-60 have been introduced during the past 19 years to areas of the harbor floor that were surveyed.

Samples of harbor water were collected from the background location (site 1), two sites (12 and 37) at the Norfolk Naval Shipyard, one site (48) at the Norfolk Naval Station, and two sites (91 and 115) at Newport News Shipbuilding. No tritium (< 200 pCi/L) or any gamma-ray emitting radionuclides, other than trace amounts of those occurring naturally, were detected in any of the harbor water samples. Concentrations of the natural occurring radionuclide, K-40, were the highest observed and ranged around 200 $\pm$ 70 pCi/L.

An algae sample, collected from a floating boom near dry dock No. 1 at the Norfolk Naval Shipyard (site 10), contained only small amounts of natural radioactivity and a trace of Cs-137 (0.10 $\pm$ 0.04 pCi/g dry weight).

Samples from Public Areas

Sediment and water samples were collected in three areas having ready access by the public. These sampling locations were: 1) Deep Creek Canal west from the I-64 bridge over the Elizabeth River (site 122); 2) about 25 meters from the Tourist Ferry Boat Landing in the Elizabeth River (site 123); and 3) in the Lafayette River at the Lafayette Marina and the Norfolk Yacht Club (site 124). Only natural radioactivity was detected in these samples. Tritium concentrations were less than the minimum detectable level in the water samples (< 200 pCi/L), and Co-60 concentrations were also less than the minimum detectable level in the sediment samples (< 0.01 pCi/g dry wt.). A grass sample collected in the picnic area near Deep Creek Canal (site 122) also contained only natural radioactivity.

Table 4. Summary of Radionuclide Concentrations in Core Samples

Facility/Site No.	Core Depth, Inches	^{137}Cs[a] pCi/g	^{60}Co pCi/g /Depth, Inches
Norfolk Naval Shipyard			
4	14	0.40 (0.27-0.52)	N.D.[b]
9	20	0.32 (0.18-0.49	N.D.
13	12	0.31 (0.16-0.43)	N.D.
17	23	0.37 (0.18-0.55)	N.D.
20	21	0.39 (0.22-0.53)	N.D.
42	19	0.29 (0.20-0.45)	N.D.
43	17	0.30 (0.12-0.49)	1.14/5
Norfolk Naval Station			
52	19	0.32 (0.20-0.46)	0.21/5
70	16	0.30 (0.22-0.42)	0.11/6
Newport News Shipbuilding			
85	20	0.45 (0.28-0.95)	N.D.

[a]The average and range of concentration is given.
[b]N.D.-Not detected, less than 0.1 pCi/g.

Three drinking water samples were collected in the area of the shipyards for radionuclide analyses. Samples of drinking water were collected from the pier near site 105 in Newport News, from the McDonald's Restaurant across the road from pier 11 in Norfolk (site 126), and from the McDonald's Restaurant near the Holiday Inn in Portsmouth (site 127). These samples contained no detectable tritium or radionuclides that emit gamma-rays.

From the results of the analyses of these samples, it is concluded that no measurable quantities of radionuclides have been introduced into public areas that are attributable to operations of Naval nuclear-powered warships.

Gamma-Ray Surveys

A summary of the gamma-ray exposure rates measured during the survey are shown in Table 5. The first set of exposures were obtained from measurements made at each sampling site in the harbor and closely resemble the background exposure rate at location No. 1 of 4.5 μR/hr. The exposure rates measured in the exclusion area along the waterfront of each facility as well as along public shorelines of the Elizabeth River and the South Branch indicate exposures to be within the expected background range. Gamma-ray exposure measurements made in an area near the inlet to the Lafayette Marina that contains exposed granite rock exceeded background by about 4 times. The higher exposure rate in this area is attributed to elevated concentrations of naturally occurring radionuclides that often exist in granite rock. Thus, gamma-ray exposure rates were not measurably elevated in the vicinity of the nuclear ship facilities because of naval operations.

Table 5. A Summary of Gamma-Ray Exposure Rates

Location of Survey	Gamma-Ray Exposure Rates, μR/hr	
	Average	Range
Harbor Sampling Sites		
Norfolk Naval Shipyard	4.5	3.6-5.3
Norfolk Naval Station	4.2	3.7-4.9
Newport News Shipbuilding	4.3	3.8-6.0
Exclusion Areas Along Waterfront		
Norfolk Naval Shipyard	4.2	3.8-6.0
Norfolk Naval Station	4.0	3.5-4.8
Newport News Shipbuilding	4.0	3.5-5.0
Along Public Shorelines		
Elizabeth River		
Portside-Municipal Building to Tourist Area	N.R.	5-7
Across From Portside along concrete wharf	N.R.	5-8
Area of Granite near Lafayette Marina Inlet	N.R.	15-20
South Branch		
Near Chesapeake Toll Bridge	5.5	5-6

N.R.-Not Reported.

