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NSB NEW LONDON
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DEPARTMENT OF THE NAVY
PORTSMOUTH NAVAL SHIPYARD
PORTSMOUTH, N.H. 03 04-5000

IN REPLY REFER TO:

5090
Ser 105.5/138
06 MAR 1996

Ms. Kymberlee Keckler
Remedial Project Manager
U.S. Environmental Protection Agency
Region I
JFK Federal Building
Boston, MA 02203-2211

Dear Ms. Keckler:

This letter is in response to your comments on the Draft Historical Radiological Assessment (HRA), Volumes I and II, Naval Submarine Base New London.

A preliminary response to your comments was provided to you in a letter from NAVSEA 08 (Guida) dated 16 June 1995. Enclosed are more detailed specific responses to your comments. Several of the responses are deferred for discussion at a planned future meeting between EPA Region I and Portsmouth Naval Shipyard. Please contact Mr. Jeff Brann at (207) 438-1283 at your convenience to arrange this meeting.

Sincerely,

J. Tarpey
Acting
Director, Radiological Controls

Encl:
(1) Navy Responses to Environmental Protection Agency Region I Comments/Questions on December 1994 Draft Historical Radiological Assessment for Submarine Base New London
(2) Copy of Bldg 174 Release Report
(3) Copy of EG & G Report
(4) PNS Aerial Radiation Survey

Copy to:
CTDEP (Mr. Mark Lewis)
NAVFAC NORTHDIV (Mr. Mark Evans)
USEPA Region I (Mr. James Cherniak)

VOLUME I

Navy Responses to Environmental Protection Agency Comments/Questions on December 1994 Draft
Historical Radiological Assessment for
Naval Submarine Base New London

Ref: (a) Attachment A to June 2, 1995 EPA letter to Northern Division, Naval Facilities Engineering Command
(b) "Guidance for Performing Preliminary Assessments Under CERCLA," EPA/540/G-91/013, September 1991
(c) NAVSEA 08 (Guida) letter to EPA Region I (Keckler) dated 16 June 1995

EPA Region I comments is reference (a) and corresponding Navy responses are listed below:

A. Volume I

Comment 1: Page 1-2, Para. 4. *The statement that since 1973 no radioactivity has been intentionally released by the NSB implies that there have been unintentional releases. If there have been any unintentional releases either before or after 1973, the number of unintentional releases, the circumstances, and time frames should be addressed.*

Response: All known unintentional releases are addressed in Table 5-4. Liquid volumes were also included in Table 5-1 as appropriate.

Comment 2: Page 2-2, Para. 5. *The phrase "detailed radionuclide analysis" should be changed to read "and gamma spectroscopy analysis." Nothing was found in the documentation to indicate that any radiochemistry was performed on samples to obtain radionuclide specific data. If radiochemistry was performed, the standard methodology should be described as well as the suite of specific radionuclide analytes.*

Response: The HRA will be revised to explain this refers to "radionuclide-specific gamma spectroscopy analysis."

Comment 3: Page 2-4 & 2-5, Section 2.3.3. *The text states that the Navy considered interviewing individuals assigned to NNPP radiological work to confirm the past practices of the program at the base. The text discusses various means of locating potential interviewees, and concludes that it would be an arduous task and was therefore not conducted for this assessment. Locating potential interviewees should not be a difficult task. The Navy should attempt to interview past employees as originally considered. Interviews are a vital tool in identifying critical information and addressing data gaps not documented in historical documents. Interviews may be especially useful for addressing the many uncertainties identified in the Navy's HRA (e.g., disposal of radiological equipment and sources).*

Paragraph 2 of Page 2-5 indicates that radiation exposure records for military and civilian personnel are available. The Navy could easily identify a pool of potential interviewees by

screening these records. Suggested screening criteria include identifying personnel who have been exposed to radiation and/or involved in accidents or spills.

Response: The Navy stands by its evaluation as presented in the draft HRA. The screening tasks, identification of a pool of potential interviewees, and locating such individuals would not be "easy," and would require a level of effort far in excess of the ref (b) guidance for preparation of Preliminary Assessments (PAs). In addition to the arduous nature of such an effort, as stated in the draft HRA, the outcome of such efforts would be uncertain at best. The HRA notes prior interviews that were conducted; in addition, PNS interviewed current New London personnel.

Comment 4: Page 2-5, Para. 2. *The last sentence in this paragraph should be deleted. The sentence states that Section 5 of the HRA shows that there is no radioactivity associated with the NNPP at or near the NSB that requires remediation. The information contained in Section 5 does not support this conclusion..*

Response: The sentence will be deleted.

Comment 5: Page 3-1, Para. 2 & Page 3-2, Figure 3.1. *The NSB is not clearly designated on Figure 3-1. It appears that the base extends beyond the boundary of one-quarter mile radius. The figure needs to be clarified.*

Response: The base boundaries, as printed on the U.S. Geological Survey (USGS) Uncasville quadrangle map, were highlighted on the draft Figure 3.1 by tracing with a thick black line. As indicated in the December 30, 1994 letter which forwarded the draft HRA to you, Figure 3.1 is a reproduction of four spliced USGS 7.5 minute quadrangle maps; the original spliced and marked quadrangle maps will be provided to you with the final HRA. The radii on Figure 3.1 are concentric circles around the site, as specified in Section 2.4.1 of ref (b). The sample Site Location Map in ref (b), "Sample PA Narrative Report," page C-4, contains a circle drawn around an irregular-shaped site, rather than a line which is equidistant from the borders of that irregularly shaped site. We accordingly had concentric circles drawn around Subase at the radii specified in Section 2.4.1 of ref (b), with circles centered at the quay wall between Piers 12 and 13 where most NNPP radiological work was performed. Portions of the base do extend beyond one-quarter mile from this point.

Comment 6: Page 3-3, Figure 3.2. *The 15-mile downstream arc is cut-off on Figure 3-2. Important features highlighted in the HRA cannot be identified. The figure needs to be clarified.*

Response: Figure 3.2 is "extra" relative to the ref (b) guidance for PAs. Ref (b) contains a "Sample Narrative Report" with only a sketch of the site and no 15-mile downstream arc. Conclusions relative to targets within 15 miles downstream are stated in the text of the "Sample Narrative Report," and this is also done in the draft HRA. As with Figure 3.1, Figure 3.2 is a reproduction of a USGS map, and the original will be sent to you with the final HRA. Figure 3.2 as supplied to you with the draft HRA is the clearest, most legible reproduction available. The names of the shaded areas (e.g., State parks and forests, Fish and Wildlife areas, etc.), appear to

be legible. The map from which Figure 3.2 is reproduced is a very detailed USGS map of the entire state, listing several features of interest for a PA. We did not think that the Legend box, which cuts off a limited portion of the 15-mile downstream arc, resulting in about 1.5 "arc-miles" being hidden from view several miles out into Long Island Sound, would be of concern.

Comment 7: Page 3-16, Para. 1. *The first sentence in this paragraph appears to be out of context and should be deleted.*

Response: PNS considers this sentence provides a useful cross-reference to aid the reader.

Comment 8: Page 3-16, Para. 3. *The last sentence in this paragraph states that the Radiological Control Barge, YRR-14, was released from radiological controls in 1984 (sic, YRRS-4 is noted in this sentence of the HRA as the barge that was released from radiological controls in 1984). The Navy should describe the release survey procedures and testing conducted, and the barge's current use or status.*

Response: The sentence will be revised to read, "The YRRS-4 was removed from Subase subsequent to being released from radiological controls in 1984." The current use or status of Navy vessels no longer at the Subase is not of relevance to the HRA. Information about Naval craft (e.g., barges and floating drydocks) in the draft HRA is primarily intended to indicate the nature and degree of operational radiological controls which have been applied to these craft. NNPP release survey procedures are described in Section 5.4, beginning on page 5-21.

Comment 9: Page 3-16, Para. 4. *The text states that Building 174 was released from radiological controls in 1982. The Navy should describe the building release procedures and testing conducted, and the building's use after 1982.*

Response: NNPP release survey procedures are described in Section 5.4, beginning on page 5-21. The northern portion of Building 174 was used for paint storage prior to and after 1982. The former location of the radioactive material storage area (southern portion of Building 174) has been used for a variety of purposes since 1982, including bicycle repair, sandblasting, and storage of painting equipment. A copy of the Building 174 release report is attached.

Comment 10: Page 3-16, Para. 5. *Add "or any G-RAM radiological material" after "NNPP" in the first sentence of this paragraph.*

Response: This HRA is a two-volume document. All G-RAM considerations are addressed in Volume II.

Comment 11: Page 3-22, Para. 9. *The text states that the Area A Wetland was filled in 1958 with dredged sediments from the Thames River. The text needs to clarify whether the dredged sediments from Thames River were sampled and/or characterized before being used as fill in the Area A Wetland. The Navy should discuss any potential environmental impacts.*

Response: It is not known whether the dredge spoils were sampled and/or characterized prior to being used as fill at Area A. This area is being characterized extensively in the ongoing Remedial Investigation (RI), which includes radiological analyses.

Comment 12: Page 3-37, Table 3-2. *Table 3-2 lists the distances of public water supply sources from the NSB. The Navy needs to document whether these distances are measured radially or are located downstream along the surface water pathway.*

Response: These are approximate radial distances from Subase, since they are of interest in considering the ground water pathway. The text introducing this Table ("Regional Supply," page 3-37) will be modified to reflect the method of measurement.

Comment 13: Page 3-40, Para. 4. *The Navy needs to expand its evaluation regarding sensitive environments. The sensitive environments need to be evaluated separately for the surface water and air pathways in accordance with the Hazards Ranking System. In addition, this section entitled "Sensitive Environments" does not mention any efforts to evaluate the impacts of site contamination on endangered species. The Navy should discuss any surveys or studies conducted to identify endangered species habitat, especially plants and hawks (Cooper's and peregrine falcons).*

Response: All pathways are evaluated with greater specificity in Section 8. Where appropriate, these evaluations address sensitive environments, including endangered species habitats. The results of current surveys to identify any endangered species are summarized on pages 8-6 and 8-7 in Section 8.2.2. The 1992 Subase Phase I Remedial Investigation (Reference 4 of the draft HRA) concluded: "No known threatened or endangered species are known to exist in the project area."

PNS also notes that page 13 of EPA document 402-R-93-084 of September 1993, "Issues Paper on Radiation Site Cleanup Regulations," indicates that if human radiological concerns are adequately addressed, then other species are also sufficiently protected.

Comment 14: Page 4-2, Para. 2. *The text states that leakage of fission products into the cooling system, or leakage of the cooling system, are not compatible with ship operation and are not tolerated. This statement alone does not demonstrate that such leaks do not occur or have never occurred. In fact, the analytical data would support that there may have been leakage, since fission products (cobalt-60 and cesium-131 [sic]) were detected in Thames River sediments.*

Further, the text states that over 40 years of experience with Naval nuclear propulsion plants have shown that fission products are contained in the fuel elements. Again, this statement alone does not demonstrate that fuel elements have never leaked fission products at the NSB property or vicinity. There are many circumstances which could lead to fission products leaking from fuel elements, from simply "bad fuel" to exceeding technical specifications during reactor operations. The Navy needs to address these concerns, and the text should be based on supporting information.

The Navy also needs to address the release of gaseous fission products such as krypton and xenon isotopes, iodine isotopes, tritium, and tritiated water.

Response: The comment regarding "bad fuel" or fission products from fuel leaking into the coolant was addressed in ref (c).

Regarding the EPA desire to further address gaseous fission products and tritium in the HRA, PNS will revise the final HRA as follows (including expansion of the carbon-14 discussion, for completeness):

a. New third and fourth paragraphs will be added to Section 4.2 of Volume I of the HRA, to read:

> "While fission products produced in the fuel, including iodine and the fission gases krypton and xenon, are retained within the fuel elements, it is true that trace quantities of naturally occurring uranium impurities in the surface of reactor structural materials release small amounts of fission products to the reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides comprises only a small fraction of the total long-lived gamma radioactivity releases discussed elsewhere in this section of this report.
>
> "The primary mechanism by which environmental releases of NNPP radioactivity occur include: (1) inadvertent releases of small volumes of liquids (or pre-1972 historical releases) to the river, as discussed in Section 5.1.1; (2) inadvertent releases of small amounts of liquid or solid material (or, very rarely, gases), as listed in Section 5.1.3; (3) the particulate output from HEPA-filtered air exhausts at work areas, as discussed in Section 5.1.2; and (4) the release of trace quantities of fission product gasses and carbon-14 gaseous products from primary coolant which has been depressurized (including that which is removed from ships for processing into controlled pure water, as discussed in Section 5.1.1.1). Note that ships are prohibited from discharging reactor cooling water overboard in the vicinity of shore; hence, shipboard reactor operations are not considered a significant potential source of environmental contamination."

b. Secondly, a new paragraph will be added at the end of Section 5.1.2 to read:

> "The NESHAPS 40CFR61 calculations demonstrate an exposure level to on-site residents (and hence the general public) of less than 1 mrem/yr, including the contributions from trace levels of fission product gases and gaseous carbon-14 products as discussed in Sections 4.2 and 4.2.3. Noble gasses such as isotopes of argon, krypton, or xenon do not accumulate in the environment and are therefore not a potential candidate for site remediation. Also, even if radioiodines had ever been released in significant quantities (which they haven't been), they would not constitute a potential remediation issue due to their short half lives. Finally, carbon-14 does not accumulate in the environment, as discussed in Section 4.2.3."

c. Thirdly, Section 4.2.3 will be revised as follows:

(1) The second sentence of the first paragraph of Section 4.2.3 will be revised to read, "This carbon is in the form of a gas, primarily methane and ethane, although some insoluble carbonates may be present; following reprocessing of reactor coolant (to make controlled pure water), it is possible some carbon-14 has been converted to carbon dioxide."

(2) The third paragraph of Section 4.2.3 will be revised to delete the third and last sentences, and a new fourth paragraph will be added to read:

> "Typical annual releases of carbon-14 at Subase are about 1 curie per year, virtually all as a gas. This is much less than the approximately 7 curies per year discharged by the typical commercial nuclear power plant per Reference ___ [NCRP 81; new HRA reference]. These gaseous releases are dispersed in the atmosphere and are not concentrated in the environment. Calculations using the EPA COMPLY computer code indicate that the resulting dose is less than 1 mrem per year. Furthermore, studies around a large civilian nuclear power plant showed no measurable carbon-14 in downwind foliage (Reference ___ [Health Physics, Vol. 63, No. 6, December 1992; new HRA reference]) For these reasons, carbon-14 is not judged a remediation concern, and carbon-14 data has not been combined with the data on other radionuclides in other sections of this report."

d. Finally, a new paragraph will be added as the next-to-last paragraph in Section 5.1.1.1, to read:

> "The tritium (hydrogen-3) concentration in both reactor coolant and controlled pure water is the same, at about $2x10^{-3}$ μCi/ml or less. This is below the 10 CFR 20 sanitary sewer release criteria for tritium which the Nuclear Regulatory Commission uses for sites it regulates. Any such water which entered the river would be rapidly diluted and become indistinguishable from background tritium levels, as discussed in Section 4.2.2. If any small volume spilled on land and went undetected, it would be quickly washed into the river (e.g., by rainwater, or possibly by entering the shallow ground water system which discharges into the river as discussed in Section 3.3.3.3). No environmental mechanism to concentrate this radionuclide exists."

For comparison, a typical commercial nuclear power plant releases several hundred curies of tritium in liquid effluents every year. Since the amounts of tritium released at Subase were small, the releases ended over 20 years ago (except for small post-1972 spills), and tritium does not accumulate in the environment, tritium does not pose a remediation concern at Subase.

Comment 15: Pages 4-2 to 4-4, Sections 4.2.1 to Section 4.2.3. *Sections 4.2.1 through 4.2.3 discuss the rationale for concluding that cobalt-60 is the primary radionuclide of interest for the NNPP. The text lists 12 radionuclides present in corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water, and concludes that cobalt-60 is the primary radionuclide of interest because it has the most restrictive concentration limits. The text*

also states that tritium and carbon-14 are formed in reactor coolant systems, but minimizes their releases because they are negligible compared to other releases and the global inventory.

The radionuclides nickel-63, iron-55, tritium, and carbon-14 should not be excluded from the Navy's study protocol. These low energy beta and x-ray emitters have half-lives of long enough duration to warrant inclusion in the study program and have an adverse input on public health and the environment. Although their global inventories are huge compared to the Navy releases, the Navy must still determine the dose consequences of those releases and evaluate them in terms of "As Low As Reasonably Achievable" ("ALARA").

Since the Navy is a current Nuclear Regulatory Commission ("NRC") license holder, the Navy must comply with 10 CFR 20, which considers both environmental impacts and occupational exposures. The Navy radiation protection program can no longer just monitor the environment; the program must also evaluate the dose consequences to public health.

Additionally, the Navy must also comply with the National Emission Standards for Hazardous Air Pollutants ("NESHAPS") regulated under 40 CFR Part 61, Subpart I, which limits annual radionuclide emissions to the atmosphere to such quantities that will not result in any member of the public receiving an effective dose equivalent in excess of 10 millirem per year (mrem/yr).

Further, the Navy must follow the current criteria for the unrestricted release of areas formerly used for radioactive material use or storage as covered in NUREG/CR-5849, NUREG-1496 Volumes 1 and 2, NUREG-1500, and NUREG-1501. The process of NRC license termination and decommissioning of facilities and grounds is rigorous and detailed, and must be based on an accurate and precise determination of background levels to define the required cleanup criteria.

The Navy's methodology should follow the cited NRC guidance or demonstrate that ALARA screening methodology (modeling vs. sampling, default parameters/assumptions) and statistical tests and data quality control demonstrate NRC equivalency.

Response: There are several parts to this comment:

a. Tritium and carbon-14 are further discussed in comment 14 above. PNS considers the identified changes should adequately address these issues in the HRA.

b. Regarding other activation products besides cobalt-60, the following supplements the discussion in the HRA:

The NNPP radioactivity which could accumulate in the environment is in the chemical form of insoluble metal oxides. Any NNPP radioactivity in this form would have detectable cobalt-60. The cobalt-60 in effect serves as a "tag" for all of the activated corrosion product radionuclides. Any corrosion product radionuclides outside the gamma energy range monitored by the NNPP, or pure beta emitters, would not be present without cobalt-60 also being present. Also, cobalt-60 does not occur naturally, so background determinations are irrelevant.

With regard to nickel-63, it is present along with the other activated corrosion and wear products. While nickel-63 is a pure beta emitter and is undetectable by gamma analysis, it would always be associated with cobalt-60, which is readily detectable. Specific radiochemical

analysis of corrosion and wear product radioactivity from NNPP plants shows that nickel-63 is typically about 8% of cobalt-60 activity.

In preliminary calculations circulated by EPA Headquarters (OAR) in support of EPA's draft rule for radiological release of property ("Radiation Site Cleanup Regulations: Technical Support Document for the Development of Radionuclide Cleanup Levels for Soil," Appendix H), nickel-63 would have to be present in a concentration 10,000 times higher than cobalt-60 ($100m^2$ scenario) to have the same dose impact. Since nickel-63 is present as a small fraction of cobalt-60 whenever cobalt-60 has been released, and is much less significant radiologically, nickel-63 is not a controlling radionuclide for Naval nuclear propulsion plants. Similar logic applies to other corrosion and wear radionuclides.

c. The comments concerning NRC regulations, NESHAPS, and public health were addressed in ref (c).

