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GENERAL RADIOACTIVE MATERIAL (G-RAM) RADIOLOGICAL FINAL REPORT FOR DECOMMISSIONING OF CHARLESTON NAVAL SHIPYARD VOLUME I CNC CHARLESTON SC

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RADIOLOGICAL ENGINEERING DIVISION

GENERAL RADIOACTIVE MATERIAL (G-RAM) RADIOLOGICAL FINAL REPORT FOR THE DECOMMISSIONING OF CHARLESTON NAVAL SHIPYARD

(VOLUME I)

Prepared by
Radiological Engineering Division
Charleston Naval Shipyard
Charleston, South Carolina

April 1, 1996

NAVAL NUCLEAR PROPULSION PROGRAM (NNPP)

RADIOLOGICAL FINAL REPORT

FOR THE DECOMMISSIONING OF

CHARLESTON NAVAL SHIPYARD

(VOLUME I)

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VOLUME I

EXECUTIVE SUMMARY

A. Purpose

This document is the Naval Nuclear Propulsion Program (NNPP) Radiological Final Report for the Decommissioning of Charleston Naval Shipyard (CNSY). The document has been prepared by CNSY pursuant to the Defense Base Realignment and Closure (BRAC) Act of 1990, as amended, which authorized closure of Charleston Naval Shipyard, Charleston, South Carolina. The purpose of this report is to document the removal of NNPP radioactive material associated with over 30 years of radiological maintenance work on nuclear-powered ships of the U.S. Navy at CNSY.

Volume I of this report addresses the planning and production aspects of decommissioning the shipyard. Also included herein are the historical controls and requirements which existed since the inception of the NNPP. These stringent controls made the decommissioning practicable within the required time and resource constraints. Volume II contains the individual area release reports.

The shipyard also removed General Radioactive Material (radioactive material unrelated to the NNPP such as radium used in past industrial applications) from CNSY. This effort is documented in a separate report.

B. Background

Charleston Naval Shipyard was first authorized to accomplish NNPP work in 1962. During 1962 and early 1963, only limited component work was done. The first nuclear submarine overhaul commenced in 1963, and in April 1965, the first nuclear submarine refueling began. Since 1965, the shipyard conducted overhauls, or shorter restricted availabilities, on almost every type and class of nuclear-powered submarine. Thirty-three were overhauled, of which twenty-six were refueled. Eight others were inactivated.

Beginning in 1959, before any radiological work was performed, or a nuclear-powered ship was berthed at the shipyard, a baseline study of the radiological environment of the shipyard and surrounding waters was conducted. Radiological environmental monitoring continued through December 1995. Since 1967, results have been published in an annual report by the NNPP with distribution to other Federal Agencies, States, Congress, and the public. The results demonstrated that radioactivity associated with the NNPP has had no significant or discernible effect on the quality of the environment.

EXECUTIVE SUMMARY

Independent cross-checks of analytical results and independent surveys of the harbor have been an integral part of the environmental monitoring program since its inception. These independent verifications were consistent with NNPP and shipyard results and conclusions.

C. Nuclear Closure Process

The nuclear closure operations initiated by the shipyard used basic engineering principles and common industrial practices. From the outset of closure, the major program goals were to:

- Transfer appropriate facilities and equipment to other activities continuing to support Naval nuclear propulsion work.
- Minimize hazardous and low-level radioactive waste generation.
- Meet State and Federal radiological, environmental, and safety regulations.
- Control costs and complete closure within the allocated time frame.

An extensive radiological survey plan was developed to identify any remaining radioactivity associated with the NNPP. Extensive surveys with sensitive instruments were performed over all areas where radioactive material had been worked on, stored, or transported. Detailed instructions were written to prepare and survey each area for final release using the guidelines presented in the release plan. A rigorous quality assurance program was implemented to ensure the validity of survey data obtained. 4,581,000 square feet were surveyed with portable instrumentation. In addition, over 65,000 solid samples were taken and analyzed throughout the shipyard. The relatively few areas (totalling approximately 7,178 square feet) where low-level radioactivity in excess of NNPP limits was detected, were remediated for unrestricted use.

The total radioactive material volume generated during the decommissioning of the shipyard was approximately 177,000 cubic feet. Through volume reduction at a commercial processor, only 94,939 cubic feet required disposal at the Barnwell, South Carolina radioactive waste burial ground. Of the amount of material disposed of as radioactive waste, only 7,267 cubic feet were generated by remediation of CNSY facilities.

EXECUTIVE SUMMARY

D. Conclusions

This final report concludes that:

- The berthing of, and work on, nuclear-powered ships at CNSY had no adverse effect on the environment of the region.

- Those few shipyard areas in which NNPP radioactivity greater than the Program release limits were detected have been remediated.

- The State of South Carolina Department of Health and Environmental Controls and the U.S. Environmental Protection Agency agreed that the facilities are acceptable for release to the local community for unrestricted use with respect to NNPP radioactivity.

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH THE NAVAL NUCLEAR PROPULSION PROGRAM (NNPP) AT CHARLESTON NAVAL SHIPYARD (CNSY)

A. General

Charleston Naval Shipyard in Charleston, South Carolina serviced nuclear powered ships and submarine tenders from 1962 through 1994. The shipyard has overhauled thirty-three nuclear-powered submarines of which twenty-six were refueled, inactivated 8 nuclear-powered submarines, performed many shorter availabilities, and supported special fleet operations such as resin discharge, and waste disposal. Table I-1 provides a listing of the nuclear-powered ship overhaul and refueling availabilities accomplished at CNSY. Throughout these 34 years of service, the facilities in the industrial area at CNSY have been used to store and perform work on radioactive equipment, materials, and components.

The radioactivity associated with these materials originated from pressurized water reactors in Naval nuclear-powered ships. Water circulated through a closed piping system to transfer heat from the reactor core to a secondary steam system isolated from the reactor cooling water. The principle source of radioactivity in radioactive materials associated with the Naval Nuclear Propulsion Plant Program is trace amounts of corrosion and wear products from the reactor plant metal surfaces in contact with reactor cooling water. The most predominant radionuclide in these corrosion products is cobalt-60. This isotope emits two gammas (1.17 and 1.33 MeV) and a beta (maximum energy of 0.318 MeV) for every decay and has a 5.3 year half-life. Cobalt-60 has the most restrictive concentration limits as listed by organizations which set standards for exposure to radioactive isotopes. Fission products produced in the reactor are retained within the fuel elements, including the fission gases krypton and xenon. For this reason, fission products encountered during the shipyard's work were negligible and cobalt-60 was the predominant radionuclide of concern.