Summary and Conclusions

The radiological survey of the Norfolk Naval Station, Newport News Shipbuilding, and Norfolk Naval Shipyard provided the basis for the following conclusions:

1. The trace amounts of Co-60 measured in the harbor sediments are significantly less than observed during the 1968 survey and exists about 5 inches beneath the surface of the sediment indicating that no detectable Co-60 has been deposited in the sediments since the 1968 survey.

2. In addition to Co-60, only radionuclides of natural origin plus trace amounts of Cs-137 from previous nuclear weapons testing were detected in any of the harbor sediment samples.

3. No tritium or gamma-ray emitters, other than those occurring naturally, were detected in harbor water, or samples of sediment, water and vegetation collected from public areas.

4. Drinking water samples contained no detectable levels of radioactivity other than those occurring naturally.

5. The shoreline gamma-ray surveys failed to detect any elevated exposure levels except at one location where the levels are attributed to the naturally occuring radionuclides that exist in granite rock.

6. The levels and locations of radioactivity identified and the limited media in which it was found show that operations related to nuclear-powered warship activities resulted in no significant adverse effects on public health or the environment.

References

Ha68 Harvey, H.D., Toerber, E.D. and Gordon, J.A., 1968, "Radiological Survey of Hampton Roads, Virginia", Southeastern Environmental Radiological Health Laboratory, U.S. Public Health Service, unpublished.

APPENDIX A

Concentration of Co-60 in Harbor Sediment Samples, pCi/g Dry Wt.

Site	Co-60	Site	Co-60	Site	Co-60
1	0.02 ± 80	21	0.04 ± 55	42	0.02 ± 67
2	0.01 ± 78	22	< 0.01	43	0.02 ± 63
3	0.04 ± 49	23	0.02 ± 72	44	0.03 ± 48
4	0.04 ± 59	24	0.03 ± 62	45	< 0.01
5	0.03 ± 47	25	< 0.01	46	0.01 ± 97
6	0.03 ± 41	26	0.02 ± 72	47	< 0.01
7	0.03 ± 53	27	< 0.01	48	0.09 ± 15
8	0.04 ± 41	28	< 0.01	49	0.09 ± 15
9	0.02 ± 76	29	0.02 ± 100	50	0.09 ± 17
10	0.03 ± 45	31	0.02 ± 77	51	0.05 ± 46
11	0.04 ± 31	32	0.02 ± 65	52	0.10 ± 20
12	0.04 ± 58	33	< 0.01	53	0.05 ± 27
13	< 0.01	34	< 0.01	54	0.07 ± 18
14	0.02 ± 94	35	0.02 ± 94	55	0.08 ± 23
15	0.02 ± 94	36	0.02 ± 55	56	0.05 ± 24
16	0.03 ± 57	37	0.04 ± 48	57	0.08 ± 19
17	0.03 ± 41	38	0.02 ± 84	58	0.06 ± 25
18	0.02 ± 75	39	0.02 ± 58	59	0.06 ± 28
19	0.02 ± 41	40	0.04 ± 43	60	0.06 ± 23
20	0.02 ± 78	41	0.02 ± 85	61	0.02 ± 52

Concentration of Co-60 in Harbor Sediment Samples, pCi/g Dry Wt.

Site	Co-60	Site	Co-60	Site	Co-60
62	0.07 ± 25	82	0.08 ± 25	102	0.07 ± 19
63	0.07 ± 26	83	0.11 ± 17	103	0.09 ± 15
64	0.04 ± 28	84	0.04 ± 43	104	0.09 ± 20
65	0.03 ± 41	85	0.09 ± 13	105	0.03 ± 26
66	0.04 ± 25	86	0.05 ± 22	106	0.07 ± 24
67	0.03 ± 29	87	< 0.01	107	0.07 ± 17
68	0.02 ± 49	88	0.09 ± 19	108	0.04 ± 33
69	0.08 ± 18	89	0.10 ± 18	109	0.09 ± 15
70	0.06 ± 19	90	0.09 ± 16	110	0.07 ± 24
71	0.05 ± 34	91	0.08 ± 15	111	0.10 ± 18
72	0.03 ± 37	92	0.09 ± 15	112	0.06 ± 29
73	0.05 ± 35	93	0.06 ± 19	113	0.08 ± 21
74	0.04 ± 40	94	0.08 ± 15	114	0.09 ± 15
75	0.04 ± 39	95	0.09 ± 15	115	0.09 ± 20
76	0.03 ± 39	96	0.10 ± 18	116	0.12 ± 13
77	0.05 ± 36	97	0.09 ± 22	117	0.02 ± 68
78	0.06 ± 31	98	0.10 ± 19	118	0.06 ± 24
79	0.05 ± 35	99	0.07 ± 24	119	0.06 ± 25
80	0.05 ± 17	100	0.08 ± 26	120	0.07 ± 24
81	0.05 ± 26	101	0.06 ± 20	121	0.03 ± 43

Note: ± values are the 2σ counting errors in percent.

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