Comment 16: Page 4-3, Para. 1. *The second sentence of this paragraph states that the radioactivity concentration limit for tritium is at least one hundred times higher than that for cobalt-60. The text should specify tritium's concentration limits and relationship to cobalt-60.*

Response: See comment 14 above.

Comment 17: Page 4-4, Section 4.3. *The types of activities described in Section 4.3 are typical of maintenance activities that take place during scheduled nuclear power plant refueling outages. Any work requiring access into the primary coolant system or cutting, grinding, welding, sanding, or abrading of material with fixed or removable radioactive contamination could potentially create airborne radioactivity. The Navy should have standard protocol and procedures in place for authorizing radiological work. These procedures should be discussed. Documentation and associated surveys regarding past activities may be a potential source of information for the Navy's HRA; such information should be reviewed and integrated into this HRA as appropriate.*

Response: (Defer discussion to meeting.)

Comment 18: Page 4-5, Para. 1 and Page 5-7, Section 5.1.2. *There are several shortcomings with the discussions of the HEPA filtered exhaust that need to be addressed. First, all HEPA systems must be tested quantitatively to assure they are functioning as designed when the filters are changed; no mention of this is made in the HRA. Second, the schematic of a typical system shown in Figure 5.2 does not show an "active" radiological monitor for the HEPA exhaust, only a "passive" filter which is counted annually or when loaded with dust (5.1.2). Third, the schematic does not show an alarm system in the event of a HEPA failure.*

Each time the HEPA filters are checked or changed, their effectiveness is totally dependent on the sealing surfaces between the filter and filter housing. Even though pressure differential readings appear normal, small deformations in the sealing surfaces or within the filter itself, can allow small particles larger than 0.3 microns to pass unimpeded through or around the filter.

Problems in this regard are always a possibility when the air filter on the "clean-side" of the HEPA must be changed because of "dust loading" as mentioned in Section 5.1.2.

Response: There are several parts to this comment:

a. The HRA will be revised to state that HEPA filters in radiological ventilation systems are tested in place, both after installation and periodically thereafter.

b. The "passive" exhaust monitors used by the Navy provide a record of the insignificant quantities of particulate radioactivity released. This information is what is relevant in determining the current radiological condition of the environment. An "active" monitoring system, that is one which would give real time indication of a problem, does not provide any additional information on the total amount of radioactivity released. The Navy does not utilize active monitors for ventilation systems with very low potential for release of radioactivity. The installed passive monitor results confirm the very low potential for releases from the New London monitored ventilation systems since the sampling results show less radioactivity than normal outside air.

c. The overall efficiency of the HEPA filter system, including the effect of potential leakage by sealing surfaces, is measured by the in-place testing discussed in paragraph 18.a above.

Comment 19: Page 4-5, Para. 1. *The text refers the reader to Section 6 for further discussion of filtered exhaust/HEPA filter sampling results. Section 5.1.2 provides this information not Section 6. The text should be corrected.*

Response: The text will be corrected.

Comment 20: Page 4-5, Para. 4. *The text states that access to the radiologically controlled areas within the Radiological Control Barge, YRR-14, for both personnel and material is via a control point manned by radiological control personnel. The Navy should provide more details regarding the control procedures, including procedures for personnel log-in, ensuring personnel have the proper dosimetry and protective clothing, and monitoring and releasing personnel and equipment leaving the area. Also, details are needed on how personnel and equipment frisks are performed (i.e., total body, hands and feet).*

The text should note that in spite of the Navy's controls into and out of radiologically controlled areas, there have been documented cases of finding radioactive material in uncontrolled areas of the installation (see Table 5-4).

Response: (Defer discussion to meeting.)

Comment 21: Page 4-5, Para. 5. *The text indicates all radiologically controlled areas are maintained at less than 450 [pCi/]100-square centimeters (1,000 [dpm/]100-cm^2) except Controlled Surface Contamination Areas. The text should also discuss the maximum levels*

tolerated in Controlled Surface Contamination Areas, and if there are action levels requiring the use of respiratory protection. The text should describe the swipe analysis procedures, and if the swipes are evaluated for alpha, beta, and gamma contamination, or just gamma.

Response: (Defer discussion to meeting.)

Comment 22: Page 4-6, Section 4.5. *The Navy should discuss whether the annual on-site audits look at paperwork compliance or whether key personnel and workers are interviewed to get a feel for the actual controls that are being utilized. An understanding of the actual controls is important.*

Response: The annual on-site audits are thorough and comprehensive. Details would appear to be inappropriate in a CERCLA PA.

Comment 23: Page 5-1, Para. 2. *The statement that the total amount of gamma radioactivity released into the ocean by the NNPP has been less than 0.002 curies annually for the past twenty-two years needs to be substantiated. The Navy should describe how this value was determined (i.e., records of shipside discharges/releases, measurements taken, Standard Operating Procedures in place).*

Response: The basis for this statement is discussed in Section 5.1.1.2. This issue can be further addressed if desired when the EPA and Navy meet to discuss this HRA.

Comment 24: Page 5-1, Section 5.1.1.1. *This HRA lacks information on the radioactivity release policies prior to 1972. Since most of the current environmental impact of NNPP is from the time period 1954 to 1971, it is critical to know what the policies during that time period were. The Navy should describe the sampling and analysis performed to ensure the 3×10^{-5} μCi/mL limits were met, and if releases were in terms of cobalt-60 equivalent, or gross alpha, beta, and gamma measurements.*

Response: The activity concentrations were measured in terms of cobalt-60 equivalent which, as noted in Section 2.3.1, is a "gross" measurement. These determinations were made either by gross beta or gross gamma analysis. The method of measurement determined whether it was a gross beta or a gross gamma value. For gamma measurements, all counts representative of gammas within the energy range of 0.1 MeV to 2.1 MeV were summed. For beta measurements, all counts representative of betas with end point energies of about 0.1 MeV and greater were summed. In either case, the efficiency of cobalt-60 was assigned to all counts, resulting in either a gross gamma (equivalent cobalt-60) or a gross beta (equivalent cobalt-60) determination. For the NNPP, cobalt-60 is the most predominant radionuclide and has the most restrictive concentration limit in air and water of all the radionuclides identified in Naval reactor plants. As noted on page 2-3, this "equivalent cobalt-60" method provides a conservative determination of the actual amount of cobalt-60 in the sample. The activity data in Table 5-1 are footnoted as being reported as cobalt-60 equivalent. The Navy believes this information is sufficient and that no changes to the text appear necessary.

Comment 25: Page 5-4, Section 5.1.1.2. *The Navy has attempted to minimize the impacts of radioactivity discharged to the Thames River by comparing radioactivity levels in NSB releases to background levels contained in sea water. As stated in previous comments, this approach is not appropriate. A more accurate and precise determination of background levels is required.*

Additionally, it appears that not all radionuclides of concern have been evaluated. Table 5-1 only includes radionuclides with half-lives greater than 8 days. Tritium and carbon-14 releases also need to be addressed.

Response: The 1991 EPA report (Reference 1 of the draft HRA) considered other radionuclides, agreed that cobalt-60 was the most limiting (and was the only NNPP-attributable radionuclide detectable in Thames River sediment), and concluded that "..the (NNPP-attributable) concentrations have significantly decreased since the earlier two surveys and represent no radiological impact to the environment or individuals living or working in the area." The Navy agrees with this EPA assessment.

The information provided on naturally occurring radioactivity in sea water was for perspective. To the extent that consideration of environmental issues is intended to minimize significant impacts beyond the effects of nature, consideration of natural levels of radioactivity is an appropriate point of comparison. (If this comparison makes the Subase releases appear "minimal," then that is likely a valid point to be made.) As stated above, cobalt-60 does not occur naturally, so determination of background concentration is not applicable.

Table 5-2 includes radionuclides with half-lives greater than 8 days for consistency with the NRC data in that table. Short half-life radionuclides are not an environmental remediation concern. Tritium and carbon-14 are discussed in comment 14 above.

Comment 26: Pages 5-7 to 5-10, Section 5.1.2. *There are several concerns with the Navy's air exhaust monitoring program which need to be addressed. First, the text indicates that the air exhaust was sampled and analyzed annually. This frequency precludes the detection of short half-life isotopes and any gaseous releases from the facility.*

Second, it is unclear if the air monitoring data are isotope specific, or general alpha, beta, or gamma measurements. The analytical program should be sensitive to the entire spectrum of potential releases. Also lacking is air monitoring data on tritium and carbon-14 releases which would require specific sampling trains or in-line recording ionization chambers.

Response: Tritium and carbon-14 are discussed in comment 14 above. The air monitoring data for particulate radioactivity presented in Table 5-3 are based on either gross beta or gross gamma cobalt-60 equivalent radioactivity measurements as discussed in comment 24 above. Due to the containment of fission products in the nuclear fuel, fission gases or short-lived fission products are not a significant concern as discussed in comment 14 above. Therefore, frequent sample filter changes to detect short-lived radioactivity are unnecessary. Note also the discussion in Section 5.1.2 concerning NESHAPS agreements between the NNPP and EPA Headquarters.

Comment 27: Page 5-10, Para. 6. *Although it is noted that "incident reports" have been required since the inception of the program and tenant commands at the NSB have listings dating back to 1968, Table 5-4 only lists recordable potential radioactivity releases to the environment back to January 7, 1975. The text should be revised or additional information provided if available.*

Additionally, the Navy should discuss potential inadvertent releases not reported and the safeguards or controls for detecting such releases.

Response: Of those reports which date back to 1968, the oldest report which documents an occurrence which had the potential to release radioactivity beyond a controlled area was the occurrence of January 7, 1975. The controls for preventing and detecting inadvertent releases are described in Sections 4.4, 5.1.3, and 6.6.

The reporting criteria for releases requiring reports changed in about 1972, when intentional releases were canceled. During the period when releases were allowed, small inadvertent releases to the harbor may not have warranted a special report. The quantity of liquid lost would have been recorded and reported to Program headquarters (i.e., included in Table 5-1). Such events would not necessarily appear in Table 5-4. However, since total releases are in Table 5-1, the environmental impact has been addressed.

Even during this early period, other types of mistakes leading to environmental releases did require reports, and would have appeared in Table 5-4 if any occurred at Subase.

At the time intentional releases were prohibited, the incident reporting criteria were revised (e.g., all environmental releases of reactor coolant would have been separately reported). Hence, the frequency of Table 5-4 listings increases after this time.

The extensive record of environmental monitoring as documented in Section 6 of the HRA supports the fact that NNPP operations at Subase have had no significant radiological impact to the surrounding environment. No revision to the text appears necessary.

Comment 28: Page 5-11, Para. 3. *The document asserts that no significant radioactivity was left on the ground as a result of past releases, documented or otherwise, and that this is confirmed by the results of aerial monitoring conducted by EG&G and discussed elsewhere in this HRA. The only conclusion that should be reached by the aerial monitoring conducted by EG&G should be that the background readings were consistent with those found elsewhere in the region. If the method were as sensitive as the Navy is implying, the overflight should have been able to identify each and every active facility and nuclear powered submarine then docked at the facility. The Navy has not identified any such findings in the references to the aerial survey other than the Millstone Nuclear Power Station on the Atlantic Coast. The text should be revised.*

Response: A copy of the EG&G report is attached for review by EPA. It is true that the EG&G survey is a relatively large area survey. The following is excerpted from the EG&G report, third paragraph, page 4: "Aerial radiological detection systems average the radiation levels due to gamma ray emitting radionuclides over an area of several acres. The systems are capable of detecting anomalous gamma count rates and determining the specific radionuclides causing the

anomalies; however, because of averaging over a large area, they tend to underestimate the magnitude of localized sources as compared with ground-based readings."

However, these surveys are readily capable of identifying:

- radioactive material storage areas in Naval shipyards, where more such material is stored than at Subase;
- known radioactively contaminated areas at non-Navy sites; and
- major sources like Millstone.

Hence, these surveys appear to be more sensitive than the EPA believes.

The shielding in Naval vessels made them undetectable during this aerial survey, but it is not known if any submarine reactor plants were operating at the time of the survey. Relatively little radioactive material is ever stored at operating bases, so it is not unreasonable that no such areas were identified at Subase during the survey. As stated above, radioactive material storage areas are pinpointed during aerial surveys of Naval shipyards.

Based on the types of radioactive material storage areas and contaminated areas which EG&G surveys have been able to identify at other facilities, the lack of any such findings at Subase appears to support the conclusion that no significant environmental radioactivity exists at the base. No revision to the Section 5.1.3 text appears necessary. However, for clarity and correctness PNS will revise the last paragraph of Section 6.7 to add the word "significant" in front of "radioactivity" in the last line.

Comment 29: Page 5-18, Para 6. *The last sentence of this page should read "No NNPP sites have active or known inactive disposal areas for Program radioactive materials." Prior to AEC regulation of radioactive materials, DOD and nuclear weapon agencies had few controls on the disposition of radioactive materials. The Army, for example, has found numerous documented and undocumented burial grounds as the environmental restoration programs have progressed.*

Response: Section 5.2.1 is correct as written. The NNPP has strictly controlled and monitored radioactive material disposal practices since the beginning of the Program, as discussed in the text and shown in Table 5-5. The NNPP cannot speak to the past practices of other organizations.

Comment 30: Page 5-19, Para. 1. *The text states that Portsmouth Naval Shipyard has certified the proper packaging and labeling of low level radioactive waste shipments from the NSB to approved disposal sites since 1980. The text should discuss the procedures for disposing of the Navy's radioactive waste prior to 1980.*

Response: The procedures for disposing of the radioactive waste prior to 1980 are already described in general in this Section. The text will be clarified to state that prior to 1980 Navy personnel at Subase certified the proper packaging and labeling of low level radioactive waste shipments from Subase to approved disposal sites.

Comment 31: Page 5-19, Para. 4. *The text indicates that the existence of waste disposal records from 1963 through 1993, coupled with the prohibition of disposing wastes on site, provide evidence that no solid radioactive waste has been disposed on the NSB property. The Navy needs to address radioactive waste disposal pre-1963. As stated in the executive summary of the HRA, Nuclear powered submarines were first placed at the NSB in 1955. The Navy needs to address the time frame from 1955 to 1963. Lacking documentation to the contrary, it is possible that radiological solid waste could have been disposed on site during these earlier years.*

Response: The second paragraph of Section 5.2.1, page 5-18, discusses early Program policies on waste disposal. The first report on solid low level radioactive waste (LLRW) disposal for Subase is for 1963. That report attests to no such waste having been shipped for disposal in 1963. As noted on page 1-1 of the draft HRA:

- nuclear-powered submarines began infrequent and short duration visits to Subase in 1955, being towed there from 1955 to 1959 for short duration periods in the floating drydock
- during these drydockings, work such as re-ballasting and hull cleaning, inspection, and painting was performed
- the first occurrence of a nuclear-powered submarine tying to a Subase pier was in September 1959
- the first radiological repair barge at Subase was not placed into service until March 1962

The documentation that Subase did not ship solid low-level radioactive waste off-site for disposal until 1964 is consistent with this early-years workload. Waste generated by Electric Boat Division (EBDiv) during any work they performed at Subase in the early years would have been removed and disposed of by EBDiv. It would not be expected that an amount of solid LLRW sufficient for a shipment would have been generated by the Subase itself until some time after the radiological repair barge had been placed into service; it would have only been after that point that any significant maintenance work associated with the NNPP could have been performed by Subase.

Comment 32: Page 5-21, Section 5.4. *There are concerns with the Navy's methods used to release facilities and equipment previously used for radiological work. The methods discussed in Section 5.4 do not measure low energy beta emitters, low energy gamma/x-ray emitters, and alpha emitters; specifically, nickel-63, iron-55, plutonium, and tritium would not be detected.*

Response: Page 5-21 addresses only NNPP release procedures. Section 4.2 describes why low energy beta emitters, low energy gamma/x-ray emitters, and alpha emitters are not of routine concern for NNPP release surveys; see also comment 15 above. Essentially, cobalt-60 serves as a satisfactory "tag" for all radioactivity of NNPP concern. With rare exceptions, other radionuclides would not be present at unacceptable levels without cobalt-60 also being present and detectable.

The NNPP release procedures have been developed on the basis of the potential source terms of radioactivity. For the rare case of an NNPP release survey where some source other than a mid-energy beta/gamma emitter was suspected, the procedures require monitoring the item with instrumentation capable of detecting the potential radionuclide's "signature" emissions.

Note that the potential source terms of radioactivity for a G-RAM item, as opposed to an NNPP item, could more likely include beta, very low gamma/X-ray, or alpha emitters. G-RAM release procedures are also developed on the basis of the potential source terms. For example, as indicated in Volume II of the draft HRA, the G-RAM source terms have included low energy beta emitters. As is the case for all release procedures, whether for NNPP or G-RAM items, monitoring appropriate to detect the identified potential radionuclides is performed.

Comment 33: Page 5-22, Para. 4. *The paragraph regarding Ingalls shipbuilding should be deleted. This example is not relevant to the NSB. If an example is needed, the Navy should use Building 174 and the barge YRRS-4 sample statistics and protocol.*

Response: The Ingalls example is very relevant. It is cited as an example of a large-scale release of prior NNPP radiological facilities where the same radiological control standards had been in place during operation as apply at Subase. This issue was also discussed in ref (c).

Comment 34: Page 5-23, Table 5-7. *Building 456 - Calibration Laboratory should be added to Table 5-7, since it is a current use facility (see page 5-16, Table 5-4).*

Response: Building 456 is included in Table 5-3 of Volume II of the draft HRA, since it is a G-RAM concern.

Comment 35: Page 6-1, Section 6.0. *The HRA presents inadequate environmental monitoring data; analytical data are provided for only 9 of the 48 sediment sampling points. No ground water or volatile gaseous fission product monitoring data are presented; air monitoring data only include particulates. Additional environmental data are necessary to appropriately evaluate NNPP impacts to the environment. Background data are also needed.*

Response: Data for all of the thousands of surface sediment samples in the Thames River are summarized in Table 6-1 of the HRA. Data for the Subase area are provided in Table 6-2; when none of the results indicate a significant radiological concern, more precise results or location-specific data provides little useful information. Nevertheless, Table 6-3 provides all available location-specific enhanced analysis results for Subase, as performed by a DOE laboratory. This appears to PNS to provide a clear indication of the lack of environmental concern with sediment near the Subase.

Subase's environmental monitoring program was designed within the framework of the total NNPP radiological control system. Subase has not historically conducted routine monitoring of release pathways for which no reasonable potential for release was thought to exist. For example, since the beginning of the Program, radiological controls have been in place at the work site to prevent releases to the air and ground water pathways. Effective oversight of radiological work, and documentation of deviations from control requirements (e.g., as shown in Table 5-4), provide a direct indication of the likelihood for such releases to have occurred. PNS believes that the compilation of this type of information in the HRA indicates that these controls have been effective, and support the conclusion of "no reasonable likelihood of release" to such

pathways, thereby precluding the need for air and ground water monitoring as referred to by the EPA.