During submarine overhaul and refueling, portions of the piping systems containing cobalt-60 were drained, breached, and removed, in order to perform maintenance required for the continued operation of these vessels. The majority of radioactivity present at Charleston Naval Shipyard was from handling reactor coolant and work on these piping systems. In order for the shipyard to be released to the public for unrestricted use, all radioactivity associated with the Naval Nuclear Propulsion Program had to be removed. This removal was verified by extensive surveys with sensitive instruments, performed over all areas where radioactive material had been worked on, stored, or transported. Detailed instructions were written to prepare and survey each area for final release using the guidelines presented in this release plan. The surveys required to release an area were based on the use of the area and its radiological history. Areas were categorized into groups based on their potential for containing unidentified radioactivity per NNPP requirements. All radioactivity above

NNPP limits was removed. Extensive records were kept for documentation of this effort. After the process was completed, there were no restrictions placed on use of the property.

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH THE NAVAL NUCLEAR PROPULSION PROGRAM (NNPP) AT CHARLESTON NAVAL SHIPYARD (CNSY)

Table I-1
CNSY Nuclear Ship Availability

SHIP	TYPE OF AVAILABILITY*	DATE OF AVAILABILITY
USS SCORPION (SSN 589)	RO	4/63-4/64
USS SHARK (SSN 591)	RO	1964-1965
USS SKIPJACK (SSN 585)	RO/RF	04/65-10/66
USS THOMAS EDISON (SSBN 610)	RO/RF	10/66-05/68
USS JAMES MONROE (SSBN 622)	RO/RF	01/68-09/69
USS HENRY CLAY (SSBN 625)	RO/RF	10/68-02/70
USS HADDO (SSN 604)	RO	08/69-04/71
USS GEORGE WASHINGTON (SSBN 598)	RO/RF	07/70-11/71
USS THEODORE ROOSEVELT (SSBN 600)	RO/RF	11/71-03/74
USS POLLACK (SSN 603)	RO/RF	05/72-01/75
USS SAM HOUSTON (SSBN 609)	RO/RF	11/72-03/75
USS SEAHORSE (SSN 669)	RO	04/74-06/75
USS RAY (SSN 653)	RO/RF	08/75-11/76
USS STURGEON (SSN 637)	RO/RF	07/76-11/77
USS GREENLING (SSN 614)	RO/RF	02/77-12/78
USS SEAHORSE (SSN 669)	RO/RF	11/77-06/79
USS GRAYLING (SSN 646)	RO/RF	09/78-03/80
USS NARWHAL (SSN 671)	RO/RF	01/80-02/82
USS MENDEL RIVERS (SSBN 686)	RO	03/81-09/82
USS SEA DEVIL (SSN 664)	RO/RF	10/81-04/83
USS VALLEJO (SSBN 658)	RO/RF	01/83-07/84
USS RAY (SSN 653)	RO	11/83-02/85
USS JOHN C. CALHOUN (SSBN 630)	RO/RF	10/84-07/86
USS STURGEON (SSN 637)	RO	04/85-11/86

HISTORY OF RADIOLOGICAL WORK ASSOCIATED WITH THE NAVAL NUCLEAR PROPULSION PROGRAM (NNPP) AT CHARLESTON NAVAL SHIPYARD (CNSY)

Table I-1 (cont.)
CNSY Nuclear Ship Availability

SHIP	TYPE OF AVAILABILITY*	DATE OF AVAILABILITY
USS SAM RAYBURN (SSBN 635)	RO/RF	09/85-08/89
USS STONEWALL JACKSON (SSBN 634)	RO/RF	09/85-12/87
USS GEORGE BANCROFT (SSBN 643)	RO/RF	06/86-12/88
USS BENJAMIN FRANKLIN (SSBN 640)	RO/RF	07/86-12/88
USS WOODROW WILSON (SSBN 624)	RO/RF	07/87-07/90
USS BATFISH (SSN 681)	RO/RF	09/87-01/91
USS ANDREW JACKSON (SSBN 619)	INAC	06/88-09/89
USS BILLFISH (SSN 676)	RO/RF	10/88-04/91
USS NARWHAL (SSN 671)	RO/RF	10/89-12/92
USS HENRY CLAY (SSBN 625)	INAC	03/90-11/90
USS DANIEL WEBSTER (SSBN 626)	RO/RF	09/90-01/93
USS SEA DEVIL (SSN 664)	INAC	01/91-04/92
USS LEWIS AND CLARK (SSBN 644)	INAC	10/91-06/92
USS RAY (SSN 653)	INAC	08/92-7/93
USS PROVIDENCE (SSN 719)	DMP	09/92-09/93
USS GEORGE BANCROFT (SSBN 643)	INAC	03/93-03/94
USS VON STEUBEN (SSBN 632)	INAC	07/93-04/94
USS WOODROW WILSON (SSBN 624)	INAC	11/93-09/94

* Abbreviations/symbols under "Type of Availability":

RO/RF - Regular Overhaul/Regular Refueling
INAC - Inactivation
DMP - Depot Modernization Period

RADIOLOGICAL CONTROLS USED WHILE PERFORMING RADIOLOGICAL WORK

A. Introduction:

1. Radioactivity from Naval Nuclear Propulsion Plants

Naval nuclear propulsion plants differ from commercial power generating reactors in several important ways with respect to potential environmental impact. They are considerably smaller both in physical size and power output. To ensure safe operation in close proximity to operating crews under possible high shock loading of battle conditions, the reactor plants are much more durable. Leakage of fission products into the cooling system, or leakage from the cooling system, are not compatible with ship operation and are not tolerated.

In the shipboard reactors, pressurized non-boiling water (reactor or primary coolant) circulating through the reactor core picks up the heat of nuclear reaction. The reactor cooling water circulates through closed piping systems to heat exchangers, which transfer the heat to water in a secondary system isolated from the primary cooling water. The secondary water is turned into steam, which is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Reactor coolant from shipboard reactors is collected primarily when reactor cooling water expands as a result of being heated up to operating temperature.

The principal source of radioactivity encountered during maintenance work is trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives of approximately one day or greater in these corrosion and wear products include tungsten-187, chromium-51, hafnium-181, iron-59, iron-55, cobalt-58, and cobalt-60. Cobalt-60, which has a 5.3 year half-life, is the most predominant. It also has the most restrictive concentration limits as listed in 10 CFR 20. Therefore, cobalt-60 is the primary radionuclide of interest for Naval nuclear propulsion plants.

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and as a result of certain other nuclear reactions. Although tritium has a 12.3 year half-life, the radiation produced is of such low energy (weak beta; no gamma) that the 10 CFR 20 radioactivity concentration limit for tritium is at least one hundred times higher than for cobalt-60. This tritium is in the oxide form (i.e., water) and is chemically indistinguishable from normal water; therefore, it does not concentrate in marine life or collect on sediment as do other radionuclides. Carbon-14 is also formed in small quantities in reactor coolant systems as a result of neutron interactions with nitrogen and oygen. This carbon is in the form of hydrocarbons. Carbon-14 decays with a half-life of 5,730 years; however, only low-energy beta radiation is emitted as a result of this decay process. As a result, the 10 CFR 20 radioactivity concentration limit for carbon-14 in its chemical form in air is sixty times higher than for cobalt-60.

2. Type of Work Activities

CNSY performed a wide range of radioactive work associated with Naval nuclear propulsion plants, including refueling reactor plants. Refueling involves removal of spent fuel into special shipping containers and installation of new fuel. No work on or processing of fuel was performed at CNSY. Radioactive materials encountered during reactor plant work included reactor coolant that was processed and reused, reactor plant components (including removed and/or unusable components), tools and equipment used to perform work, reusable (laundered) contamination control clothing, and contamination control waste products such as rags, plastic bags, tape, plastic bottles, and impervious fabrics.

Trade skills required for reactor plant work were the same as for typical shipyard operations. Work was directed by engineers and monitored by inspectors and radiological control technicians. The primary differences from other work were the extremely high quality standards and the interaction with radiation and radioactive materials.

B. Control of Radioactivity

A major objective of the shipyard in the performance of Naval nuclear propulsion plant work was avoiding releases of low level radioactivity into the environment. From the beginning of the NNPP, radiological work was performed under strict controls to preclude the spread of contamination, by containing radioactivity at the source to the smallest practicable area or volume. Facilities where work on radioactive materials was performed were specifically designed to contain radioactivity. Design criteria included impervious walls, easily decontaminated surfaces, absence of floor drains, and ventilation systems with high efficiency particulate air (HEPA) filtered exhaust to maintain a negative pressure differential in work areas. The HEPA filters are 99.97% efficient at removing 0.3 micron particles. The filtered exhausts were monitored with an environmental monitoring system.

Most work on radioactive materials was performed inside Contamination Containment Areas inside ships or inside radiological facilities. This provided double isolation of radioactivity from the environment. In the event of a loss of containment (e.g., a liquid spill or a puncture in a containment), immediate action was taken to isolate and correct the problem and to sample/survey to verify complete recovery.

RADIOLOGICAL CONTROLS USED WHILE PERFORMING RADIOLOGICAL WORK

Radioactive material in storage areas was packaged to contain any loose radioactive contamination and surveyed prior to transfer by radiological control personnel, to ensure the outside of the packaging was not contaminated. Radioactive material storage areas were surveyed for loose radioactive contamination periodically by radiological personnel.

Radiological work facilities within Buildings 222 and 79A were designated as Radiologically Controlled Areas. These areas were physically separated from the rest of the building. Access to the Radiologically Controlled Areas for both personnel and material was via a control point manned by radiological control personnel. Personnel and material exiting a Radiologically Controlled Area were surveyed for radioactive contamination in portal monitors or with beta-gamma friskers.

All areas within a Radiologically Controlled Area were maintained less than 450 $pCi/100cm^2$ (by swipe analysis), except for those areas designated and specially controlled as Controlled Surface Contamination Areas. Radiologically Controlled Areas and Controlled Surface Contamination Areas were surveyed frequently by radiological control personnel to ensure that radioactive contamination levels were held below NNPP limits.

The NNPP, and therefore CNSY, controlled radioactivity at the source by using the concept of total containment. This policy minimized the spread of radioactive contamination to adjacent surfaces and to personnel. Engineered ventilation systems containing HEPA filters, drapes, glovebags, and tents were utilized to accomplish this goal. Any personnel, instructional, or equipment errors that resulted in even a minor spread of contamination halted the work until the cause was determined and corrective action taken. This policy and its successful application allowed most radiological work to be performed with minimal personal protective clothing and in most instances without respirators. In addition to permitting work to be accomplished more efficiently, the number and extent of radiological areas requiring release were minimized.

Radioactive materials were either maintained within controlled areas, or when moved were attended or physically secured at all times. Movement and storage of radioactive materials outside controlled areas required a strict accountability system. All movements were verified by an individual other than the one performing the move.

Routine radiological surveys in and around radiological or radioactive material storage facilities where work on radioactive material was performed to confirm that controls were effective. Corrective actions were taken immediately in the unusual event that surveys identified unexpected radioactivity. Inadvertent releases were cleaned up immediately (within hours if practicable), and a critique was held to identify and correct the cause of the problem.

The basic policies covering control of radioactivity did not change during the course of the shipyard's involvement with the NNPP. There was a continuous upgrading of work procedures over the 30 years of radiological work. An example of this is the development of processing methods to make radioactive liquids reusable as reactor coolant. Other examples of upgrading include improved work facilities, development of improved contamination containment area designs, solid radioactive waste volume reduction, improved radiological analysis of environmental samples, and the extensive use of engineered ventilation systems. Upgraded monitoring methods verified the effectiveness of the basic control methods which were used from the beginning of the Program.