(a) Controlling radioactivity at the source (worksite) is the most effective means not only of ensuring environmental protection, but of minimizing personnel exposure. Such controls include the immediate cleanup of any spill whenever it is discovered, including removal of asphalt, soil, etc., to whatever depth is necessary. In this context, no contamination remains to become a future soil or ground water pathway concern. This is far different from other, non-Program sites of which the shipyard is aware, where spills (e.g., chemicals) were documented but no action was taken at the time. It is appropriate to consider this difference when judging the potential for a contaminant pathway to exist.

(b) For the air pathway, the effectiveness of the source-level controls used since the beginning of the NNPP has been substantiated by recent NESHAPS testing as documented in the HRA. As such, no further actions are necessary to monitor the air pathway.

While controls have also been in place to minimize the potential for releases to the surface water pathway (i.e., to the ground, on piers, or into the river), it is acknowledged that this is the pathway most likely affected by spills as listed in Table 5-4 of the HRA; more importantly, the river was the target of intentional releases prior to 1972. Hence, the major target of NNPP environmental monitoring remains the river.

Based on the above, PNS does not consider the absence of air or ground water pathway monitoring to be a data gap. In the CERCLA sense, no reasonable likelihood of contamination exists which would warrant progressing beyond the Preliminary Assessment stage for radioactivity associated with the NNPP. (PNS also notes that ground water sampling was recently performed as part of the CERCLA RI process at Subase. Only naturally occurring potassium-40 was detected.)

As discussed elsewhere, cobalt-60 is the primary radionuclide of NNPP interest, and it is not naturally occurring. Therefore, specific cobalt-60 background data would have no value.

Comment 36: Page 6-3, Para. 1. *Typically, Environmental Radiation Monitoring ("ERM") Plans include one or more reference or background areas. There are no background areas noted for the NSB. The inclusion of reference or background areas in the ERM plan makes long-term monitoring more sensitive to subtle environmental changes. For example, the Navy contends that the EPA concludes that the cesium-137 in the sediment samples is attributable to worldwide fallout as opposed to fission product released from NNPP. Similar levels of cesium-137 in background areas would support this conclusion; as presently written, nothing noted in the Navy HRA supports this conclusion other than reference to an EPA survey. The Navy needs to address this data gap.*

Response: There is no "contention" about the EPA conclusion in Reference 1 of the HRA concerning cesium-137. In that reference the EPA discusses the cobalt-60 detected in core samples and concludes: "The other radionuclides observed in the core samples are Cs-137, which is attributed to fallout from previous atmospheric nuclear tests, and K-40, Ra-226, and

Th-232, which are naturally occurring radionuclides." The Cs-137 activity concentration values reported in Volume II of the HRA for the enhanced sediment monitoring (Table 6-2) and for the core sample monitoring (Tables 6-6 through 6-10) are consistent with the Cs-137 activity concentrations reported by the EPA in Reference 1 for sediment and sediment core samples. No data gap exists.

The lack of value in taking specific-cobalt backgrounds is discussed above.

Comment 37: Page 6-3, Para. 3. *The last sentence in this paragraph states that sample material was placed in Marinelli containers to provide consistent counting geometry. The Navy should clarify whether the samples were placed in the containers wet or dry. This distinction is important since data are normally presented as pCi/g as dry weight; counting samples wet would not be standard.*

Response: The samples are placed in the containers wet. This is noted in Volume II, page 6-8, third paragraph. The Volume I text will be revised to include the pertinent Volume II, page 6-8 information. All NNPP data has been measured and reported this way since the beginning of the Program.

- For consistency in comparing past Program data, drying samples would be undesirable.
- Testing at Mare Island Naval Shipyard during the base closure process, reviewed by EPA Region IX and the State of California, indicated that the percentage change in pCi/g results from drying samples was not worth the effort required, just for consistency with monitoring programs at other facilities.
- Wet weight is a logical measurement standard, since that is how material exists in nature. The variability in moisture from sample to sample has little impact on sample results.

Comment 38: Page 6-7, Table 6-3. *Table 6-3 presents cobalt-60 activities for sediment samples collected at various locations in the Thames River from 1970 through 1993. The data presented in this table were subjected to statistical testing for normality by a commercial software package; Sigma Stat™ Statistic Software for Windows™.*

Normality (or normal distribution) refers to the assumption (contained within parametric tests) that a population follows a standard, bell-shaped Gaussian distribution. The software performs the Kolmogorov-Smirnow (K-S) normality test at the 95 percent confidence level. This test is often used in quality assurance/quality control reliability testing of radiation detection and measurement systems. A test that passes indicates that the data are drawn from a population with a normal distribution. For the Table 6-3 data, a normal distribution would be expected if the original radioactive materials were not disturbed or added to by events.

The data were first decay corrected (normalized) to account for the exponential decay of cobalt-60. The normalized data were then analyzed by location (i.e., the location 1 data for the years 1979 - 1993 were treated as a separate data set as were each of the remaining locations), and by then calendar year.

The majority of the decay corrected location data passed the K-S test, which indicates that the individual location data are normally distributed. However, 40 percent of the calendar year data sets failed the K-S test, indicating the calendar year data are not normally distributed. These latter results show a non-homogeneous distribution of cobalt-60 from location to location within a given calendar year, which indicates the potential existence of hot spots. These results also support the conclusion that dredging and disruption of Thames River sediments have taken place over time. The Navy needs to reinterpret its data.

Further, Table 6-2 of Volume II provides uranium, thorium, and potassium-40 activity data for sediment samples collected from nine locations within the Thames River from 1978 to 1993. Table 6-3 of Volume I provides cobalt-60 activity for the same locations and time period. The data from both these tables were subjected to a number of statistical tests by a variety of commercial software packages, including: SigmaStat™ Statistical Software for Windows™; TableCurve™ 2D for Windows™; or BestFit™ Distribution Fitting Software for Windows™.

Results of these tests strongly show that the naturally occurring isotopes (potassium-40, uranium, and thorium series) approach normal distribution; whereas, the man-made isotopes (cobalt-60 and cesium-137) are definitely skewed and log-normal distributions. This indicates that there were significant radiological releases to the environment in the vicinity of the NSB, and that there is a potential for "hot spots," which may warrant further characterization.

Response: As discussed in the HRA, liquids were intentionally released prior to mid-1972. Cobalt-60 settles into the sediment and does not migrate great distances. This would account for expected variations from location to location at the Subase, even with decay over the years.

Further, normal distributions for any natural radionuclides are not expected. Non-parametric distributions are expected, depending on the variability of the geology in the area. For example, EPA Region IX and Mare Island Naval Shipyard are using non-parametric analysis techniques during the base closure process to identify any areas where radium may be above background concentrations.

The statistical study discussed by EPA Region I appears to have had no value. This issue can be further addressed if desired when the Navy and EPA meet to discuss this HRA.

Comment 39: Pages 6-8 to 6-10, Section 6.1.1. *Section 6.1.1 discusses the radiological surveys performed by the U.S. Public Health Service ("PHS") in 1966, and EPA in 1972 and 1989 of the Thames River in the vicinity of all NNPP sites. The Navy uses these surveys to explain that the cobalt-60 activity concentrations in Thames River sediment decreased at rates faster than natural decay. The mechanism is suggested to be natural sedimentation, resulting in dilution of contaminated sediment with uncontaminated sediment. The decay rates were observed to decrease by a factor of 13 to 33 between the 1966 and 1972 surveys, and a factor of 30 between the 1972 and 1989 surveys.*

If sedimentation were the cause, the decay rates would be relatively uniform between surveys and survey points. However, this apparently is not the case. Other than major storms or floods, the major sediment disturbance in this area is most likely because of dredging. As discussed in

Section 6.2, the Thames River has been extensively dredged from the 1800s through the present. The Navy's interpretation of the radiological surveys must consider these dredging activities.

Response: Natural sedimentation rates would not be expected to be uniform, either temporally or spatially. Major storms are not uncommon, nor do currents affect all areas of the river the same. The Navy's conclusions relative to sediment are consistent with the EPA's conclusions in Reference 1 of the HRA. However, the Navy agrees that dredging could also have played a role, and this will be identified in the final version of the HRA. PNS notes that the cobalt-60 levels are so low in the sediment that, even were a residential scenario to be contemplated on dredge spoils, there would be no detectable radiological exposure above background (i.e., far below the draft EPA/NRC radiological cleanup standards).

Comment 40: Page 6-11, Section 6.1.3. *The text states that environmental monitoring of marine life (mollusks, crustaceans and non-edible marine plants) in the vicinity of the NSB has been conducted annually since 1978. The Navy should specify the species that are monitored and its rationale for monitoring such species. The rationale should be based on the local marine food chain. The Navy should be looking for bioaccumulation at all levels in the environment.*

Response: The text will be revised to reflect the following: the rationale for marine life sampling is based on the local marine food chain; local species of the three broad families are collected (if available) to determine whether any bioaccumulation is occurring; the typical species collected at Subase are lobster (crustacean), mussels (mollusk), and sea lettuce (marine plant).

Comment 41: Page 6-13, Para. 4. *The statement that "Cobalt-60 is the only radionuclide attributable to NNPP operations that is detectable in these samples" should be changed to read "only gamma emitting radionuclide between 100 - 2,100 keV.*

Response: The term "radionuclide" will be replaced with "gamma-emitting radionuclide." PNS notes that gamma spectroscopy measurements (e.g., by the EPA as well as by the Navy) extend beyond the 0.1-2.1 MeV energy range of NNPP gross gamma analyses.

Comment 42: Page 6-16, Para. 2. *The text describes the history of extensive dredging of the Thames River. The Navy should discuss if the dredge material or dredged areas were sampled and analyzed for radioactivity, prior to and during dredging; the Navy needs to present this data if available. The Navy should clearly indicate the locations where dredging took place and link the activities to the analytical data collected over the years.*

In addition, the Navy should identify any permit stipulation of dredge spoil characterization data required for disposal.

Response: No analyses for radioactivity were required or conducted prior to or during the dredging. Therefore no statements were made or can be included with regard to sampling. Regarding the locations where dredging took place, the known documented information is

included either in Table 6-11 or in the text of Section 6.2. Note also the discussion of dredge materials in ref (c).

Comment 43: Page 6-21, Para. 1. *The Navy's rationale for not sampling dredge material or dredge material disposal sites for radioactivity is unacceptable. All potential disposal sites are of concern and should be evaluated for radioactivity, including the Area A Landfill.*

Response: The Area A Landfill has been monitored for radioactivity. During Phase I of the Remedial Investigation (RI), certain groundwater samples (including monitoring wells in all three former landfill areas - Area A, Goss Cove, and DRMO) were screened for both gross alpha and for gross beta radioactivity concentrations, in accordance with the EPA-approved work plan for Phase I ("Plan of Action," April 1989). Radionuclide-specific analyses were not part of this Phase I screening. Groundwater samples exceeding either the gross alpha applicable, relevant, or appropriate requirement (ARAR) or the gross beta ARAR during Phase I were re-analyzed for gross alpha and gross beta during Round 1 of Phase II, and were analyzed for radionuclide-specific content as part of Round 2 of the Phase II sampling, in accordance with the EPA-approved work plan for Phase II (both the "Work Plan" of May 1993, and the "Addendum to Work Plan" of October 1993). In accordance with the Phase I RI recommendations, this work plan required radionuclide-specific analyses for only those monitoring wells exceeding either gross alpha or gross beta ARARs during Phase I, to determine the source of any readings in excess of ARAR values. The work plan did not require a background study to determine naturally occurring levels of radioactivity. The only radionuclide identified during the Phase II, Round 2 analyses was naturally-occurring potassium-40. The radionuclide-specific results of the Phase II, Round 2 monitoring will be included in the final Phase II RI report.

These data, in conjunction with the sediment data presented in the HRA and the dredge spoils issues discussed above and in ref (c), appear sufficient to conclude that no further dredge spoil sampling is warranted.

Comment 44: Pages 6-25 to 6-27, Table 6-13; *Table 6-13 presents the Navy's perimeter radiation monitoring data from 1979 to 1993. Based on this data the Navy concludes that radiation exposure to the general public is indistinguishable from natural background. In order to evaluate the Navy conclusion, the data were subjected to least squares linear regression testing using the commercial software package TableCurve™ 2D for Windows™.*

The average quarterly data were summed, averaged for each calendar year, and multiplied by 4 to obtain an average annual dose for each year of data. The coefficients of determination ranged from 0.556 (fair) for the perimeter data to 0.714 (good) for the background data.

The linear regression equation for the background data was:

$$mREM\ (sic)\ /yr = 3.16 \times Year - 170.9$$

The linear regression equation for the perimeter data was:

$$mREM/yr = 1.51 \times Year - 29.9$$

This analysis shows an increased exposure trend of 3.16 mREM/yr for the background areas and 1.51 mREM/yr for the perimeter. This equates to a predicted increase of 44.2 mREM/yr for the background area and 22.1 mREM/yr for the perimeter area from 1979 to 1993. Looking at this trend further, the annual exposure rate in the background areas appears to be increasing at a rate which is double that of the perimeter area.

The perimeter and background data should have similar levels of increased exposure rates over time if the NSB was not contributing to the background activity. The perimeter exposure rate increase being significantly less than the background activity rate of increase indicates a potential man-made source contributing to background activity. Since no other potential sources are known, the NSB would be high on the probable source list. The Navy needs to address this significant concern.

Response: See ref (c). (Defer any additional discussion to meeting.)

Comment 45: Pages 6-28 to 6-29, Section 6.4 and Table 6-15. *Section 6.4 discusses the Navy's gamma radiation surveys conducted in selected shore areas. Table 6-15 lists the range of the shoreline count rates. The high count rates range between 5 and 12 times the low count rates. Many radiation protection programs generically use 2 to 3 times background as an action level to determine the cause of high readings. Most of the high range count rates in Table 6-15 are more than two times background and one is four times background level (i.e., the 1986 value).*

Kcpm measurements are meaningless without an efficiency factor relative to some energy. This form of measurement gives limited data since the readings are only useful relative to one another. A much more useful measurement would be mR/hr readings with a pressurized ionization chamber ("PIC"). These readings should also be taken at a specified height above the ground (i.e., 1 meter) since the height above the ground determines how large an area the detector sees. The Navy should repeat these surveys using the PIC methodology to accurately evaluate tidal shoreline areas.

Response: Count rate measurements are meaningful, provided they are consistently recorded on equivalently calibrated instruments with equivalent detectors, as the data in Table 6-15 represent. These data are collected at waist level using portable sodium iodide (NaI) scintillation detectors. The pressurized ion chamber (PIC) is a laboratory grade device used in the field to determine actual exposure rates. The Table 6-15 data represent gross count rates, in that any incident gamma of about 80 keV or greater causes a response.

The spread in these data is reflective of the non-uniformity of natural radioactivity concentrations in the area. The data would show a comparable spread if PIC measurements were obtained (these are also "gross," and converted to actual exposure rates by elaborate calibrations and corrections for temperature, pressure, and cosmic radiation). Subase examines any new reading that exceeds twice background. These examinations have always concluded that the source of the elevation above "background" was naturally-occurring radioactivity (e.g., granite outcroppings). The text presently mentions that background measurements are taken. The text will be modified to expand on the details of this monitoring.

EPA reported on a similar series of measurements in Reference 1 and concluded that only naturally-occurring radioactivity was detected.

Comment 46: Page 6-29, Section 6.5.1. *This section discusses the radiological surveys conducted at the floating drydocks. The text states that the gamma radiation measurements are taken .5 inch from the drydock floor surface at intervals of 20 to 40 feet. This methodology is not specific enough to provide defendable, accurate data. The readings are taken at intervals of 20 to 40, which represent between 400 and 1600 ft^2. Conservatively, the SPA-3 sees about 12 ft^2 at .5 inch of the deck, representing at best less than 3 percent of the deck area being surveyed. The radiation measurements should be taken at ten foot intervals; this would represent 12 percent of the deck area and render defendable data.*

Response: (Defer discussion to meeting.)

Comment 47: Page 6-30, Table 6-16. *The 1991 ARD-5 Port and Starboard Wing Wall readings are considerably elevated compared to the 1992 and 1993 readings and should be discussed in more detail in the text or as a footnote to the table.*

Response: A review of available data indicated no known basis for the elevated readings. A footnote will be added to note this.

Comment 48: Page 6-32, Para: 3. *The last sentence of this paragraph states that there is no record that any NNPP radioactivity has been found since the radioactive material ("RAM") survey program started in 1971. This statement is contradicted by Table 5-4, which lists multiple incidents where RAM was found outside of radiologically controlled areas. This paragraph should be rewritten to reflect accurate information..*

Response: The last sentence of this paragraph will be revised: "There are two records of NNPP radioactivity being found since the RAM survey program began in 1971. In both cases the RAM was controlled, and comprehensive surveys performed at the locations found no spread of radioactive material."

Comment 49: Pages 6-32 to 6-33, Section 6.7. *The Navy continually references aerial radiological monitoring surveys performed by EG&G as a basis for concluding that there is no radiation problem at the NSB. These statements are misleading, since the method detects only relatively large scale releases and areas with high concentrations of radioactive waste. The Navy needs to provide data which demonstrate the sensitivity of the method for detecting the NSB's radiation sources, and any results which substantiate the Navy's conclusions.*

Response: See comment 28 above.

Comment 50: Page 7-1, Para. 3. *The text again states that cobalt-60 concentrations found in Thames River sediments in the vicinity of the NSB are very low, and are being reduced (owing to*

natural sedimentation) at a rate greater than would be expected by radioactive decay. As stated previously, these conclusions appear misleading and do not consider the impacts of dredging. The text needs to be revised to accurately reflect all available data.

Response: Dredging will be noted as discussed in comment 39 above.

Comment 51: Page 8-2, Para. 5. *The Navy should determine the number of wells within a 4-mile radius of the site. Well records and city water records can be easily evaluated to obtain this information.*

Response: The HRA identifies the municipal wells. The EPA PA Guidance Manual notes that "water supplies in areas outside of municipal systems" should be investigated, and provides some examples of how to estimate populations served by private domestic or community wells: count houses on the USGS map; multiply number of such houses by the county average number of persons per household. The estimate, and the method of estimation, are provided in the paragraph in question. The Navy has not identified a requirement in the EPA PA Guidance Manual to determine the actual number of all the private wells that exist within 4 miles of Subase.

Comment 52: Page 8-3, Para. 1. *The discussion of the viable mechanism of ground water transport to target receptors needs to be expanded. Based on the bedrock geology, and aquifer discussions in Section 3.3.3, more explanation of transport mechanisms needs to be provided.*

Additional discussion is required on dredge material disposed in Area A, since the material could be a potential source of radiological contamination to ground water; statements and conclusions regarding the levels of contamination must be supported by radiological survey data.

Response: No explanation of transport mechanisms is necessary, since, as stated in the questioned paragraph, there has been no identifiable release of radioactivity which could threaten the ground water in the vicinity of the base.