C. Training

From 1962 and through the closure process, radiological training became more and more crucial to the overall effectiveness of the shipyard's nuclear program. Every person who planned or executed any part of radiological work had special training and qualifications. This special training included reactor safety, cleanliness controls, quality controls, and radiological controls. This was in addition to specialized training related to their field (i.e., radiological control, crafts, engineering, quality control, etc.). All training programs were formal, and most had written, oral, and practical examinations. Personnel were required to requalify on a routine basis and, in most instances, there were random examinations to test retention of knowledge. New employees were indoctrinated upon employment through the use of an audio/slide presentation or a video tape describing, in brief, the radiological program at CNSY, the methods by which the shipyard controlled radiation and radioactivity, how to identify radioactive materials, and how to respond to unusual radiological situations. Periodic retention tests were administered to a percentage of the total shipyard work force.

D. Audits and Regulatory Oversight

In addition to the surveillance provided by radiological control personnel, an independent shipyard organization audited all aspects of radiological work. Its findings were routinely reported to shipyard management and the shipyard commander. All radiological control requirements were audited on at least an annual basis.

RADIOLOGICAL CONTROLS USED WHILE PERFORMING RADIOLOGICAL WORK

NNPP radiological controls at CNSY were overseen by NNPP headquarters. NNPP headquarters performed on-site annual inspections of CNSY radiological controls, radiological training, and compliance with work procedures and headquarters requirements. The NNPP also maintained a field office at the site, to oversee day-to-day activities.

RADIOLOGICAL SURVEY PLAN

A. INTRODUCTION

The necessary infrastructure needed to perform work in the NNPP included a group of persons possessing both professional background and knowledge in the field survey and technical aspects of radiological controls. This experienced cadre of personnel, along with available detailed documentation of the facilities and equipment used to support nuclear work, were instrumental in developing the radiological closure plan for the shipyard. The focal point and ultimate goal of the plan was to remove, from the shipyard, all radioactive material associated with the NNPP.

B. THE PROCESS

The basic considerations used in the plan's development were:

1. Removal of all known radioactivity and radioactive material from facilities and storage areas. This included liquid and solid waste processing systems, tools, work tables, ventilation systems, sinks, stainless steel decks and wainscoating, piping systems, etc. The nuclear work facilities were to be taken to the base wall and decks. The items removed would either be 1) surveyed for release from radiological control, 2) shipped to waste reduction facilities and then to the Barnwell, South Carolina low-level radioactive waste disposal facility, or 3) shipped out for disposal as low-level radioactive waste.

2. After removal of radioactive material and known radioactivity, designated areas of buildings, piers, drydocks, etc., were surveyed and sampled using the following techniques to verify the removal of radioactivity in excess of limits specified by the NNPP. The NNPP chose to perform extensive surveys as a verification of the work practices used to control radioactivity.

   - Direct scan of surfaces using a sensitive beta detection instrument (IM-247/249 with a DT-304 Probe). This instrument selection is based on its capability to detect low levels of cobalt-60 radioactivity.

   - Direct scan of surfaces using a sensitive gamma scintillation detector (IM-253 with a SPA-3 Probe). This instrument selection is based on its capability to detect low levels of cobalt-60 radioactivity and versatility in detecting other radioactive isotopes.

   - Direct scan of surfaces where alpha sources were stored using a sensitive alpha survey detector (AN/PDR-56).

RADIOLOGICAL SURVEY PLAN

- Potentially contaminated earth (e.g., sand or soil), ground covering (e.g., asphalt or concrete), paint, or building materials were to be sampled and the samples analyzed using a gamma scintillation detector with a multichannel analyzer capable of identifying low levels of radioactivity.

3. The extent of the surveys and sampling were to be commensurate with the potential for radioactive contamination. Buildings, rooms, and areas were placed in categories based on the radiological potential of a specific building, room, or area. Those with the highest potential were placed in Group 5 and those with lesser potential placed in Groups 1 through 4. In addition to categorization of areas, surfaces inside categorized areas which are more likely to be radioactively contaminated received more extensive surveys. For example, in Group 3, and 4 areas, the floors and surfaces received more extensive surveys since contamination is more likely to be deposited in those areas. In all cases, areas known or suspected of having a higher potential for contamination, such as floors, ventilation exhaust registers, and surfaces next to previous radioactive work areas received more extensive surveys than other areas in that category.

4. Rooms and areas were classified, using the following categories, in accordance with their radioactivity contamination potential.

    - Areas previously released based on the current NNPP requirements: classifications were based on use since its release and areas surveyed accordingly.

    - Group 1: areas inside buildings that were not used for radioactive work or radioactive material storage, but were frequented by personnel working in radiological areas.

    - Group 2: areas inside and immediately surrounding radiological repair facilities but not used for radiological work or radioactive material storage. A representative survey of floors was made.

    - Group 3: areas where a potential existed for low-levels of beta-gamma radioactivity (less than 1000 pCi/100 cm^2) to be deposited on small areas of building surfaces; a complete survey of the floors and walls up to 6 feet was made. Particular attention was paid to potential areas of contamination, such as walls below shoulder height, floors, and work areas. This group included controlled passageways, corridors, and areas where only sealed packages of radioactive material were handled.

- Group 4: areas in which a potential existed for higher levels of loose beta-gamma contamination (1000 pCi/100 cm^2 - 10,000 pCi/100 cm^2) to be deposited on larger areas of building surfaces. A thorough survey was made of all walls below 12 feet and floors. For walls and ceilings above 12 feet, representative surveys were made. Selected floor coverings were removed, and selected wall joints were opened along heavy traffic routes and previous work areas. Particular attention was paid to potential areas subject to exposure to contamination such as walls below shoulder height, floors and work areas.

- Group 5: areas in which a potential existed for high levels of loose beta-gamma contamination (greater than 10,000 pCi/100 cm^2) to be deposited on larger areas of building surfaces. A thorough survey was made of all walls below 12 feet and floors. For walls and ceilings above 12 feet, representative surveys were made. Floor coverings were removed, and all wall joints were opened for survey.

5. In addition to the five specific groups discussed in the previous paragraphs, an additional category was established to provide for special circumstances in addition to the classification for potential beta-gamma contamination. This category was:

   - Group 6: areas that were used to store alpha emitting radioactive material, such as sealed alpha sources. A representative survey was made of the floor of these areas and work surfaces used for storage of this material.

   Areas such as submarine berthing areas, drydocks and their adjacent areas, radioactive material transfer routes, and radioactive liquid piping trenches were individually addressed. The plan details the amount and type of radiological surveys required to release the area, and the extent and type of radiological samples to be taken.