Regarding dredge spoils, the levels of cobalt-60 in the Thames River sediment are extremely small. Since cobalt-60 does not bioaccumulate or get into the food chain, there is virtually no exposure to humans. This conclusion was reached in the EPA's radiological environmental survey reports of Subase, the most recent one issued in 1991 (HRA Reference 1). See also comment 43 above and ref (c).

Comment 53: Page 8-3, Para. 5. *The discussion of primary sensitive environments needs to be expanded. Earlier sections address endangered species, wetlands, and their distances within the 15-mile tidal zone. The two discussions need to be consistent and accurate.*

Response: Sensitive environments are discussed in more detail in earlier sections, as noted, where this more logically fits. Section 8 contains summary assessments, without repeating the expanded discussion. In that sense, Section 8 does not so much provide a "discussion" of

sensitive environments, but rather a "conclusion;" e.g., "There are no primary sensitive environments within the 15-mile tidal influence zones of concern." PNS considered it clearer to present the information in this format.

Comment 54: Page 8-3, Para. 6. *Discussion should be added to address the rainout/snowout potential sources for any air releases. Even though it may be a minor source, this air pathway should be described because of uptake potential.*

Response: Climatology, including area ranges for rainfall and snowfall, are discussed on page 3-42. The air pathway assessment is in Section 8.4, beginning on page 8-11. Essentially, air releases are so small that unrealistically conservative deposition scenarios still do not appear to result in measurable doses. No revision to the text appears necessary.

Comment 55: Page 8-6, Para. 2. *This discussion should include survey/study efforts to support the conclusion that habitat does not exist on the base, especially in the Area A Wetlands.*

Response: Support for this conclusion is provided on page 8-7, paragraph 1, where applicable conclusions from Reference 2 (the 1983 Initial Assessment Study) and Reference 4 (the 1992 Phase I Remedial Investigation) are quoted. In reference 5 (the EPA's 1989 Hazard Ranking System scoring of Subase), in response to the question "Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:", EPA determined that "Critical habitats for endangered species do not exist within 1 mile of the Subase."

Comment 56: Page 8-7, Para. 8. *the word "Tidal" should be added in front of "wetlands.*

Response: This addition will be made.

Comment 57: Page 8-8, Para. 2. *This paragraph states that the dynamics of transport of particulate cobalt-60 are such that it is unlikely for any radioactivity to reach even the closest wetland area. However, no data are provided to substantiate this statement. This discussion should be deleted or information provided to substantiate the statement.*

Response: This paragraph will be deleted.

Comment 58: Page 8-10, Para. 5-6. *The text discusses data contained in supplemental documents. The Navy needs to provide actual measurements and numbers that portray any washout, dry deposition, or body dose relationships. This section needs to be strengthened with accurate information. The HRA should be a stand alone document.*

Response: This HRA is patterned after a Preliminary Assessment (PA), in accordance with the provisions of the Federal Facilities Agreement for Subase. It is not apparent to the Navy from reviewing ref (b) that a PA should be a stand-alone document. In fact, the HRA goes far beyond the ref (b) guidance, and provides enough information to be a "stand-alone" document for most

lay readers. All the HRA's references will be provided along with the HRA in the Subase's CERCLA public document reading rooms, as will be these questions and answers, for the benefit of those readers desiring more detail.

Comment 59: Page 8-11, Section 8.4. *Since the noble gases and iodine isotopes have not been addressed, the air pathway discussion is incomplete. They need to be included to put the discussion in perspective. In addition, Area A needs to be included in the discussion on potential soil contamination.*

Response: There have been no historical releases of airborne radioactivity above allowed limits or sufficient to contribute measurable exposure to any individual. This has been confirmed independently by the NESHAPS program COMPLY calculations. Controls over airborne radioactivity releases have not changed since the beginning of the Program. Improved monitoring methods have continued to confirm that no changes to control procedures are needed.

A historical record that radiological controls have been effective in preventing significant environmental releases provides a valid basis for concluding that continued application of such controls will result in a minimal likelihood for future such releases. See also the response to comment 14 above. Details follow.

Since 1993, PNS has performed analysis for Subase to provide a quantitative estimate of the radiation exposure to which any member of the general public might be exposed as a result of radioactivity in airborne effluents. The EPA COMPLY computer program is used for this analysis, as required by EPA regulations in 40 CFR 61 Subpart I. Site-specific input parameters include radionuclide releases and distance to members of the public. Cobalt-60 values used in the calculation include actual measurements of cobalt-60 emissions from the exhaust of monitored ventilation in addition to very conservative estimates of other potential sources of cobalt-60. Values for other airborne radionuclides, including iodine-131, are conservative estimates based upon detailed study of land-based Naval nuclear propulsion prototype plants; for example, the very conservative assumption that half of the radioactive water handled by Subase evaporated from collection and storage tanks. Thus, the actual exposures to members of the public are expected to be lower than the results of this analysis.

Since the controls for airborne releases have remained the same over the years, the assessment for 1993 can be used for evaluation purposes. The result of the airborne effluent analysis in 1993 was 0.03 millirem from particulate and gaseous radionuclides and 0.000006 millirem from radioiodine releases. The estimated maximum radiation exposure to a member of the general public from releases of airborne radioactivity is much less than the standard of 10 millirem per year established by the EPA in 40 CFR 61. This section will be revised to clarify these points.

It is assumed that the reason for including Area A in this comment is EPA's earlier stated questions regarding the possibility of radioactivity being introduced to Area A when it was filled with dredge spoils. See the response to comment 52 above.

Comment 60: Page 8-13, Section 8.4.3. *The Area A Landfill should be considered a source of radiation since dredge material from the river channel were disposed in the landfill.*

Response: Only the naturally-occurring radionuclide potassium-40 has been identified as a result of gamma spectroscopy analyses of groundwater monitoring wells in the Area A Landfill. The final Phase II RI will contain this data. See the response to comment 52 above.

Comment 61: Page 9-1, Section 9.0. *This section needs to be completely revised once all comments and concerns noted in this review have been addressed. The information provided in this HRA does not currently substantiate a no further action decision. Additional data and information is necessary as described in previous comments.*

Response: (Defer discussion to meeting.)

VOLUME II

Navy Responses to Environmental Protection Agency
Comments/Questions on December 1994 Draft
Historical Radiological Assessment for
Naval Submarine Base New London

B. Volume II

Comment 62: Page 2-2, Paras. 5,7. *The phrase "detailed radionuclide analysis" should be changed to read "gamma spectroscopy analysis." Nothing was found in the documentation to indicate that any radiochemistry was performed on samples to obtain radionuclide specific data.*

Response: See comment 2 above.

Comment 63: Page 2-4, Para. 1. *Interviews should be conducted to determine the operational history and disposal practices at the NSB as commented on in Volume I (see comment for Page 2-4 and 2-5, Section 2.3.3). Interviews could clarify areas of uncertainties regarding disposal of radiological equipment and sources.*

Response: The Navy stands by its evaluation as presented in the draft HRA. See comment 3 above.

Comment 64: Page 2-4, Para. 2 [sic; para. 1]. *The last sentence of this paragraph should be deleted. The sentence states that Section 5 of the HRA shows that there is no radioactivity associated with G-RAM at or near the NSB that requires remediation. The information contained in Section 5 does not support this conclusion.*

Response: The sentence will be deleted.

Comment 65: Page 3-1, Para. 2. *The NSB, state parks, forests, fish and wildlife areas, and other sensitive areas are not clearly depicted on Figure 3-1 as stated in this paragraph. The photocopy of Figure 3-1 is not clear, and the shading used to highlight sensitive areas within pathway-specific target distance limits obscures the map features.*

Response: See comment 5 above.

Comment 66: Page 3-16, Para. 1. *A discussion of Building 86 release, testing, and use or status should be added. Additionally, the HRA should indicate the building release survey procedures and testing for Buildings 438, 141, and 148 and use after the release.*

Response: In this paragraph, it is noted that "the source(s) most likely were used at Building 86 . . ." (emphasis added). No release surveys for Building 86 were identified; they would have been noted in this draft had any such surveys been identified. Buildings 426, 156, and 86 (for

use other than that speculated on in this paragraph) will be added to Table 5-2 in the final HRA, based on recently discovered information; no release reports have been located for these three buildings. G-RAM release survey procedures are described in Section 5.4, on page 5-7. Descriptions of use after release for all these buildings will be added in the final HRA.

Comment 67: Pages 3-19 to 3-20, Section 3.3.2. *The PA guidance requires that target residential populations be apportioned to specific target distance rings which are measured from the boundaries of on-site source areas. Table 3-1 should list only the populations within each town that reside within each radius. The total populations in towns surrounding the NSB is not pertinent to a PA investigation.*

Response: If a population total within a specified target distance ring is required by ref (b), that data is noted in the appropriate "targets" subsection in Section 8. The last paragraph on page 3-17 provides the totals for resident population living within 1 mile, 10 miles, and 50 miles of Subase. These data are derived from Figures 3.7 and 3.8. Resident populations within other distances may be determined from the data presented in Figures 3.7 and 3.8. Estimates of the populations within a given town that reside within a given radius are not required. Table 3-1 is included for information, not to support any requirement of the PA.

Comment 68: Pages 3-20 to 3-21, Section 3.3.2. *Population densities within 10 and 50 radial miles of a site are irrelevant since the PA guidance requires that only populations within 4 radial miles of a site be counted. Additionally, the annular segments of Figures 3.7 and 3.8 do not subdivide the populations within one mile of the site into one-quarter and one-half mile segments as required by the PA guidance. The figures should be revised accordingly.*

Response: It is correct that "population densities" are irrelevant for purposes of a PA. Figures 3.7 and 3.8 have been titled as "Population Density" maps, but they provide the data from which the total population within a given radius from Subase may be determined and they are accordingly relevant. Estimates of populations within one-quarter mile and one-half mile radii from Subase will be provided in the final HRA, if practical; if these are essential, EPA should already have such information from prior (chemical) Preliminary Assessments, and PNS could include these numbers in the HRA.

Comment 69: Page 3-40, Section 3.3.3. *Sensitive environments should also be identified along the surface water pathway. The Navy should discuss the surveys or studies conducted to identify potential endangered species habitat.*

Response: All pathways are evaluated with greater specificity in Section 8. Where appropriate, these evaluations address sensitive environments. This discussion for the surface water pathway is on pages 8-3 and 8-4 in Section 8.2.2. Further detail regarding sensitive environments is on pages 8-6 and 8-7, where the results of negative findings regarding endangered species habitats in the region are summarized based on the studies conducted for HRA Volume II's Reference 1 (the 1983 IAS) and Reference 3 (the 1992 Phase I RI).

Comment 70: Page 4-4, Table 4-1, Status Column, Block 5. *The entry on permit No. 0635977-82NP should include a discussion on later release or use at other locations under another permit.*

Response: The use at another location under another permit and ultimate release is discussed. This block ends with "NUMI facilities remained in use for other NUMI NRMP." The "other NUMI NRMP" is the other permit for the Naval Undersea Medical Institute addressed in block 6.

Comment 71: Page 4-7, Section 4.5. *The discussion on annual on-site audits should be expanded. The text should clarify whether the audits looked at paperwork compliance or if key personnel and workers were interviewed. The text should also specify, if independent contractors or agencies outside of the Navy were utilized for independent verification.*

Response: Details of operational compliance such as this do not appear appropriate to a CERCLA PA. This can be further discussed when the Navy and EPA meet to discuss this HRA.

Comment 72: Page 5-1, Para. 1. *The last sentence in this paragraph states that Section 4.4 describes current and historical G-RAM control. However, Section 4.4 does not provide specific information concerning G-RAM control. More specific information concerning controls should be provided.*

Response: The Navy believes the Section 4.4 discussion is consistent with PA guidelines. Additional details could be provided during an on-site visit, if desired, or specific questions could be addressed when the Navy and EPA meet to discuss this HRA.

Comment 73: Page 5-1, Para. 3. *The text should state if the release surveys discussed in this paragraph were carried out to meet the 95 percent confidence level required by NUREG-5849. This kind of information would ensure the survey results were obtained through standard methodology and meet data quality control.*

Response: These release surveys were carried out well before draft NUREG/CR-5849 was published. The release surveys are discussed in Section 5.4. As noted in that section, release criteria consistent with federal regulations are (and have been) specified by NAVSEA or BUMED, as appropriate. (NUREG 5849 is also still a draft document; it does not yet represent federal regulations.)

Comment 74: Page 5-2, Para. 2. *Mention is made of 10 CFR, but there is no discussion of any applicable requirements of 40 CFR 61. This should be discussed.*

Response: Considerations of 40 CFR 61 are discussed in Section 8.4.3, Air Pathway Assessment.

Comment 75: Page 5-2, Para. 3. *The last two sentences in this paragraph are inaccurate and need to be rewritten or deleted. Technetium-99M decays to technetium-99 with a half-life of $2x10^5$ years, and iodine-131 decays to xenon-131m 0.6 percent of the time.*

Response: The next-to-last sentence is accurate: "Tc-99m is occasionally used in aerosol form for diagnostic lung studies."

Several short-lived radionuclides decay to very long-lived radionuclides. The very long-lived radionuclides are effectively decay chain "stoppers." By common practice, decay products which are of no radiological consequence, such as those with extremely long half-lives (very low specific activity) and those that are produced in an extremely small fraction of all parent disintegrations, are not listed with the parent radionuclide. For example, the decay products of radon-222 are listed as Po-218 ("Radium A"), Pb-214 ("Radium B"), Bi-214 ("Radium C"), and Po-214 ("Radium C' "). At-218 (0.02% yield, 2 second half-life), Tl-210 (0.02% yield, 1.3 minute half-life), Pb-210 (21 year half-life; thus the "stopper" for the radon-222 chain), and the other members of the chain descendent from Pb-210 (Bi-210 and Po-210) are not listed nor are they accounted for in typical radon-222 calculations.

Comment 76: Page 5-2, Section 5.1.3. *The Navy needs to discuss survey equipment and methodology. Gamma specific and liquid scintillation are not suitable for alpha emitters such as plutonium-239, americium-241 (maybe 60 keV beta) and daughter uranium-234, and polonium-210. The survey protocol should also meet the 95 percent confidence limit as required by NUREG-5849.*

Response: Surveys are conducted based on the radionuclides of concern for a specific area (gamma, alpha, etc.). Detailed equipment descriptions do not appear appropriate to a CERCLA PA. NUREG 5849 is a draft document; it does not represent federal requirements. This subject can be further reviewed when the Navy and EPA meet to discuss this HRA.

Comment 77: Page 5-4, Para. 1. *Table 5-1 lists incidents involving inadvertent releases of radioactive material dating back to only 1981. The Navy should address inadvertent releases that may have occurred prior to 1981, potential inadvertent releases not reported, and the safeguards or controls for detecting such releases.*

Response: All known unintentional releases are addressed in Table 5-1. It is, however, reasonable to presume that older G-RAM releases occurred for which such records are unavailable. Safeguards and oversight are addressed in Sections 4.4 and 4.5 (pages 4-3 through 4-7).

Comment 78: Page 5-3, Para. 2. *The text concludes that no significant radioactivity was left on the ground as a result of past releases, documented or otherwise, and that this is confirmed by the results of aerial monitoring conducted by EG&G and discussed elsewhere in this HRA. The only conclusion that should be reached by the aerial monitoring conducted by EG&G should be that the background readings were consistent with those found elsewhere in the region. The text should be revised.*

Response: See comment 28 above. For correctness, PNS will revise the last paragraph of Section 6.7 to add the word "significant" in front of "radioactivity" in the last line.

Comment 79: Page 5-5, Para. 1. *The Navy should describe storage and disposal procedures and facilities (i.e., specific buildings) used for medical low-level radioactive waste in the past. Specifically, Buildings 438, 141, and 148 and their decommissioning/release procedures need to be addressed.*

Response: As noted in Sections 4 and 5, these medical operations were always conducted in accordance with NRC license requirements. Release procedures are addressed in Section 5.4.

Comment 80: Page 5-5, Para 2. *The last sentence in this paragraph states that records indicating the volume and activity of wastes are not available. The text should indicate when and where these record searches were conducted (i.e., only on-site, central repository).*

Response: The text will be modified to reflect that thorough searches were conducted both on-site and at the central repository.

Comment 81: Page 5-6, Para. 2. *This paragraph states that the Navy performed gamma spectroscopy of 15 well water samples from various locations at the NSB. As stated in previous comments, there may be sources that emit beta radiation with no associated gamma radiation. The Navy needs to address this concern.*

Response: The text will be expanded to note the results of the Phase II RI independent analyses, which reported only the presence of the naturally-occurring potassium-40 in some of the ground water samples. See also comment 43 above.

Comment 82: Pages 6-1 to 6-20, Section 6.1. *This section presents data collected for the NNPP, including sediment, surface water, and marine sampling data from the Thames River; the text, for the most part, is identical to that presented in Volume I of this HRA. This data alone does not address G-RAM concerns. Sampling data and discussions need to be focused on the areas where G-RAM was once stored or used, inadvertent releases, and potential disposal areas. Such areas as identified by the Navy in this document include Buildings 86, 141, 148, 438, and 449. All potential disposal areas should be investigated as well, including the DRMO, Area A Landfill, and Goss Cove. Much more information and data are required.*

Response: These data itself is not identical to that presented in Volume I. Volume I presents data for cobalt-60. Within pages 6-1 to 6-20, data for all other detected radionuclides, including Cs-137, K-40 in sediment, cosmogenically-produced Be-7 (when detected), other fallout products when detected in prior years (Ru-106, Ru-103, Ce-144), uranium series average, and thorium series average are presented. This Section will be expanded to include the data for K-40 in core samples.

These sediment data, in conjunction with the Phase II RI data for ground water monitoring in the Area A Landfill, Goss Cove, and DRMO, appear sufficient to alleviate concerns for significant G-RAM in the environment with respect to this PA. Were this facility to shut down, significant additional sampling and surveying would be performed prior to releasing the facility for unrestricted use, consistent with that currently underway at Charleston and Mare Island Naval Shipyards. If the EPA has specific outstanding G-RAM concerns regarding the current Subase environment, and desires a limited additional sampling program, this can be reviewed when the Navy and EPA meet to discuss this HRA.

Comment 83: Page 6-2, Para. 4. *It is unclear if the samples are counted as collected (wet) or dried and then placed in the Marinelli containers. Since data is normally presented in pCi/g as dry weight counting samples wet would be a non-standard method. The text needs to be clarified.*

Response: See page 6-8, third paragraph, where it is noted that the samples are placed in the containers wet. See also comment 37 above.

Comment 84: Pages 6-6 to 6-7, Table 6-2. *See comment on Volume I, page 6-7, Table 6-3 regarding the sediment data. As noted in that comment, statistical analysis of the data indicate that there may have been significant radiological releases to the environment in the vicinity of the NSB, and that there is a potential for "hot spots," which may warrant further characterization. The Navy needs to address this major concern.*

Response: See comment 38 above.

Comment 85: Pages 6-7 to 6-8, Section 6.1.1. *It seems the data presented in Table 6-3 have not been subjected to statistical tests (t-Tests) to ensure the mean data are from the same population and the variances are consistent with those found in background data elsewhere. The data need to be subjected to a statistical analysis.*

Response: (Defer discussion to meeting.)