C. DETERMINATION OF NATURAL BACKGROUND RADIATION LEVELS

Three primary sources contribute to natural or background radiation. Part of this radiation is of terrestrial origin. Rocks, soils, water, air, plants and animal life contain some natural radioactivity. For example, a handful of typical garden soil contains several billion atoms which will undergo radioactive decay and emit radiation. The most significant terrestrial radioisotopes are potassium-40, uranium-238 and thorium-232 and their decay products, radium-226, and radon-222.

Another source of radiation in our environment is cosmic radiation. This radiation, in the form of high energy particles, originates primarily from outer space. These particles interact with the earth's atmosphere and produce charged particles, gamma rays, and neutrons.

The third component of natural background radiation exposure is from radionuclides within the body, primarily potassium-40.

Background radiation levels vary widely with location, primarily due to variations in the terrestrial component of natural background. This is caused by several factors. The geology of the area can cause significant variation in the background levels. For example, areas rich in rock formations such as granite, which generally contain some quantity of uranium and its decay products, often exhibit higher natural background radiation levels than an area where no rock formations are present. For the Charleston area, large natural phosphate deposits, which are high in potassium and radium, cause higher background radiation levels than occur in other parts of the state.

Climate can also alter the background levels by altering the geologic makeup of an area through the action of wind and precipitation. Similarly, human activities such as soil excavation, mining, building, road and other construction, and fossil fuel combustion affect the background radiation field. Finally, the intensity of cosmic radiation depends upon the shielding provided by the atmosphere. Thus at higher elevations, the cosmic contribution to background radiation levels is higher because there is less atmospheric shielding.

Within a relatively small area, background radiation levels can also vary significantly. This is because of several factors. First, the activity in the soils and rocks may not be distributed uniformly throughout the area. Secondly, significant variations are found in different lots of similar construction materials. For example, if an area has multiple pours of concrete or asphalt, the aggregates may have come from different sources and contain significantly differing amounts of natural radioactivity.

RADIOLOGICAL SURVEY PLAN

The fact that natural radioactivity varies so widely is important when taking surveys which are used to determine radioactivity added to the environment as a result of shipyard activities. When surveying with portable instrumentation, which measures only radiation levels without regard to which radioisotopes are present, it is necessary to account for the effects of natural background radiation to determine if activity has been added by shipyard work. To accomplish this, a comparison must be made with an area made up of similar material which has not been affected by shipyard radiological activity.

The protocol for background determination called for surveys to be performed in unaffected structures and areas similar in all respects to the structure or area being surveyed. The scope of the background determination surveys in these analogous areas was based on the size and physical configuration of the area. For example, an outdoor area paved with asphalt would be scanned near the perimeter and at several locations in the center and the readings would be averaged to determine the specific background value for the area. In the case of a building with a concrete floor and concrete block walls it was necessary to take more readings. In the center of the structure, background levels are generally less than near the walls. This is because in the center, the primary contributor to the background levels is the floor while near the walls of the structure, the floor and walls contribute to the levels. In some areas, because of the differences in the levels near the walls as opposed to the interior areas of the building not directly adjacent to the walls, it was necessary to assign different background levels to the grids adjacent to the walls than to those in the interior of the building.

The analogous areas were surveyed with both the IM-247 and the IM-253 (HV-1 PHA and HV-2 Gross modes) to provide background readings for all the surveys to be done in the affected areas. The characteristics of these instruments are discussed in Section IV of this volume. In addition, a rapid scan of the affected area was conducted prior to the actual survey to ensure that no significant differences or anomalies existed which could invalidate the survey results.

In determining which analogous areas would be used for a specific location, where several analogous areas fit the characteristics of the affected area, the most conservative background levels (lowest levels) were used. This approach led to more areas requiring solid samples; however, this approach offered the best chance of identifying very low levels of radioactivity added as a result of shipyard work. For the areas of higher potential for contamination (Group 3 and above areas), since solid samples were required in each grid, the determination of background levels took on a lesser importance as the solid samples were taken from the location in the grid which indicated the highest level of radioactivity.

D. NNPP CRITERIA FOR CNSY DECOMMISSIONING SURVEYS

Table III-1 provides a summary of the criteria established by NNPP headquarters for the radiological decommissioning surveys of CNSY areas addressed above.

RADIOLOGICAL SURVEY PLAN

Table III-1
Summary of NNPP Criteria
for Radiological Decommissioning Surveys

Survey/Sample Method	NNPP Criteria
1. Direct Scan	
a. Beta-Gamma	Survey with an IM-247/PD with DT-304 probe. Survey within 1/2 inch of all surfaces within a grid, including attachments and depressions. Unrestricted release criteria: not to exceed 450 pCi by direct frisk.
b. Gamma Scintillation (Cobalt-60 Energy Range)	Scan with an IM-253/PD with SPA-3 probe operating in the HV-1/PHA mode, approximately three feet above the floor/ground/shoreline. Any readings which exceed twice established background for that area shall be investigated and the cause identified.
c. Gamma Scintillation (Gross Gamma Energy Range)	Scan with an IM-253/PD with SPA-3 probe operating in the HV-2/GROSS mode, approximately three feet above the floor/ground/shoreline. Any readings which exceed twice established background for that area shall be investigated and the cause identified.
d. Gamma Scintillation Surveys (Cobalt-60 Energy Range)	Survey with the IM-253/PD with SPA-3 probe operating in the HV-1/PHA mode. Survey within 1/2 inch of all surfaces within a grid including attachments and depressions. Readings equal to, or exceeding, twice the background readings on the X1 range shall be investigated and the cause identified. Any discernible increase above natural background on the X10, X100, and X1K range shall be investigated and the cause identified. Natural background shall be determined in the HV-PHA mode by measuring levels of similar building materials in analogous areas of the shipyard, based on environmental factors that affect natural background radiation levels. The site selected for determination of natural background shall not have been affected by radioactive material handled by the shipyard.
e. Gamma Scintillation Surveys (Gross Gamma Energy Range)	Survey with the IM-253/PD with SPA-3 probe operating in the HV-2 GROSS mode. Survey within 1/2 inch of the surface including attachments and depressions. Readings equal to, or exceeding, twice the natural background reading shall be investigated and the cause identified. Natural background shall be determined in the HV-2 GROSS mode by measuring levels of similar building materials in analogous areas of the shipyard, based on environmental factors that affect natural background radiation levels. The site selected for determination of natural background shall not have been affected by radioactive material handled by the shipyard.
2. Gamma Counting	
a. Solid Samples	Analyze solid samples (other than paint removed from metal surfaces) with a multichannel analyzer (MCA) for a minimum detectable activity (MDA) of 1 pCi/gram gross gamma equivalent cobalt-60. Analyze paint samples taken from metal surfaces with a MCA for a MDA of 3pCi/gram gross gamma equivalent cobalt-60. If detectable radioactivity is measured, isotopic analysis shall be performed to characterize any residual radioactivity. Potentially contaminated earth (for example, sand or soil), ground coverings (for example, asphalt or porous concrete), paint (other than from metal surfaces), or building materials shall not be released for unrestricted use until the area is inspected and samples do not exceed a concentration of 1 pCi/gram specific cobalt-60. Potentially contaminated paint taken from metal surfaces shall not be released for unrestricted use until the area is inspected and samples do not exceed a concentration of 3 pCi/gram specific cobalt-60. Samples will be taken from material near the surface. If contamination is found, material samples shall be taken at greater depths until sample results are less than 1 pCi/gram.

RADIOLOGICAL SURVEY PLAN

Table III-1 (continued)
Summary of NNPP Criteria
for Radiological Decommissioning Surveys

Survey/Sample Method	NNPP CRITERIA
b. Water Samples	Analyze water samples with an MCA to an MDA of 1×10^{-7} µCi/ml, for cobalt-60 or other non-naturally occurring radionuclides, and report readings which exceed 1×10^{-7} µCi/ml.
c. Sediment and Marine Life	Analyze sediment samples with an MCA to an MDA of 1 pCi/gram gross gamma equivalent cobalt-60. If detectable radioactivity is measured, isotopic analysis shall be performed to characterize any residual radioactivity. The area shall be investigated and the cause identified. If contamination is found in sediment samples, samples shall be taken at greater depths until sample results are less than 1 pCi/gram.
3. Isotopic Analysis	Analyze samples greater than MDA to identify the radioactive isotopes present. If NNPP radioisotopes are present, designate the area for further sampling. Otherwise verify that no photopeaks from NNPP radioisotopes are present, and determine all naturally occurring radioisotopes present for documentation in the final survey report.
4. Alpha Survey	Survey with an AN/PDR-56. Survey within a distance of 1/16 to 1/8 of an inch of all surfaces within a grid, including attachments and depressions. Unrestricted release criteria: no detectable activity.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

A. Introduction

Sensitive radiation detection/indicating and computation (RADIAC) instrumentation was required to perform decommissioning surveys. CNSY used its inventory of standard Navy supplied instruments. However, because the scope of the decommissioning process was so large, supplemental devices such as more efficient sample counting equipment were investigated. In addition, more efficient sample gathering techniques were pursued. The radiac instrumentation and sampling equipment used in decommissioning the radiological facilities as well as examples of the techniques employed during utilization of this equipment are discussed in this section.

B. Radiation equipment used for direct surveys

1. Gamma Scintillation Equipment

Gamma scintillation surveys were performed using either an Eberline Instrument Corporation, Model PRM-5N count rate meter with an Eberline Model SPA-3 Scintillation probe assembly or a Nuclear Corporation IM-253/PD with a DT-640 Scintillation probe assembly. These instruments are equivalent and are hereafter referred to as an IM-253/PD. They were used to detect low levels of gamma radiation. The gamma scintillation detector probe consists of a cylindrical housing containing a 2" diameter x 2" long sodium iodide with thallium [NaI(Tl)] crystal. The instruments have a linear scale ranging from 0 to 1,000 counts per minute (CPM). Scale multipliers of X1, X10, X100, and X1K are selected according to the radiation levels being measured. Surveys to detect low levels of gamma radiation were performed by slowly scanning (i.e., approximately one to two inches per second) surfaces with the probe held within one-half inch of the surface and parallel to the surface. (To ensure compliance with the one-half inch distance factor the probes were mounted on the base of a survey cart which was moved over the surface being monitored). Results of this type of survey were reported in CPM. The gamma scintillation survey meter assembly is calibrated to respond to an energy range of 1.0 to 1.5 million electron volts (MeV) (which includes the two cobalt-60 gammas of 1.17 and 1.33 MeV) in the high voltage setting number one (HV-1) PHA counting mode and energies from 0.1 to approximately 8.0 MeV in the high voltage setting number two (HV-2) GROSS mode. The PHA (pulse height analyzer) mode measures low level radiation over a narrow gamma energy range whereas the GROSS mode allows a wide energy range to be detected. The instruments were response source checked such that any measurements taken with the instrument would be accomplished within one day after a satisfactory response source check. The check consisted of verifying that the needle of the meter responded correctly to a known value within a given response check range and was not merely checked to see if the meter needle moved. The instruments were calibrated every six months.

Characteristics of the IM-253/PD calibrated to detect gamma radiation within energy range of 1.0 to 1.5 MeV in HV-1/PHA mode are:

• Accuracy	± 20%
• Minimum Sensitivity	100 CPM (equivalent to 0.0012 millirem per hour)

Characteristics of the IM-253/PD calibrated to detect gamma radiation within energy range of 0.1 to approximately 8.0 MeV in HV-2/GROSS mode are:

• Accuracy	± 20%
• Minimum Sensitivity	100 CPM

2. Direct Scan Survey (Alpha) Equipment

Direct scan (alpha) surveys were performed using a Nuclear Research Corp. AN/PDR-56 Alpha Survey Meter. The AN/PDR-56 uses silver-activated zinc sulfide scintillation detectors that effectively discriminate against low levels of beta, gamma, and neutron radiation. A main probe and a smaller auxiliary probe are provided. The sensitive area of the main probe for detecting alpha radiation through the slots in the protective base plate is 17 square centimeters; for the auxiliary probe, the sensitive area is 10 square centimeters. Only the main probe was used for direct scans of surfaces during decommissioning surveys. The linear scale reads in CPM in four ranges that have maximum readings of 10^3, 10^4, 10^5, and 10^6 CPM. These CPM readings equate to pCi on the area immediately adjacent to the sensitive portion of the probe. The minimum reading within calibration accuracy is 50 CPM (or 50 pCi). These surveys were performed by slowly scanning (i.e., one inch per second) surfaces with the probe held within 1/16 to 1/8 of an inch of the surface. The instrument was source checked such that any measurements taken with the instrument were accomplished within one day after a satisfactory response source check. This check consisted of verifying that the needle of the meter responded correctly to a known value within a given response check range and was not merely a check to see that the meter needle moved. The instruments were calibrated every six months.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