Comment 86: Pages 6-8, Para. 6 and Page 6-9, Para. 2. *The text discusses the EPA and U.S. PHS radiological surveys conducted in the Thames River. The text is identical to that presented in Volume I. The Navy states that radionuclides detected were owing to past atmospheric nuclear tests and/or are naturally occurring. As stated in previous comments, the Navy needs to provide or collect background data to substantiate its conclusions. Also, it should be noted that nuclear propulsion may be a source of fission products found in these surveys.*

Response: The Navy statements are either repetitions of or consistent with the EPA's own conclusions as stated in Reference 5 to Volume II of the HRA. For example, the EPA concludes in Reference 5 (after discussing the cobalt-60 detected in core samples), "The other radionuclides observed in the core samples are Cs-137, which is attributed to fallout from previous atmospheric nuclear tests, and K-40, Ra-226, and Th-232, which are naturally occurring radionuclides." The

Cs-137 activity concentration values reported in Volume II of the HRA for the enhanced sediment monitoring (Table 6-2) and for the core sample monitoring (Tables 6-6 through 6-10) are consistent with the Cs-137 activity concentrations reported by the EPA in Reference 5 for sediment and sediment core samples. The NNPP is not the source of the fission products (e.g., Cs-137), as discussed above and in ref (c). The Navy agrees with the conclusions of the EPA in Reference 5 that these fission products are attributable to past atmospheric tests.

Comment 87: Page 6-9, Para. 1-4. *See comment on Volume I regarding the Navy's use and interpretation of the 1966 PHS survey, 1972 EPA survey, the 1989 EPA survey (pages 6-8 to 6-10, Section 6.1.1).*

Response: See comment 39 above.

Comment 88: Page 6-9, Para. 3. *This paragraph about the State of Connecticut radiological monitoring implies that earlier state data contradicted the federal agency data. The text should be expanded or clarified as appropriate.*

Response: The text will be clarified. All state data of which the Navy is aware are consistent with federal data. However, the Navy is not in possession of very recent state data; hence, the wording used.

Comment 89: Pages 6-1 to 6-20, Tables 6-6 to 6-20. *It is unclear why the minimal detectable activity ("MDA") values increased from 0.030 pCi/g in 1983 to between 0.102 and 0.259 pCi/g from 1984 to 1989. The Navy should discuss this anomaly.*

Response: This comment does not state which analysis pattern of MDA values is being questioned (specific cesium-137, average thorium series, or average uranium series). However, since no MDA values are reported for either the thorium or uranium series averages (see Note (a) at the top of page 6-16), it is assumed the EPA is referring to the cesium data.

For 1983, the reported cesium-137 MDAs range from 0.021 to 0.037 pCi/g; for 1984 to 1989, they range from 0.052 to 0.195 pCi/g (refer to all data preceded by a "less than" symbol in Tables 6-6 to 6-9). Differences among MDA values could be due to a number of reasons, such as varying sample size, sample counting duration, or adjustments in counting systems and procedures. Navy records do not identify a specific cause for this variation for these data. However, the Navy does not view this as being problematical, since all results (both detectable values and MDAs) indicate cesium-137 is within the expected environmental range and no indication exists that Subase contributed to any results.

Comment 90: Pages 6-29 to 6-31, Table 6-23. *See comment on Volume I regarding statistical analysis of the Background and Perimeter Base data (Pages 6-25 to 6-27, Table 6-13).*

Response: See ref (c). (Defer any additional discussion to meeting.)

Comment 91: Page 6-33, Section 6.5. *The discussion on drydock sampling is identical to the NNPP information in Volume I. The Navy needs to explain how this information applies to the G-RAM concerns of the NSB. Also, the Navy should refer to Volume I comments concerning the drydock sampling methodology.*

Response: (Defer discussion to meeting.)

Comment 92: Page 6-34, Table 6-26. *The 1991 ARD-5 Port and Starboard Wing Wall readings are considerably elevated compared to the 1992 and 1993 readings and should be discussed in more detail in the text or as a footnote to the table.*

Response: A review of available data indicated no known basis for the elevated readings. A footnote will be added to note this.

Comment 93: Page 6-34, Table 6-26, note (b). *Effort was made to explain these elevated readings; similar efforts should be made to explain shoreline elevated readings.*

Response: Elevated shoreline readings will be discussed. Essentially, all values greater than twice background were followed up, and confirmed the cause was natural radioactivity. Note also the EPA conclusion on page 6-33, 2nd paragraph: "...EPA concluded that `The slightly elevated measurements...over those taken along the shoreline are attributed to natural terrestrial radiation or areas where rock high in granite content was used as fill.'" (See also comment 45 above.)

Comment 94: Page 6-35, Section 6.6. *This discussion on Routine Radiological Surveys is identical to that contained in Volume I for the NNPP. The discussion does not address G-RAM concerns.*

Response: Although the surveys discussed in Section 6.6 are performed by the NNPP, they are capable of finding G-RAM items, as noted in the HRA. Hence, it appears appropriate.

Comment 95: Page 6-36, Para. 1. *The last sentence in this paragraph states that there is no record that any G-RAM has been found since 1971. This statement is contradicted by data in Table 5-1, which lists multiple incidents where G-RAM was found outside of radiologically controlled areas. This paragraph should be rewritten to reflect accurate information.*

Response: The referenced sentence is correct: "There is no record that any G-RAM requiring controls has been found since this survey program started in 1971." The survey program referred to is described in this paragraph; it is conducted by NSSF personnel, and is limited to Lower Base as stated in the draft HRA.

Comment 96: Page 6-37, Section 6.7. *This discussion regarding EG&G's radiological aerial survey needs to be tied into G-RAM activity. The discussion should focus on G-RAM disposal area, and NSB areas that used or stored G-RAM.*

The Navy uses the aerial radiological monitoring surveys performed by EG&G as a basis for concluding there is no radiation problem at the NSB. The method detects only relatively large scale releases and areas with high concentrations of radioactive waste. The Navy needs to provide data which demonstrate the sensitivity of the method for detecting G-RAM sources at the NSB.

Response: See comment 28 above. No known on-site G-RAM disposal areas exist.

The aerial data were acquired for photons having energies between 0.04 MeV and 3.0 MeV; thus, gamma-emitting G-RAM would be detected. While this survey is not sufficient to conclude that no buried G-RAM exists (e.g., radium), it is capable of verifying that no significant sources exist in the environment, as demonstrated by the survey's ability to show variations in naturally occurring radioactivity.

Comment 97: Page 6-37, Para. 1. *The text concludes that the radiation levels of NSB property are no different that those found in the survey areas remote from any base activities. However, the Navy provides no data to substantiate this conclusion. The sensitivity of the method may not be sufficient to identify local "hot spots." The whole area of background survey analysis needs to be closely evaluated and rewritten based on a more accurate process/methodology discussion.*

Response: The conclusions based on the EG&G report appear appropriate based on the aerial survey itself. See comments 28 and 96 above. As a further example of the sensitivity of aerial surveys, a copy of the PNS survey is attached, showing radioactive material storage areas. Corresponding maps for some other Naval shipyards are even clearer, and these can be provided on request. This subject can be further addressed, if desired, when the Navy and EPA meet to discuss this HRA.

Comment 98: Page 7-1, Section 7.0. *The conclusion that there is no residual G-RAM radioactivity remaining in the environment at the NSB is not substantiated by the information contained in this report. The report identifies several sources of G-RAM which have not been adequately evaluated, including Buildings 86, 141, 148, 438, 449, DRMO, Area A Landfill, and Goss Cove. In addition, during Phase I of the Remedial Investigation, gross radiological screening parameters were exceeded in 14 of 38 ground water monitoring wells located in the DRMO, Area A, and Goss Cove. This indicates that G-RAM radioactivity is remaining in the environment.*

The Navy must evaluate all potential G-RAM source areas. All possible G-RAM isotopes of concern must be addressed, including pure beta emitters and alpha emitters.

Response: First, it is noted that the buildings and areas specified in this comment are not "sources of G-RAM." Rather, they are buildings or areas which either did or do potentially contain G-RAM. While they would require follow-up surveys if the Subase were to be shut

down, prior to their unrestricted release, they do not constitute sources of uncontrolled environmental radioactivity as applicable under CERCLA.

Second, it is noted the Navy is addressing issues within the context of the Remedial Investigation (RI), in accordance with EPA-approved work plans, as described in detail in comment 43 above. G-RAM has been shown not to be a ground water concern in any areas of the Subase.

Finally, the HRA does address all potential G-RAM radionuclides, based on a review of prior and current Subase activities. In the absence of any known or alleged burial sites or unremediated spill sites, and in the absence of any data indicating a potential problem, no further action appears warranted at this time within the context of CERCLA. The Navy acknowledges that additional characterization of both buildings and environmental areas would be necessary were Subase to be shut down, consistent with practices at other closing Naval facilities.

Comment 99: Page 8-1, Para. 4. *This paragraph states that 85 percent of the NSB is covered with pavement or structures that would isolate the soil zone and prevent G-RAM percolation into the aquifer. G-RAM contaminated dredge material and other material which were used as fill in Area A could migrate to the aquifer since the water table is at or above the ground surface in this area. The text should be revised to reflect this.*

Also, the Navy needs to specifically address potential G-RAM source areas.

Response: The ground water monitoring of wells within Area A performed during the RI concluded that only naturally-occurring potassium-40 was identified, as discussed above and on page 8-2, Section 8.1.2. There is no indication any dredge material is contaminated with G-RAM. No revision appears necessary.

Comment 100: Page 8-1, Para. 5. *This paragraph states that there has been no identifiable release of G-RAM which could threaten the ground water in the vicinity of the NSB. The text should note that gross radiological screening parameters were exceeded in 14 of 38 ground water monitoring well samples collected from Area A, DRMO, and Goss Cove during Phase I of the RI.*

Response: Exceeding a gross radiological screening parameter in the Phase I RI does not, in and of itself, indicate a release of G-RAM. As noted above, the only radionuclide detected during Round 2 of the Phase II analyses (described in Section 8.1.2) was naturally-occurring potassium-40.

Comment 101: Page 8-2, Para. 2. *Since it is possible for G-RAM to enter the aquifer beneath the NSB, primary ground water targets need to be evaluated for this site.*

The text notes that gross radiological screening parameters were exceeded in 14 of 38 ground water monitoring well samples collected from Area A, DRMO, and Goss Cove during Phase I of the RI. The text further states that the Navy subsequently performed radionuclide-specific analysis via gamma spectroscopy and that only naturally occurring radionuclides at background

levels were identified. The detection of gross screening parameters should have triggered the need for specific radiochemical analysis for radium and strontium, not gamma spectroscopy analysis, because of non-gamma emitters. The text should be qualified to reflect this limitation and future survey procedures modified to address non-gamma emitters.

Response: "Triggers" for follow-up when exceeding gross radiological screening parameters were agreed to by EPA in RI Work Plans as described in comment 43 above.

Comment 102: Page 8-2, Para. 4. *The Navy should determine the number of wells within a 4-mile radius of the site.*

Response: See comment 51 above.

Comment 103: Page 8-3, Para. 3. *This paragraph states that only naturally occurring radioactive material has been detected in water and marine biota at normal background levels, including the uranium series of which radium-226 is a component. Normal radium-226 activity should match all daughter activity between uranium-238 and radium-226 in soil, but no such assumptions apply to water owing to the differences in chemistry and disturbance of the normal equilibriums of parent-daughter. The text should specify if the levels have been tested to see if they are different statistically from other water sources in the area. This paragraph should be rewritten with a change in the water partition assumption; the Navy should reevaluate the resulting conclusions.*

Response: (Defer discussion to meeting.)

Comment 104: Page 8-3, Para. 4. *The discussion of primary sensitive environments needs to be expanded. Earlier sections address endangered species, wetlands, and their distances within the 15-mile tidal zone. The two discussions need to be consistent and accurate.*

Response: See comment 53 above.

Comment 105: Page 8-3, Section 8.2.1. *This section on release mechanisms is identical to that contained in Volume I for NNPP and may not be applicable to G-RAM activity. The text should address the specific G-RAM areas.*

Response: The Navy disagrees. Volume I Section 8.2.1 is not identical to this section. G-RAM is adequately addressed in this section, which addresses only the subject of release mechanisms affecting surface waters.

Comment 106: Page 8-6, Para. 2. *The text states that no federally designated threatened or endangered species habitat have been identified at the base. The Navy should discuss the surveys or studies conducted to document that such habitats do not exist, especially in the Area A Wetland.*

Response: Support for this conclusion is provided on page 8-7, paragraph 1, where applicable conclusions from Reference 1 (the 1983 Initial Assessment Study) and Reference 3 (the 1992 Phase I Remedial Investigation) are quoted. In Reference 4 (the EPA's 1989 Hazard Ranking System scoring of Subase), in response to the question "Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:", EPA determined that "Critical habitats for endangered species do not exist within 1 mile of the Subase." No revision to the text appears necessary.

Comment 107: Page 8-7, Para. 8. *The word "Tidal" should be added in front of the word "wetlands."*

Response: This addition will be made.

Comment 108: Page 8-8, Para. 2. *This paragraph states that dynamics of transport of particulate cobalt-60 [sic] are such that it is unlikely for any radioactivity to reach even the closest wetland area. However, no data are provided to substantiate this statement. This discussion should be deleted or information provided to substantiate the statement.*

Response: The first sentence of this paragraph will be deleted..

Comment 109: Page 8-9, Section 8.3.2. *The text states there are 9,000 employees who work at the NSB. The Navy should discuss if any of these employees are on routine bioassay for radioactive materials and if any positive samples/individuals have been identified.*

Response: Operational information is not relevant to a CERCLA PA.

Comment 110: Page 8-10, Para. 2. *This paragraph concludes that the potential source of airborne radioactivity owing to contaminated soil or spills is negligible based on a lack of detectable soil contamination. The text needs to discuss what soil monitoring programs are in effect and present any relevant data. An expanded discussion is needed in both Volumes I and II.*

Response: See response 35(a) above. Since any spills (G-RAM or NNPP) are immediately contained and cleaned up, and since no significant unremediated past spill or burial sites are identifiable by aerial survey, the Navy knows of no residual soil source terms which could result in exposure. Routine monitoring surveys would detect any significant, previously-unidentified sources (e.g., a slow leak from a tank that had recently developed). Hence, additional on-site soil monitoring programs have not been established (either NNPP or G-RAM). No additional discussion appears warranted in either volume of the HRA.

Comment 111: Page 8-10, Para. 4. *Airborne releases cannot contribute more than 10 mREM/yr to the general public and no more than 3 mREM/yr owing to iodine isotopes as required by 40 CFR 61. The radioactive releases under discussion in this paragraph need to be compared to these regulatory requirements.*

Response: These issues are discussed in regards to 40 CFR 61 requirements on page 8-12, paragraph 3.

Comment 112: Page 8-10, Para. 5. *This paragraph discusses two inadvertent airborne radioactivity releases of NRMP-controlled G-RAM. The text notes that small amounts carbon-14 and tritium were released, but points out that these radionuclides are naturally occurring. The Navy needs to discuss these releases in terms of background concentrations.*

Response: As noted in Table 5-1 of the draft HRA, these two inadvertent releases were not reportable by the applicable 10 CFR criteria. This will be repeated in the Section 8.4 paragraph. No further discussion appears necessary.

Comment 113: Page 8-12, Section 8.4.3. *All of the assumptions in this section about minute releases and their insignificance must be converted to potential dose to the general public (workers and patients within the hospital) in terms of a most credible release scenario.*

Response: As noted in this section, the hospital operations for 1993 were evaluated for compliance with the Clean Air Act emission standards. This evaluation proved that the hospital operations present an airborne exposure potential well below the 40 CFR 61 screening level requiring reporting. The Navy maintains that any dose assessment for this area that goes beyond the EPA protocol for 40 CFR 61 screening also goes beyond any requirement for inclusion in a Preliminary Assessment.

Comment 114: Page 9-1, Section 9.0. *This section needs to be completely revised once all comments and concerns noted in this review have been addressed. The information provided in this HRA does not substantiate a no further action decision. Additional data and information is necessary as described in previous comments. Specifically, all areas that may have stored or contain G-RAM must be evaluated, including Building 86, 141, 148, 438, 449, DRMO, Area A Landfill, and Goss Cove. All possible G-RAM isotopes of concern must be addressed, including pure beta emitters and alpha emitters.*

Response: (Defer discussion to meeting.)

DEPARTMENT OF THE NAVY
NAVAL SUBMARINE SUPPORT FACILITY NEW LONDON
BOX 300
GROTON, CONNECTICUT 06349

NSSF:775:crs:RCLT1
11000
Ser [illegible]

18 NOV 1982

From: Commanding Officer, Naval Submarine Support Facility New London
To: Commander, Naval Sea Systems Command (08R)
Via: (1) Commander Submarine Squadron TWO
(2) Commander Submarine Force, U. S. Atlantic Fleet

Subj: Summary Record of Surveys to Release Building 174 for Unrestricted Use; forwarding of

Ref: (a) NAVSEA 389-0153 Radiological Controls
(b) NAVSHIPS 389-0362 Radiological Work Practices Handbook
(c) KAPL A-GESC-1 Procedure for Radionuclide Analysis

Encl: (1) PRM-5N/SPA-3 Direct Scan Survey Results
(2) Cement Sample Radioactivity Measurement Results

1. The purpose of this letter is to forward the results of surveys performed to release Building 174 at Naval Submarine Base New London, Groton, CT for unrestricted use as required by article 520 of reference (a).

2. Background:

a. A portion of building 174 was used for long term storage of radioactive material from September 1975 to September 1982. All the material stored in this building was packaged such that the outside of the container was less than 450uuC/100cm^2 beta-gamma loose surface contamination as measured with a DT-304/PDR detector. Generally this material was stored in 55 gallon drums pending shipment as radioactive waste.

b. The building is constructed with brick walls and cement floors, neither of which are or have ever been covered with paint. The radioactive material storage area was separated from the rest of the building by a locked metal screen. The general layout of building 174 is shown in enclosure (1).

c. A review of incident reports and radiological surveys indicate that surface contamination levels in the building were maintained at less than 450uuC/100cm^2 during the entire period it was used for storage of radioactive material.