Characteristics of the AN/PDR-56 Alpha Survey Meter are:

- Accuracy ± 20%
- Minimum Sensitivity 50 CPM
- Minimum Detectable Activity 50 pCi

3. Direct Scan Survey Equipment (Beta-Gamma)

Direct scan surveys (beta, gamma) were performed using a DT-304/PDR frisker probe, HP-260/PDR frisker probe, or equivalent. The HP-260 probe is the unshielded version of the DT-304 probe and is used for performing surveys in low background areas. Since the background in most areas was expected to be low, the HP-260 probe was considered equivalent to the DT-304 probe and hereafter referred to as a DT-304/PDR probe. These probes were used in conjunction with either a Eberline E-140N, WM. B. Johnson & Associate Inc. IM-247/PD, RAM 3400 or RM-3C frisker, or equivalent. These instruments are equivalent and hereafter are referred to as a IM-247/PD. These instruments were used to detect both fixed and loose surface radioactive contamination. The instruments have a linear scale reading indicating over at least 3 ranges, 0-500, 0-5000, 0-50,000. When equipped with the DT-304/PDR frisker probe, the instrument can be used in a low background (i.e., less than 300 CPM) to measure radioactivity levels from less than 450 pCi. The DT-304/PDR probe or equivalent consists of a 900v, 2-inch diameter flat Geiger-Muller tube having a window thin enough to transmit a high percentage of the low energy beta particles associated with cobalt-60. These surveys were performed by slowly scanning (i.e., two inches per second) surfaces with the DT-304/PDR frisker probe or equivalent held within one-half inch of the surface to detect both loose surface and fixed contamination. (To ensure compliance with the one-half inch distance factor the probes were mounted on the base of a survey cart which was moved over the surface to be monitored). The instruments were response source checked such that any measurements taken with the instrument were accomplished within one day after a satisfactory response source check. This check consisted of verifying that the needle of the meter responds correctly to a known value and was not merely a check to see if the meter needle moved. The instruments were calibrated every six months while in use.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

Detection characteristics of the IM-247/PD with DT-304 probe, or equivalent are:

- Accuracy ± 20%
- Minimum Sensitivity 100 CPM
- Minimum Detectable Activity 450 pCi (equivalent to 100 CPM above background)

C. Counting Systems Used to Determine Sample Radioactivity

1. Solid Sample and Environmental Counting Systems

CANBERRA Series 35+ Multi Channel Analyzer with two 3" x 3" 30%-35% efficient intrinsic Germanium Detectors.

Capabilities of the System.

Water, solid/sediment, and marine life samples were analyzed for radioactivity in the gross gamma and cobalt-60 ranges for specific cobalt-60 and other non-naturally occurring radionuclides. Gross range radioactivity measurements in the 0.1 to 2.1 MeV energy range provide information on significant changes in environmental radioactivity. The cobalt-60 energy range refers to gamma radioactivity in the 1.1 to 1.4 MeV energy range. Cobalt-60 was specifically analyzed since it is a sensitive tracer used to follow environmental distribution of radioactivity and because it is the predominant long-lived radionuclide associated with nuclear-powered ship operations. Each sample was placed in a petri dish or Marinelli counting container and the measurements were made with a multichannel analyzer and a germanium detector. This system was used for all types of samples associated with decommissioning surveys.

The system was calibrated and counting efficiencies determined by counting calibrated standard reference sources of cobalt-60 and cesium-137 under the same conditions of geometry and sample size as the samples. For Marinelli geometry samples, the counting procedure provided a typical minimum detectable activity for cobalt-60 of less than 0.1 picocurie/gram (pCi/g) for sediment and marine life, and 1.0×10^{-7} microcurie/milliliter (μCi/ml) for water. For petri dish geometry samples, the counting procedure provided a typical minimum detectable activity for cobalt-60 of less than 0.5 pCi/g for concrete and asphalt, and less than 1.0 pCi/g for paint.

Standardization. To ensure standardization, some sediment and all marine life samples were independently checked by a U.S. Department of Energy laboratory. The independent checks verified the shipyard results.

Use. The system was used for counting petri dish geometry samples of paint chips, concrete, etc. An MDA of 1 pCi/g over the 0.1 to 2.1 MeV range can be achieved with the following minimum limiting factors:

Sample Mass	- 15-20 grams
Background Count Time	- 2000 seconds (33 minutes)
Sample Count Time	- 1000 seconds (16.6 minutes)

Calculation Methods. All calculations of MDA and activity concentration were performed via spread sheets. These programs were very flexible and allowed the user to determine the necessary count time to achieve the desired MDA based on knowledge of the sample mass.

D. Sample Gathering Techniques

1. Solid Samples

Solid samples refer to samples of surface material such as paint, concrete, asphalt, wood, soil, and building material. Sampling was conducted by obtaining a representative sample of the surface of the entire grid. Samples were obtained by removing material from the surface by using hand tools or mechanical devices. Removal methods included scraping, chipping, or cutting depending on the material sampled. Needle guns were used to minimize surface damage and defacing. Methods such as vacuuming were utilized to prevent cross contamination of samples. The samples were analyzed in petri dishes, or in Marinelli counting containers.

2. Solid Material Core Sample

Solid material core samples were obtained by drilling with a core drill bit to a depth sufficient to obtain a one inch soil sample. Material representative of the plug, including soil, was removed to provide a minimum sample of 500 grams. The samples were crushed and placed into a Marinelli counting container. These samples were analyzed with the environmental counting system.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

3. Water Samples

Water samples were obtained by lowering a one liter bottle into the water at the specified sampling location. A 500 ml sample was obtained and placed in a Marinelli counting container. Samples were analyzed with the environmental counting system.