3. Survey instruments and survey techniques used to perform release survey:

a. A complete scan of all accessible surfaces up to a height of about 8 feet above the deck was conducted using an Eberline 140N portable frisker equipped with a DT-304/PDR probe. This instrument is capable of detecting radioactivity levels from 450uuC/100cm^2 Co-60 when the probe is held within ½ inch of the surface being surveyed. The criteria for releasing the area using this survey technique is that no surface exceeds 450uuC/100cm^2 as indicated by

Encl (2)

a count rate of less than 100cpm above background. The background count rate was measured as 80cpm and no surfaces were found which exceeded 80cpm.

b. A PRM-5N/SPA-3 high sensitivity gamma scintillation survey meter was used to perform a 100% scan of the floor and walls (probe within ½ inch of the surface) up to 8 feet high in the radioactive material storage area. The instrument was used in the HV1 (high voltage setting) and PHA (Pulse Height Analyzer) mode. In this mode the instrument will measure gamma radiation in the 1.0 to 1.5 MEV (Cobalt-60) range. The instrument is calibrated so 833 counts per minute is equal to .01 mr/hour. Background radiation readings were obtained at the north end (nonradioactive material storage) of building 174 and buildings 175 and 176 (buildings of similar construction built about the same time as building 174 that have never been used for storage of radioactive material associated with the Naval Nuclear Propulsion Program). These survey results are forwarded as enclosure (1). None of the areas surveyed were greater than twice background.

c. Cement samples were obtained in all areas surveyed by the PRM-5N/SPA-3 that were greater than 30% above the background radiation levels and in a random sampling of other areas. These samples were collected and counted using the PRM-5N/SPA-3 survey meter and the Eberline pulse integrator model PI-1 using the procedures of section 6 part 12 of reference (b). The minimum detectable activity (MDA) per sample was less than 3uuC/gram Co-60 radioactivity for the 10 gram samples used. The release criteria for this survey was all areas sampled be less than 30uuC/gram Co-60 radioactivity. The results of the cement chip samples are forwarded as enclosure (2) to this letter. The average Co-60 activity of the 34 samples counted was less than 3.3 uuC/gram with no samples exceeding 7.6 uuC/gram.

d. The energy of gammas emitted by eight samples that were above the minimum detectable activity was investigated over the range of .1 to 2.1 MEV using a Canberra Series 30 multi-channel analyzer and a NaI detector. In all samples analyzed, no photo peaks associated with nonnaturally occurring radionuclides were observed.

e. The Health Physics Laboratory at Portsmouth Naval Shipyard verified the radioactivity and energy range analysis of the eight samples greater than MDA and five other randomly selected samples. This verification was conducted independent of NAVSUBSUPPFACNLON analysis using a Ge-Li detector and the procedures of reference (c). The MDA for the 10 gram samples provided was 2uuc/ gram equivalent Co-60 for both the gross gamma and Co-60 gamma energy ranges.

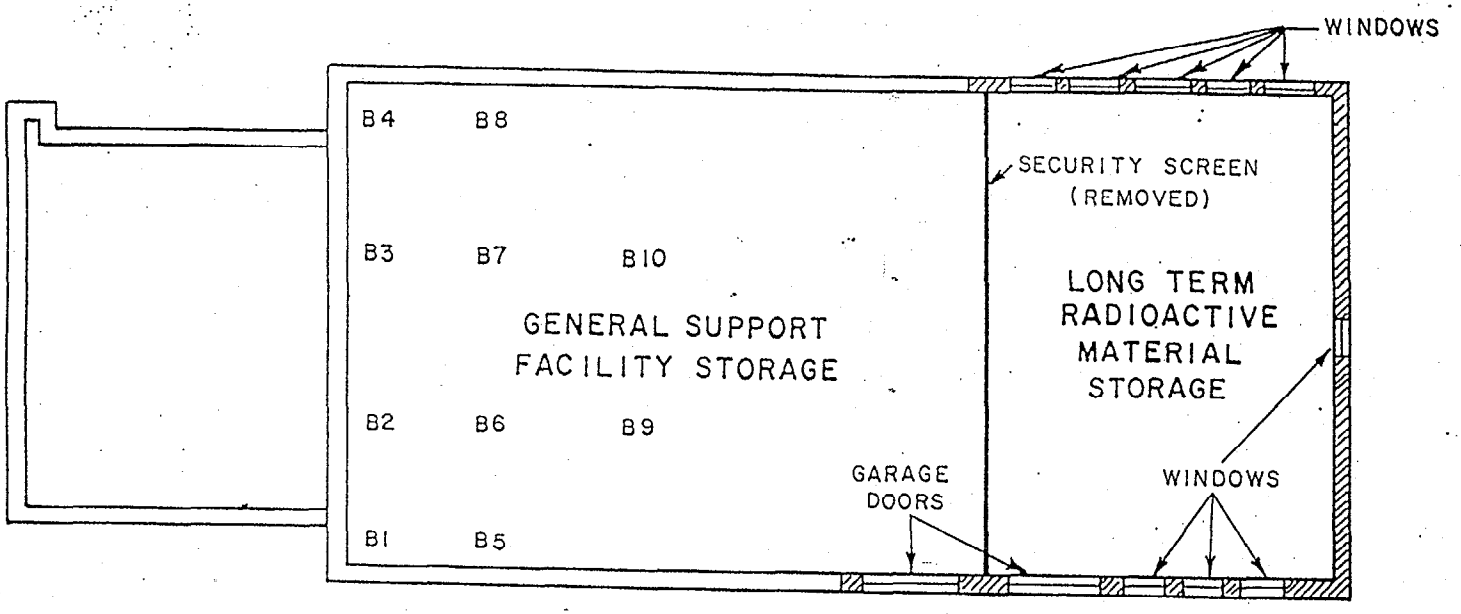
f. A swipe survey of all smooth surfaces, i.e., window panes, garage door, divider screen structural supports, was conducted by wiping a piece of dry swipe material over a 100 square centimeter area. These swipes were counted for equivalent Co-60 radioactivity using an RM-3 ratemeter equipped with a DT-304/PDR probe. The minimum sensitivity of this survey technique is 450 uuC/100cm^2. The release criteria applied to this survey is that all areas swiped be less then 450uuC/100cm^2. None of the swipes taken indicated greater then 450uuC/100cm^2 equivalent Co-60 radioactivity.

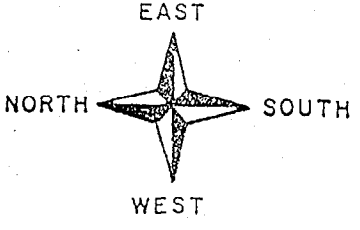
4. Based on the history of building 174 and the results of surveys conducted by NAVSUBSUPPFACNLON the building has been released for unrestricted use. A copy of this letter and enclosures will be maintained for 75 years by NAVSUBSUPPFACNLON Radiological Controls Division.

J. R. LANG

Copy to:
NAVSEA 08R (advance)
CO SUBASENLON

BUILDING 174 GENERAL LAYOUT AND BACKGROUND SURVEY INFORMATION





	HV_1 PHA (CO-60)	HV_2 GROSS (GROSS)
B1	820 CPM	15,000 CPM
B2	640	14,000
B3	660	14,000
B4	700	15,000
B5	660	15,000
B6	700	14,000
B7	640	14,000
B8	660	13,000
B9	740	14,000
B10	740 CPM	14,000 CPM
BUILDING 174 AVE	696 CPM	14,200 CPM
BUILDING 175 AVE	680 CPM	15,750 CPM
BUILDING 176 AVE	683 CPM	15,750 CPM

ALL READINGS TAKEN WITH AN EBERLINE PRM-5N WITH SPA-3 PRODE (SERIAL NUMBER 120)

PRM-5N SURVEY CONDUCTED ON 22-SEPT-82 WITH INSTRUMENT SERIAL NUMBER 120
(ALL READINGS ARE IN COUNTS PER MINUTES)

NORTH

820	800	780	800	780	(1) 700	780	780	800	800	860
780	840	740	840	820	880	860	900	880	800	880
800	780	780	780	(2) 800	(3) 840	820	880	(4) 920	900	(5) 960
880	820	840	840	880	780	880	840	860	860	(6) 920
(7) 900	(8) 800	(9) 780	(10) 840	(11) 860	(12) 820	840	(13) 740	780	880	(14) 880
(16) 880	(15) 800	720	860	880	840	900	880	860	820	840
880	900	860	880	820	840	860	880	840	860	820
(18) 900	880	860	780	(17) 860	880	800	860	880	800	840
840	860	880	860	(19) 840	(20) 900	820	800	840	860	880
880	860	820	820	840	880	(23) 820	860	(22) 920	(21) 920	860
900	860	900	880	(24) 920	900	900	900	880	(25) 920	880
820	780	760	760	800	780	800	860	800	840	760

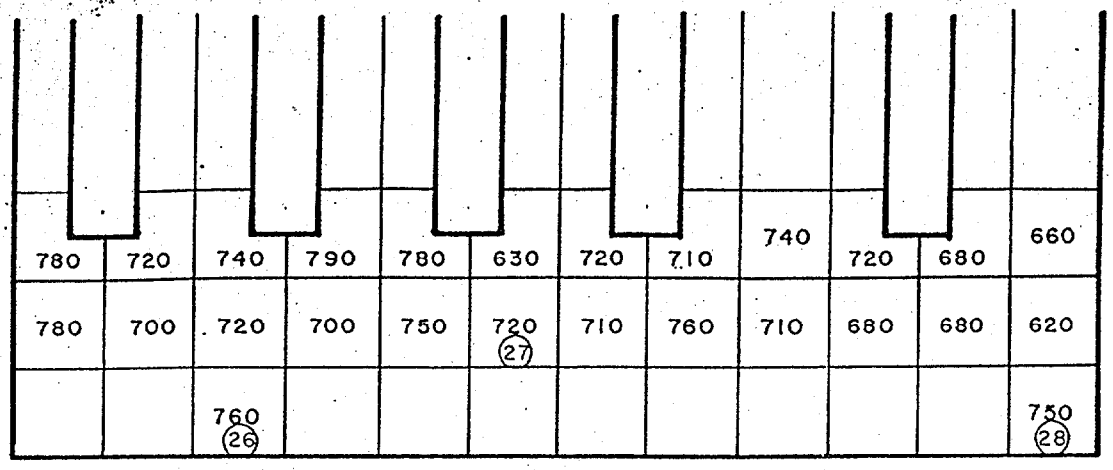
SOUTH

833 CPM = .01 MR/HR CO-60 ENERGY RANGE GAMMAS
GROSS GAMMAS READINGS WERE ALL 15,000 CPM (.025 MR/HR)
(1) INDICATES CEMENT SAMPLE LOCATIONS

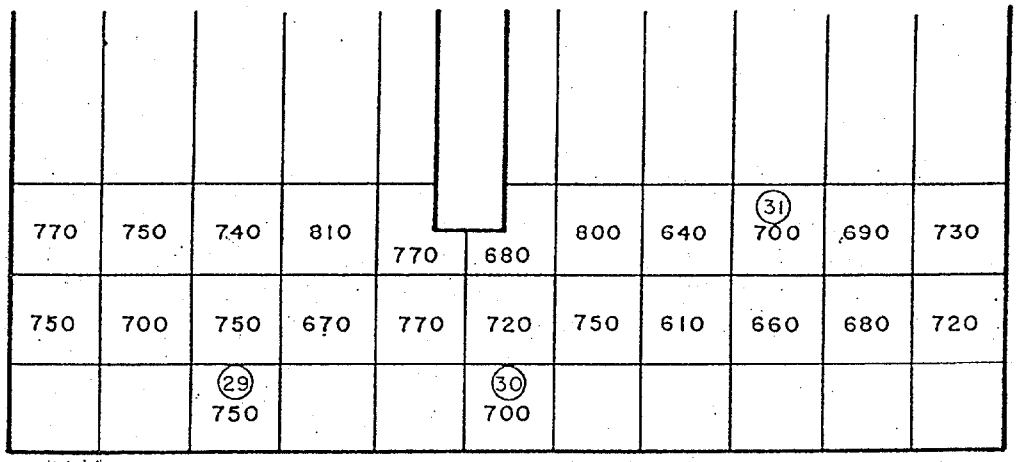
ENCLOSURE (1)

PRM-5N SURVEY RESULTS

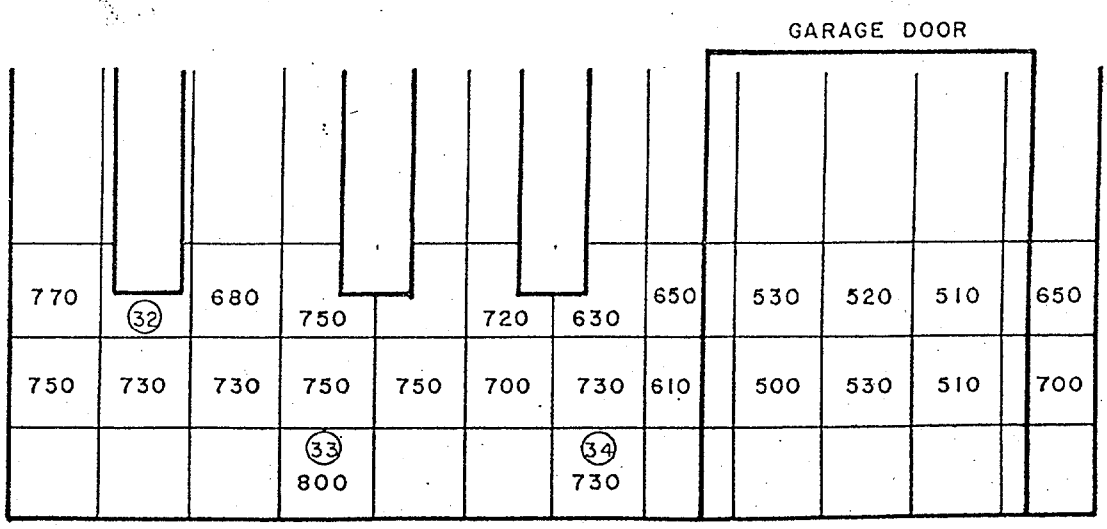
(CONTINUED)



EAST WALL



SOUTH WALL



WEST WALL

ENCLOSURE (1)

CEMENT/BRICK SAMPLES FROM BUILDING 174
CO-60 ENERGY GAMMA ANALYSIS DATA

Sample Location (Encl 1)	Sample Identification	Co-60 Energy Range (Co-60 Equivalent) Activity (uuC/gram)	Minimum Detectable Activity (uuC/gram)
1	C127	NDA	2.8
2	E104	3.3	2.8
3	E105	3.7	2.8
4	E108	3.7	2.8
5	E110	NDA	2.8
6	F89	NDA	2.8
7	G78	3.8	3.1
8	G79	NDA	2.8
9	G80	NDA	2.8
10	G81	NDA	2.8
11	G82	NDA	2.8
12	G83	NDA	2.8
13	G85	NDA	2.8
14	G88	NDA	2.8
15	H76	6.5	3.1
16	H77	7.6	3.1
17	J51	4.4	3.1
18	J55	4.9	3.1
19	K38	NDA	3.1
20	K39	NDA	3.1
21	L24	NDA	3.1
22	L25	NDA	3.1
23	L27	NDA	3.1
24	M16	NDA	3.1
25	M21	NDA	3.1
26	P1	NDA	2.8
27	P2	NDA	2.8
28	P3	NDA	2.8
29	P4	NDA	2.8
30	P5	3.3	2.8
31	P6	NDA	2.8
32	P7	NDA	2.8
33	P8	NDA	2.8
34	P9	NDA	2.8

EG&G ENERGY MEASUREMENTS

EG&G/EM SURVEY REPORT
DOE/NR-8305
DECEMBER 1983

THE REMOTE SENSING LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY BY EG&G/EM

AN AERIAL RADIOLOGICAL SURVEY OF
THE NATURAL BACKGROUND RADIATION OVER

GROTON, CONNECTICUT

AND SURROUNDING AREA

DATE OF SURVEY: JUNE 1982

Encl (3)

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EG&G ENERGY MEASUREMENTS

EG&G/EM SURVEY REPORT
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DATE OF SURVEY: JUNE 1982

J. L. Hobaugh, Jr.
Project Scientist

REVIEWED BY

Z. G. Burson, Staff
Nuclear Radiation Department

This Document is UNCLASSIFIED

G. P. Stobie
Classification Officer

This work was performed by EG&G/EM through a Purchase Order issued by Westinghouse Electric Corporation/Bettis Atomic Power Laboratory to Contract Number DE-AC08-83NV10282 with the United States Department of Energy.

ABSTRACT

An aerial radiological survey was performed during June 1982 over approximately a 290-square-kilometer (110-square-mile) area surrounding Groton, Connecticut. A gamma ray exposure rate contour map was constructed using the aerial data. The background exposure rates ranged from 5 to 16 microroentgens per hour (μR/h), which is normal for the coastal plains bordering the Atlantic Ocean. Ground-based measurements made during the same time period were consistent with those obtained from the aerial data.

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1.0 INTRODUCTION

An aerial radiological survey over Groton, Connecticut and vicinity was conducted during the period 4 to 16 June 1982. The survey was conducted using the Aerial Measuring System (AMS), operated for the U. S. Department of Energy (DOE) by EG&G Energy Measurements, Inc. from the Remote Sensing Laboratories located in Las Vegas, Nevada and Washington, D. C.

The AMS program is a continuing nationwide program to document baseline conditions surrounding energy-related sites of interest to the DOE. Since 1958, hundreds of baseline radiation surveys have been performed as a part of the AMS program.[1] The surveys have documented background radiation levels throughout the United States. AMS aircraft have the additional capability of being equipped with mapping and multispectral scanners for ultraviolet, visible and infrared imagery; a broad array of meteorological sensors; and air sampling systems for particulate and molecular gas measurements.

Aerial radiological detection systems average the radiation levels due to gamma ray emitting radionuclides over an area of several acres. The systems are capable of detecting anomalous gamma count rates and determining the specific radionuclides causing the anomalies; however, because of averaging over a large area, they tend to underestimate the magnitude of localized sources as compared with ground-based readings.

The results of the survey are reported as radiation exposure rates in microroentgens per hour (μR/h) at 1 meter above the ground surface. Approximate radiation dose equivalent rates, expressed as millirem per year (mrem/y), are obtained by multiplying μR/h by 8.76. These results apply only to the external radiation dose component.

A United States Geological Survey (USGS) map was used to define the survey area over Groton, Connecticut and vicinity. Radiological data were taken at an altitude of 122 meters (400 feet) above ground level (AGL) along flight lines spaced 229 meters (750 feet) apart. The survey covered approximately 290 square kilometers (110 square miles) with the northern part of Groton in the center of the survey area. The eastern boundary of the survey area was approximately 8 kilometers (5 miles) east of the Thames River with the western boundary approximately 8 kilometers (5 miles) west of the Thames River. The Atlantic Ocean formed the southern boundary of the survey area, while the northern boundary was approximately 11 kilometers (7 miles) north of the Gold Star Memorial Bridge. This part of Connecticut was very heavily flooded prior to the aerial survey. The survey was started after the water had receded to its normal pathways.

The purpose of the survey was to measure the exposure rates due to gamma ray emitters on the ground and produce an exposure rate coutour map showing the background radiation levels in the survey area. This survey report does not include results from the man-made sources of radioactivity at nuclear facilities located within the survey boundaries.

2.0 NATURAL BACKGROUND RADIATION

Natural background radiation originates from radioactive elements present in the earth and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Local concentrations of these nuclides produce radiation levels at the surface of the earth ranging from 1 to 15 μR/h (9 to 130 mrem/y), depending upon the type of soil and bedrock immediately below and surrounding the point of measurement. Some areas with high uranium and thorium concentrations in surface minerals exhibit even higher radiation levels. For example, on the Colorado Plateau the average radiation level is above 100 mrem/y.

One member of both the uranium and thorium decay chains is a noble gas which can both diffuse through the soil and be transported in the air to other locations. Therefore, the level of airborne radiation depends upon the meteorological conditions, mineral composition and permeability of the soil, as well as other physical conditions existing at each location at any particular time. The airborne radiation contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays, the space component, interact in a complex manner with the elements of the earth's atmosphere and the soil. These interactions produce an additional natural source of gamma radiation. Radiation levels due to cosmic rays vary with altitude and geomagnetic latitude and range from 3.7 to 11 μR/h (up to 100 mrem/y).[2]

3.0 SURVEY PROCEDURES AND EQUIPMENT

The survey and data analysis procedures and the equipment used during this survey are described only briefly in this section. Detailed descriptions can be found in previously published reports.[1,3]

3.1 Operational Support

A Messerschmitt-Bolkow-Blohm (MBB) BO-105 helicopter was used for the survey. The aircraft carried a crew of two along with all the data collection and recording instrumentation. The base of operations was located at the Waterford Airport near New London, Connecticut.

3.2 Detectors and Data Recording System

The detector package consisted of an array of 20 sodium iodide (thallium-activated), NaI(T*l*), scintillation crystals. Each detector was 12.7 cm in diameter and 5 cm thick. Two equipment pods, each containing ten detectors, were mounted on the exterior of the helicopter (Figure 1).

Figure 1. *MBB BO-105 HELICOPTER WITH DETECTOR PODS*

A photomultiplier tube mounted to each NaI(T*l*) crystal converted the scintillation pulses to voltage pulses. The voltage pulses from 19 detectors were normalized and combined in summing amplifiers in order to produce a single gamma ray energy spectrum with high sensitivity. The remaining single tube was used to provide lower sensitivity data useful in areas with greatly enhanced radiation levels. Both spectra were simultaneously acquired and recorded, resulting in a wide operating range.

The outputs of the summing amplifier and the single tube were analyzed in separate analog-to-digital converters (ADC's) in the Radiation and Environmental Data Acquisition and Recorder (REDAR) system. The REDAR system is a multi-microprocessor, portable data acquisition and real time analysis system. It has been designed to operate in the demanding environments associated with helicopters and fixed-wing aircraft.

The ADC signals were adjusted so that the photopeaks due to calibration sources appeared in preselected channels of the multichannel analyzers (MCA's). Each MCA collected a 1024-channel gamma ray energy spectrum once every second. The collected spectrum was scaled to 4 keV per channel. The 1024-channel spectrum was compressed into 256 channels before storage on magnetic tape according to the partitioning scheme shown in Table 1. The energy resolution of the NaI(T*l*) crystals varies with energy, permitting the compression of the spectral data without compromising photopeak identification and data analysis techniques. This spectral compression technique reduced the data storage requirement by a factor of four.

All 1-second data acquired by the REDAR system were placed into a buffer. After accumulating data for 4 seconds, the buffered information was recorded on magnetic tape as a 4-second record. In addition to gamma ray spectral data, other information acquired and recorded by the REDAR system included gross count data (gamma ray activity integrated over the energy range 0.04 to 3.0 MeV), aircraft position data, system live time information, and environmental conditions, i.e., absolute barometric pressure and outside air temperature.

3.3 Aircraft Positioning

The helicopter position was established by two systems: a microwave ranging system (MRS) and a radar altimeter. The MRS consisted of two remotely-located transponders and an on-board interrogator. The on-board interrogator used the transit time of a microwave pulse to obtain the distance from the aircraft to each remote unit. The radar altimeter similarly measured the time lag of the return of a pulsed signal and converted this delay to aircraft altitude above ground level. In addition to being recorded on magnetic tape, position and altitude information were also

Table 1. Partitioning Scheme Utilized for Gamma Ray Energy Data Compression

Eγ (keV)	Channel Input	Energy Coefficient ΔE (keV/channel)	Compressed Channel Output
0 - 300	0 - 75	4	0 - 75
304 - 1620	76 - 405	12	76 - 185
1624 - 4068	406 - 1017	36	186 - 253
4072 - 4088	1018 - 1022	N/A	254
>4088 - Analog Cutoff	1023	N/A	255
	1024	Unused	256

processed in real time by the steering microprocessor. These data provided steering information to the pilot for flying predetermined flight lines at the desired altitude.

3.4 Data Processing Equipment

The data recorded on magnetic tapes during the survey were processed on a minicomputer located in a mobile data processing laboratory (Figure 2). A large variety of software routines and supporting equipment was available for detailed analysis of the data. Some of the data was processed during the survey to assure data acquisition integrity and to provide preliminary results.

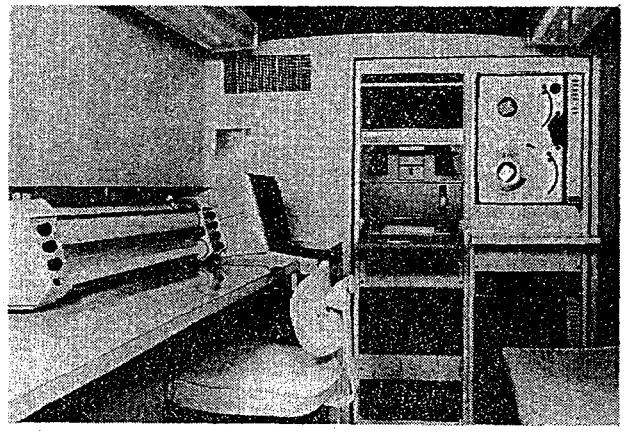

Figure 2. *INTERIOR OF THE MOBILE DATA PROCESSING LABORATORY*

4.0 GROUND-BASED MEASUREMENTS

Ground-based measurements were made at four locations, shown in Figure 3, within the boundaries of the aerial survey. Exposure rates were measured with an ionization chamber for comparison to the values inferred from the aerial data. Soil samples were taken at each ground-sampling point to determine the radionuclide concentrations typical of the natural background in the area. In addition, estimates of the exposure rates due to these radionuclide concentrations were made from soil sample analyses. The soil samples were analyzed and the results tabulated for this report by scientists at EG&G/EM's Santa Barbara Laboratory. Systems and procedures for soil sample data collection and analysis are outlined in a separate publication.[4]

5.0 EVALUATION OF DATA

Gross count rate data for gamma rays with energies between 0.04 and 3.00 MeV were used to generate a natural background exposure rate contour plot of the Groton survey area. Corrections for non-terrestrial sources of gamma rays were made by subtracting contributions from aircraft background, cosmic rays, and airborne radionuclides. These contributions were determined by flying over a large body of water (Long Island Sound) before each survey flight.

Letter labels were used to identify discrete count rate intervals. Radiation intensity contours were then constructed by plotting the radiation data as a function of position after the position information was properly scaled for the particular maps desired.

0 2 MILES

0 1 2 3 KILOMETERS

High count rates over the Millstone Nuclear Power Station prevent an accurate determination of natural radiation levels in this area.

CONVERSION SCALE	
LETTER LABEL & COLOR LEVEL	GAMMA RAY EXPOSURE RATE AT 1 m AGL (μR/h)*
A	< 5
B	5 - 9
C NO COLOR	9 - 12
	12 - 16

*Calculated from aerial data obtained at an altitude of 122 m (AGL). Values include an estimated 3.7 μR/h due to cosmic ray contributions.

GROUND SAMPLING LOCATIONS

LOCATION DIAGRAM

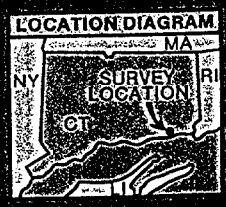

Figure 3: NATURAL RADIATION EXPOSURE RATE CONTOURS SUPERIMPOSED ON A USGS MAP OF GROTON, CONNECTICUT AND THE SURROUNDING AREA

Terrestrial exposure rate values in μR/h at the 1 meter level were inferred from the gross count rate using the approximate conversion factor of 627 counts per second equals 1 μR/h. A cosmic ray contribution of 3.7 μR/h was then added to the aerial data to obtain the total exposure rate values due to natural background radiation minus any contribution from airborne radionuclides.

6.0 RESULTS

The results of this survey are shown in a natural background exposure rate contour plot (Figure 3) and as a comparison with the ground-based measurements (Table 2). These data provide baseline radiation levels for future reference.

6.1 Aerial Results

Shown in Figure 3 are exposure rate contours (derived from gross count rates) overlaid on a USGS map. The background exposure rate values in the survey area ranged from 5 μR/h to 16 μR/h with the majority of the area in the 9 to 16 μR/h range. In addition to the natural background radiation, a man-made source of radiation was detected over the Millstone Nuclear Power Station.

The presence of this man-made activity masked the natural background radiation at that location. Thus, the background radiation levels present at that location, which is south of Waterford, Connecticut, have not been included in Figure 3. Other than the Millstone Nuclear Power Station, no other man-made source of radiation was detected within the survey area.

The exposure rate variations present throughout the survey area are typical of background exposure rate fluctuations for the coastal plains bordering the Atlantic Ocean. A gamma ray energy spectrum typical of the natural background radiation in the survey area is shown in Figure 4. The peaks in the spectrum occur at energies corresponding to the gamma rays emitted by uranium and thorium in equilibrium with their daughter products and potassium-40.

6.2 Comparison with Ground Data

The primary difference between data obtained with the airborne system and that obtained from ground measurements is in the area covered in a single measurement. Each 1-second data point obtained with the airborne system covers an area several thousand times as large as a measurement made at 1 meter, such as with a survey meter, and several million times as large as a typical soil sample. For an ideal uniform distribution extending over a large area, each type of measurement should, in principle, lead to the same results. In practice, however, it is not unusual to find differences in radiation levels from point to point on the ground, even over relatively constant areas.

A summary of the ground-based measurements and a comparison with the aerial data are given in Table 2. The estimated gamma ray exposure rates from soil analysis showed agreement with the exposure rates derived from the aerial data. Two of the four gamma ray exposure rates measured with the pressurized ion chamber showed agreement with the aerial data. The other two areas had values that were slightly higher than the aerial data. These two samples were acquired in areas that were near a generally higher radiation level. Also, the pressurized ion chamber data includes an exposure rate contribution from radon while the aerial data has had the radon exposure rate removed.

Table 2. Comparison of Ground-Based and Aerial Measurement Results

Site Number	Soil Moisture (%)	Exposure Rate (μR/h at 1 Meter)		
		Soil Sample Estimate[1]	Ion Chamber	Aerial Data[1]
1	15	11.5	12.1	9 - 12
2	21	11.4	12.3	9 - 12
3	25	10.9	11.3	9 - 12
4	14	9.9	10.0	9 - 12

[1] Includes a cosmic contribution of 3.7 μR/h.

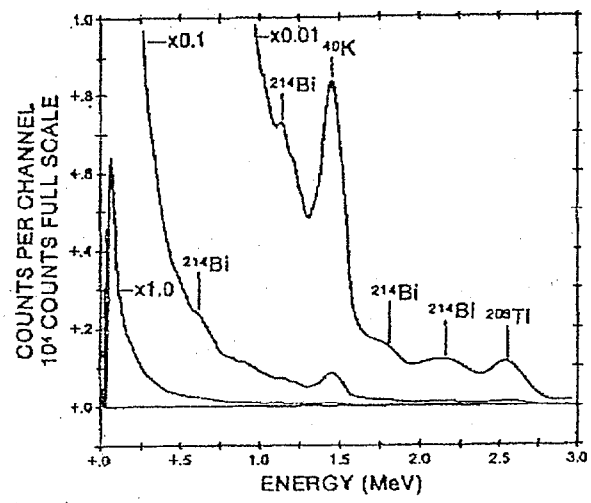

Figure 4. *GAMMA RAY ENERGY SPECTRUM TYPICAL OF THE NATURAL BACKGROUND RADIATION IN THE SURVEY AREA*

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EG&G ENERGY MEASUREMENTS

EG&G/EM SURVEY REPORT
DOE/NR-8306
SEPTEMBER 1983

THE REMOTE SENSING LABORATORY
OPERATED FOR THE U.S. DEPARTMENT OF ENERGY BY EG&G/EM

AN AERIAL RADIOLOGICAL SURVEY OF

PORTSMOUTH, NEW HAMPSHIRE

AND SURROUNDING AREA

DATE OF SURVEY: OCTOBER 1982

Encl (4)

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This Document is UNCLASSIFIED

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Classification Officer

This work was performed by EG&G/EM through a Purchase Order issued by Westinghouse Electric Corporation/Bettis Atomic Power Laboratory to Contract Number DE-AC08-83NV10282 with the United States Department of Energy.

ABSTRACT

An aerial radiological survey over a 260-square-kilometer (100-square-mile) area surrounding Portsmouth, New Hampshire was conducted during the period 4 to 12 October 1982. Background exposure rates throughout the area ranged between 7 and 16 microroentgens per hour (μR/h), which is normal for the coastal plains bordering the Atlantic Ocean. Ground-based samples taken in five locations within the survey area provided results which were in agreement with the aerial data.

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1.0 INTRODUCTION

An aerial radiological survey over the Portsmouth, New Hampshire area was conducted during the period 4 to 12 October 1982. The survey was conducted using the Aerial Measuring System (AMS), operated for the U.S. Department of Energy (DOE) by EG&G Energy Measurements, Inc. from the Remote Sensing Laboratories located in Las Vegas, Nevada and Washington, D.C.

The AMS program is a continuing nationwide program to document baseline conditions surrounding energy related sites of interest to DOE. Since 1958, hundreds of baseline radiation surveys have been performed as part of the AMS program.[1,2] The surveys have documented background radiation levels throughout the United States.

Aerial radiological detection systems average the radiation levels due to gamma/ray emitting radionuclides existing over an area of several acres. The systems are capable of detecting anomalous gamma count rates and determining the specific radionuclides causing the anomalies; however, because of averaging over a large area, they tend to underestimate the magnitude of localized sources as compared with ground-based readings.

The results of the survey are reported as radiation exposure rates in microroentgens per hour (μR/h) at 1 meter above the ground surface. Approximate radiation dose equivalent rates, expressed as millirem per year (mrem/y), are obtained by multiplying μR/h by 8.76. The aerial survey results apply only to the external radiation dose component.

The aerial radiological survey over Portsmouth covered a 260-square-kilometer (100-square-mile) area, bounded on the east by the Atlantic Ocean. The survey area extended 16 kilometers (10 miles) west of the ocean and approximately 8 kilometers (5 miles) north and south of the Piscataqua River. In addition to the survey area over Portsmouth, measurements were made over the Isles of Shoals located approximately 16 kilometers (10 miles) southeast of Portsmouth. Ground-based measurements were made at five locations within the survey area. The survey area boundaries and the locations of the ground sampling points are shown in Figure 1. The purpose of the survey was to measure the exposure rates due to gamma ray emitters on the ground and generate an exposure rate contour map showing the background radiation levels in the survey area. This survey report does not include man-made sources of radioactivity located in nuclear facilities.

2.0 NATURAL BACKGROUND RADIATION

Natural background radiation originates from radioactive elements present in the earth and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Local concentrations of these nuclides produce radiation levels at the surface of the earth ranging from 1 to 15 μR/h (9 to 130 mrem/y), depending upon the type of soil and bedrock immediately below and surrounding the point of measurement. Some areas with high uranium and thorium concentrations in surface minerals exhibit even higher radiation levels, especially in the western states. For example, on the Colorado Plateau the average radiation level is above 100 mrem/y. One member of both the uranium and thorium radioactive decay chains is a noble gas which can both diffuse through the soil and be transported in the air to other locations. Therefore, the level of airborne radiation depends upon meteorological conditions, mineral composition and permeability of the soil, as well as other physical conditions existing at each location at any particular time. The airborne radiation typically contributes from 1 to 10% of the natural background levels.

Cosmic rays, the space component, interact in a complicated manner with the elements of the earth's atmosphere and the soil. These interactions produce an additional natural source of gamma radiation. Radiation levels due to cosmic rays vary primarily with altitude and slightly with geomagnetic latitude. Typical values range from 3.3 μR/h at sea level in Florida to 12 μR/h at 3,000 meters (10,000 feet) in Colorado.[3]

3.0 SURVEY PROCEDURES AND EQUIPMENT

The survey and data analysis procedures and the equipment used during this survey are described briefly here. Detailed descriptions can be found in previously published reports.[1,2]

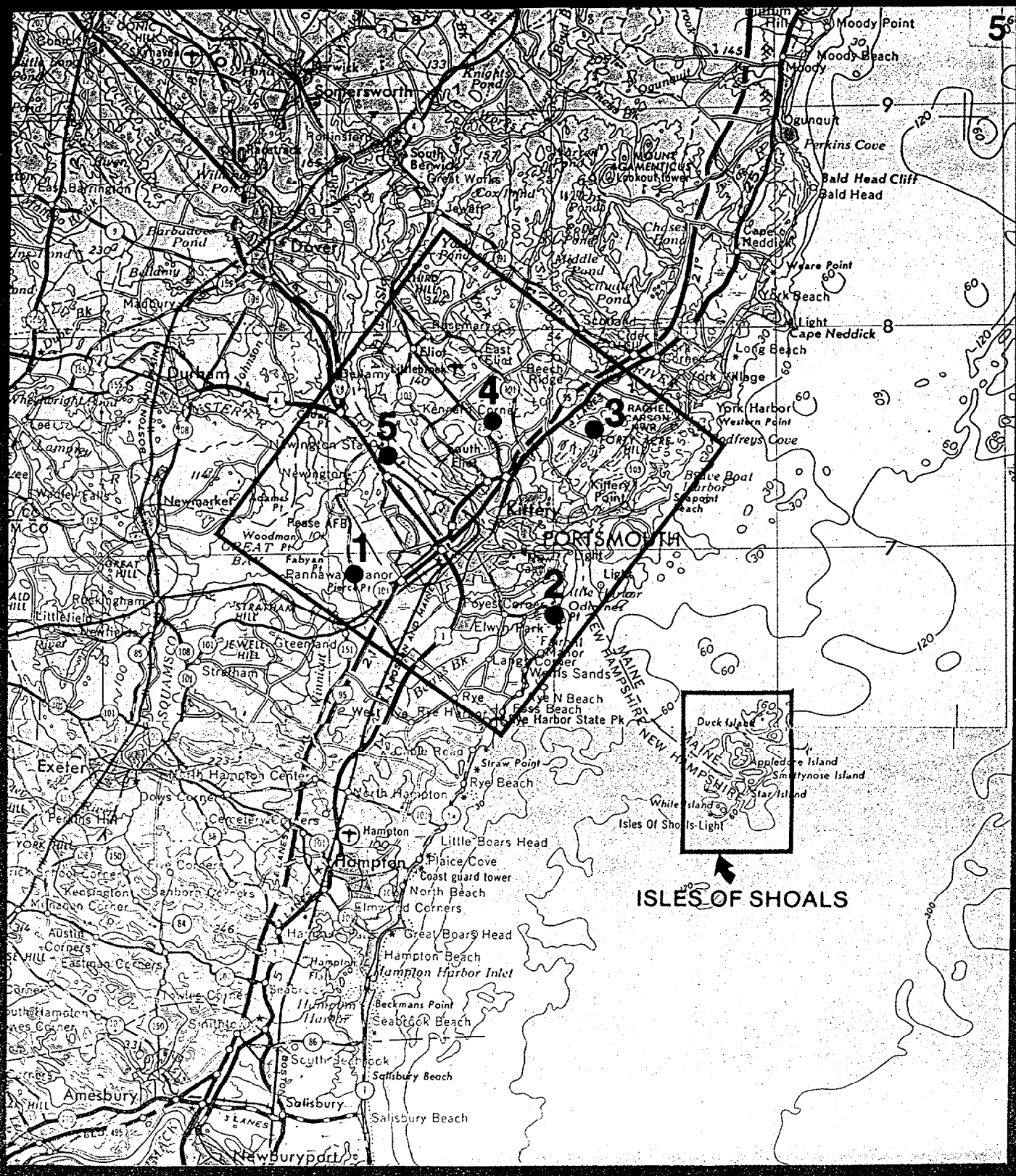


Figure 1. AERIAL SURVEY BOUNDARIES AND GROUND SAMPLING LOCATIONS

3.1 Operational Support

A Messerschmitt-Bolkow-Blohm (MBB) BO-105 helicopter (Figure 2) was used for the survey. The aircraft carried a crew of two along with all the instrumentation. The base of operations during the survey was Pease Air Force Base located west of Portsmouth.

Figure 2. *MBB BO-105 HELICOPTER WITH DETECTOR PODS*

The BO-105 helicopter was flown over the Portsmouth survey area at an altitude of 91 meters (300 feet) with a ground speed of 36 meters per second (70 knots). The 260-square-kilometer (100-square-mile) area was covered with 107 flight lines, 16 kilometers (10 miles) in length, and spaced 152 meters (500 feet) apart. Single passes at an altitude of 45 meters (150 feet) were made over each island comprising the Isles of Shoals. During each flight, the airborne system was flown over the Atlantic Ocean east of the survey area. The background radiation contributions from all non-terrestrial sources were estimated from measurements made while flying over this "water line." These data enabled the removal of those contributions from the aerial measurements and provided a check on flight-to-flight variations in the levels of airborne radiation.

3.2 Detectors and Data Recording System

Two pods were mounted outside the aircraft; each contained ten 12.7 cm diameter by 5.1 cm thick thallium activated sodium iodide, NaI(Tl), detectors. The preamplifier signal from each detector was calibrated with an americium-241 (0.060 MeV gamma) and a sodium-22 source (0.511 and 1.27 MeV gamma energies). Normalized outputs of each detector were then combined for each array in a ten-way summing amplifier. The outputs of the arrays were matched and combined in a two-way summing amplifier. Finally, the signal was adjusted in the analog-to-digital converter (ADC) so that the calibration peaks appeared in preselected channels of the multichannel analyzer.

The data recording system was a multi-microprocessor, portable data acquisition and real time analysis system. It was designed to operate in the severe environments associated with platforms such as helicopters, fixed wing aircraft, and various ground-based vehicles. The system displayed to the operator all required radiation and system information, in real time, via a 5-inch CRT display and multiple LED readouts. All pertinent data were recorded on 3M cartridge tapes for post-mission analysis on minicomputer systems.

The system employed five Z-80 microprocessors with AM9511 arithmetic processing chips to perform the data collection, data analysis, data display, position and steering calculations, and data recording which were all under operator control. The system allowed access to the main processor bus through both serial and parallel data ports under control of the control processor.

The system consisted of the following subsystems:

1. Two independent radiation data collection systems
2. A general purpose data I/O system
3. A tape recording/playback system
4. A CRT display system
5. A real-time data analysis system
6. A microwave ranging system with steering calculation and display

The multichannel analyzer collected 1024 channels of gamma ray spectral data once every second during the survey operation. The 1024 channels of data were sent to the single channel processor and were compressed into 256 channels with partitions, as summarized in Table 1. This partitioning scheme reduced the data storage requirements by a factor of four without compromising photopeak identification and data analysis techniques.

Table 1. Partitioning Scheme Utilized for Gamma Ray Energy Data Compression			
Eγ (keV)	Channel Input	Energy Coefficient ΔE (keV/channel)	Compressed Channel Output
0 - 300	0 - 75	4	0 - 75
304 - 1620	76 - 405	12	76 - 185
1624 - 4068	406 - 1017	36	186 - 253
4072 - 4088	1018 - 1022	N/A	254
>4088 - Analog Cutoff	1023	N/A	255
	1024	Unused	256

3.3 Aircraft Positioning

The aircraft position was established by two systems: a microwave ranging system (MRS) and a radar altimeter. The MRS master station, mounted in the aircraft, interrogated two remote transceivers mounted several kilometers from the survey area. By measuring the round-trip propagation time between the master and remote stations, the master computed the distance to each. These distances were recorded on magnetic tape once each second. In subsequent computer processing, they were converted to position coordinates.

The radar altimeter aboard the helicopter similarly measured the time lag for the return of a pulsed signal and converted this delay to aircraft altitude. The data were also recorded on magnetic tape so that any variations in gamma signal strength caused by altitude fluctuation could be accurately compensated, if necessary.

Positioning and altitude information were also processed in real time by the steering microprocessor. These data provided steering indication to the pilot for flying predetermined flight lines at the desired altitude.

3.4 Data Processing Equipment

The data recorded on magnetic tapes during the survey were processed on a minicomputer located in a mobile data processing laboratory (Figure 3). The mobile laboratory was parked at Pease Air Force Base during the survey.

A large variety of software routines and supporting equipment was available for detailed analysis of the data. Some of the data was processed during the survey period to assure data acquisition integrity and to provide preliminary results as soon as possible.

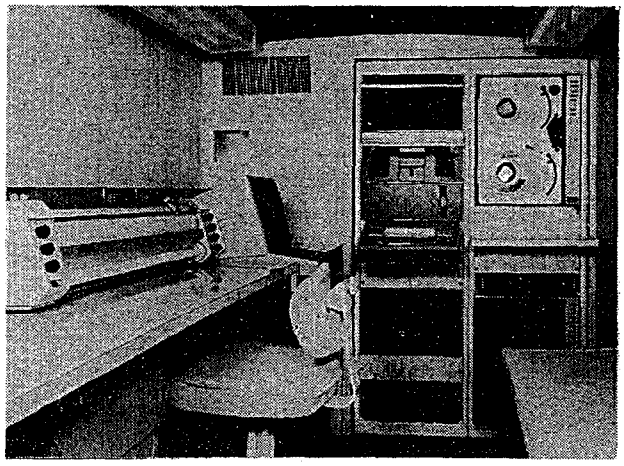


Figure 3. *INTERIOR OF THE MOBILE DATA PROCESSING LABORATORY*

4.0 GROUND-BASED MEASUREMENTS

Ground-based measurements were made at five locations, shown in Figure 1, within the boundaries of the aerial survey. Exposure rates were measured with a pressurized ionization chamber for comparison to the values inferred from the aerial data. Soil samples were taken at each ground sampling point in order to determine the radionuclide concentrations typical of the natural background in the area. In addition, estimates of the exposure rates due to these radionuclide concentrations were made from the soil sample analysis. The soil samples were analyzed and the results tabulated for this report by scientists at EG&G/EM's Santa

Barbara Laboratory. Systems and procedures for soil sample data collection and analyses are outlined in a separate publication.[4]

5.0 EVALUATION OF DATA

Gross count rate data for gamma rays in the energy spectrum between 0.04 and 3.0 MeV were used to construct a contour plot of radiation levels. Before plotting the gross count rate data, corrections for non-terrestrial sources were made by subtracting contributions from aircraft background, cosmic rays, and airborne radioactivity.

The resulting net counting rates due to terrestrial sources of radiation were converted to exposure rates at 1 meter above the ground level. This was accomplished by applying a conversion factor of 771 counts per second per μR/h. This factor was derived from many measurements made over areas with known concentrations of naturally occurring radioisotopes. The total exposure rate at 1 meter above the ground level minus any contribution from airborne radionuclides was then derived by adding the estimated cosmic ray contribution of 3.7 μR/h.

Contour lines of equal exposure rate were plotted utilizing the processed gross count rate data along with the recorded position information. The exposure rate contour map was scaled to overlay a United States Geological Survey (USGS) topographical map of the Portsmouth area. Thus, the spatial distribution and intensity of the exposure rates due to terrestrial gamma ray emitters within the survey area were defined. The recorded gamma ray spectral data were utilized to determine the identity of the radionuclides within the survey area.

6.0 RESULTS

The results of this aerial survey are shown in a contour plot of naturally occurring radioactivity. Man-made sources of radioactivity located in nuclear facilities are not included. The data from this survey also provide baseline radiation levels for future reference.

6.1 Aerial Results

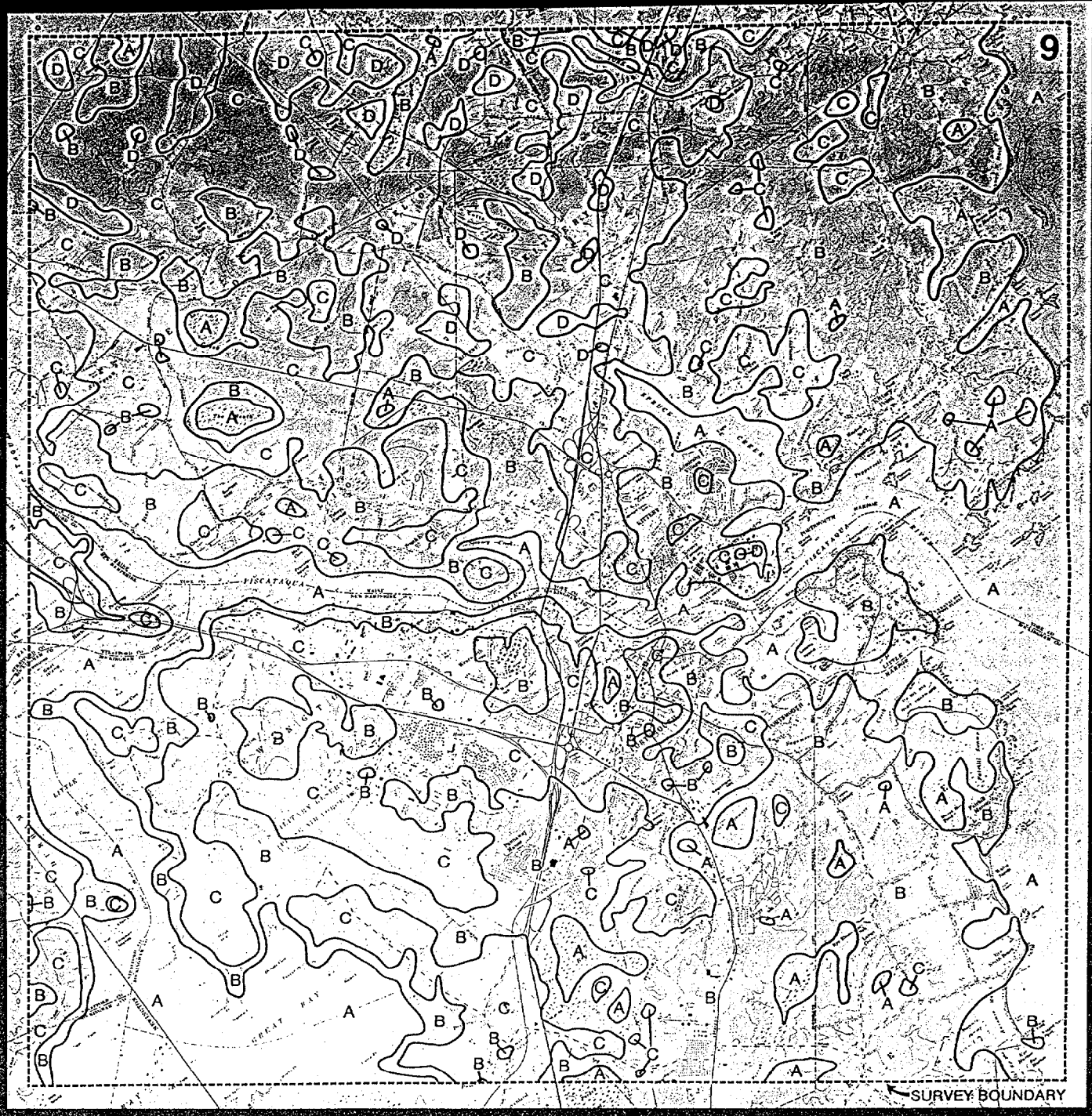
A natural background exposure rate contour map of the Portsmouth survey area is shown in Figure 4. A contour map is not shown over the Isles of Shoals since a single pass was made over each island. Average background exposure rates throughout the area and over the Isles of Shoals generally ranged from 7 to 13 μR/h. This is consistent with the findings for coastal plains bordering the Atlantic Ocean.[5,6]

A gamma ray energy spectrum typical of the natural background radiation in the survey area is shown in Figure 5. The peaks in the spectrum occur at energies corresponding to the gamma rays emitted by naturally occurring radionuclides. A gamma ray energy spectrum collected while flying over the Isles of Shoals is shown in Figure 6. Comparison of this spectrum with that shown in Figure 5 indicates that the relative concentration of thorium and its daughter products was lower on the Isles of Shoals than in the rest of the survey area.

6.2 Comparison of Aerial and Ground-Based Results

The primary difference between data obtained with the airborne system and that obtained from ground measurements is in the area covered in a single measurement. Each one-second data point obtained with the airborne system covers an area several thousand times as large as a measurement made at 1 meter, such as with a survey meter, and several million times as large as a typical soil sample. For an ideal uniform distribution extending over a large area, each type of measurement should, in principle, lead to the same results. In practice, however, it is not unusual to find differences in radiation levels from point to point on the ground, even over relatively constant areas.

Results of the ground-based measurements are given in Table 2 along with the exposure rates inferred from the aerial data obtained over each site. In general, there was good agreement between the results from the different measurement techniques.



0 0.5 1 2 MILES

0 0.5 1 2 KILOMETERS

N

CONVERSION SCALE	
LETTER LABEL	GAMMA EXPOSURE RATE AT 1 m LEVEL (μR/h)
A	<7
B	7 - 10
C	10 - 13
D	13 - 16

*Values are inferred from aerial data obtained at an altitude of 91 m AGL. Also includes an estimated cosmic ray contribution of 3.7 μR/h.

Figure 4: NATURAL RADIATION EXPOSURE RATE CONTOUR MAP SUPERIMPOSED ON A USGS MAP OF THE PORTSMOUTH, NEW HAMPSHIRE SURVEY AREA.

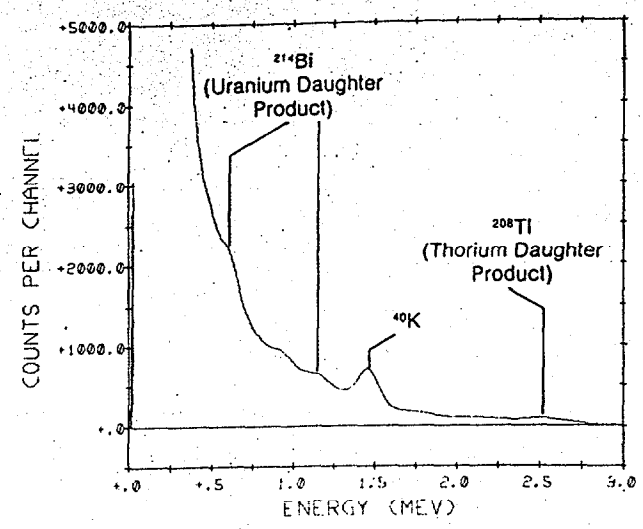


Figure 5. *GAMMA RAY ENERGY SPECTRUM TYPICAL OF THE NATURAL BACKGROUND RADIATION IN THE SURVEY AREA*

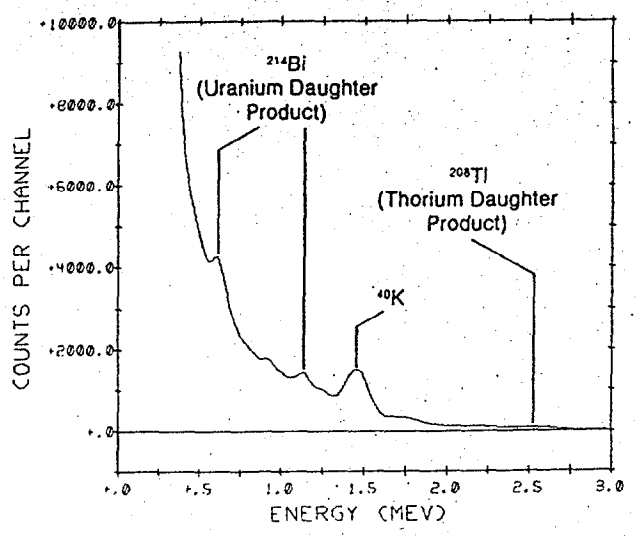


Figure 6. *GAMMA RAY ENERGY SPECTRUM OBTAINED OVER THE ISLES OF SHOALS*

Table 2. Comparison of Ground-Based and Aerial Measurement Results

Site Number	Soil Moisture (%)	Exposure Rate At 1 Meter Above Ground Level (μR/h)		
		Soil Sample Estimate[1,2]	Ion Chamber[3]	Aerial Data[2]
1	21	12.6±2.8	12.1±0.8	10 - 13
2	14	11.1±2.7	9.5±0.8	7 - 10
3	20	9.5±1.4	9.6±0.8	7 - 10
4	20	10.5±0.6	9.7±0.8	7 - 10
5	19	15.3±1.6	13.0±0.8	10 - 13

[1] This estimate includes a correction for soil moisture (Reference 7).

[2] Includes estimated cosmic contribution of 3.7 μR/h.

[3] Reuter-Stokes Model RSS-111, Serial No. R574. These values include a contribution from airborne radionuclides that is not included in the other results.

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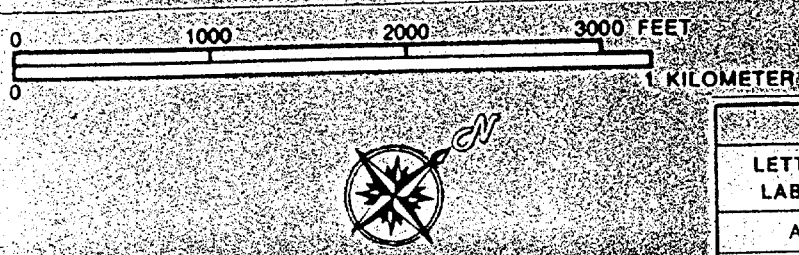

CONVERSION SCALE	
LETTER LABEL	MAN-MADE GROSS COUNT RATE (cps)[1]
A	−400 to 400
B	401 to 700
C	701 to 1000
D	1001 to 1500
E	1501 to 2500

[1]At an altitude of 91 m. See text for algorithm.

Figure A-1. MAN-MADE GROSS COUNT CONTOUR MAP SUPERIMPOSED ON AN AERIAL PHOTOGRAPH OF THE PORTSMOUTH NAVAL SHIPYARD