4. Harbor Bottom Sediment Sample

Harbor bottom sediment samples were obtained by using a six-inch square Birge-Ekman dredge modified so that only a thin top layer (approximately one inch) of sediment is collected. Sufficient material was obtained from each sampling location to provide a minimum sample size of 500 grams. The samples were analyzed with the environmental monitoring system.

5. Harbor Bottom Core Samples

Harbor bottom core samples were obtained by using a three-inch diameter plastic sampling tube by approximately three feet long. The sampling tube was inserted by divers into the harbor bottom at the specified sampling location to a depth of 24", where possible. A sample size of at least 12" was required.

6. River Water Sample

River water samples were obtained by lowering a weighted one liter sample bottle into the river at the specified sampling locations. The collection method ensured that the water collected represents all depths from the surface to the river bottom. Sufficient sample material was obtained from each sample location to provide a minimum sample size of one full Marinelli counting container. The samples were analyzed with the environmental counting system.

7. Ground Water Samples

Sampling locations were located outside the facility of interest and were selected on the basis of available data on ground water flow underneath the facility. Maximum use was made of existing water monitoring wells. Samples were retrieved by lowering a sampling container into the well. A 500 ml sample was placed in a Marinelli counting container. The samples were analyzed with the environmental counting system.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

8. Sample Control

To ensure the integrity of the samples, sample identification, collection, chain of custody and retention procedures were established.

a. Sample Identification

Samples were gathered per a Task Group Instruction (TGI) and annotated with sample identifying information (TGI number, location, date, time, sampler, etc.) recorded on a sample sheet. Sample containers and shipping packages were sealed and labeled to ensure integrity of the sample.

b. Chain-of-Custody for Samples

Samples collected were traceable from the time they were collected through the analysis phase, during the retention period, and until they are disposed of properly. To maintain and document sample possession, chain-of-custody procedures were followed.

(1) Sample Custody

All samples collected were maintained under secure conditions. In general, as few people as possible were part of the chain-of-custody.

(2) Transfer of Custody and Shipment

Samples were accompanied by a Chain-of-Custody Sheet. When transferring the possession of samples, the individual relinquishing and the individual receiving sign, date, and note the time on the record. This record documents the sample custody transfer.

(3) Sample Packaging

Samples were collected, placed in plastic bags at the point of generation and heat sealed by trained personnel. These bags were brought to a sample preparation area, opened, and the sample substance placed into either petri dishes or Marinelli beakers.

SURVEY AND SAMPLING TECHNIQUES AND INSTRUMENTATION

c. Retention of Samples

The samples collected were the primary source of evidence to support the test data compiled for the survey. These samples were retained in storage for as long as feasible to support analysis data. Samples, when analyzed, were retained in secure storage 30 days. After this time period, samples were disposed of.

RADIOLOGICAL DECOMMISSIONING STRATEGY

A. Introduction:

In July 1993 CNSY established a Nuclear Closure Planning Committee. Its charter provided for the development of a master strategy and key event/ milestone schedule designed to execute nuclear closure of CNSY by April 1996. The committee was chaired by the Deputy Director of Radiological Control with the Head, Reactor Engineering Division, Nuclear Facilities Manager, Head, Naval Operations Branch, and the Nuclear Material Manager serving as core members. Other key personnel such as Group Nuclear Directors were added as Ad Hoc members when required. The committee defined an organizational structure for executing work, developed a plan of action to identify and procure long lead time material, made recommendations for specialized training and incentives, identified critical skills, prepared manpower and skill mix profiles, and reviewed controlling processes that would have a significant impact on work execution. A "Quick Start" work schedule was developed to guide accomplishment of nuclear closure task which required a minimum of engineering and planning support.

B. Discussion:

The "Shipyard Closure Schedule Key Event/Milestones" for planning and execution of shipyard closure work was issued in September 1993 and a preliminary overview of the nuclear propulsion closure process at CNSY was made available. Charleston's plans for decommissioning were based on NNPP technical instructions, and on the release plans approved by NNPP headquarters for Ingalls Shipbuilding Division, of Pascagoula, Mississippi, the State Pier Complex, at New London, Connecticut, and Norfolk Naval Base Pier 23, Norfolk, Virginia, which all followed the same general outline. This approach as exercised by CNSY included:

1. Review of use and work history:

   - Records prior to 1971 were limited. Information from records of this time were supplemented by interviews with shipyard personnel involved with the NNPP during that period.

   - Records of the period between 1971 and 1980 were available, but incomplete. The information provided by personnel was more detailed and complete. From this a good history of the areas was developed.

   - Records and information provided by personnel made for a complete history of the use of all areas from 1981 to present.

RADIOLOGICAL DECOMMISSIONING STRATEGY

2. Removal and disposal of portable radioactive equipment, and contaminated systems, decontamination of known radioactivity, and exposing of potentially contaminated surfaces for survey:

   - Radioactive material was to be disposed of as soon as practicable, because the surveys required for closure could not commence until all radioactive material was removed from the area.

   - Refueling equipment would be shipped to other NNPP activities.

   - All radiological ventilation systems would have to be removed.

   - The radioactive liquid waste systems in Buildings 79A and 222 would be removed. This included the removal of six 3000 gallon tanks from the basement of Building 222, and the removal of radioactive piping fixed in underground trenches at Building 79A.

   - Removal of the radiological work tents in Building 79A.

   - Additional personnel needed to be trained on handling shipment of radioactive material. In the past 30 years 100,000 cubic feet of material had been shipped for burial. It was anticipated that in excess of 150,000 cubic feet would be shipped during the two year closure process.

3. Decontamination of known radioactivity.

   - Known radioactivity would be remediated from all areas prior to surveys.

4. Exposure of potentially contaminated surfaces for survey.

   - Areas which have a potential for radioactivity above 1000 pCi/100cm^2 would have crevices that are inaccessible to surveying made accessible.

5. Gridding areas and survey grids:

   - Areas not used for radioactive work, storage or transfer would be surveyed with an IM-253/PD.

   - Areas that may have been exposed to low levels of contamination (less than 1000 pCi/1000 cm^2) would be gridded off based on history of use and surveyed with the E-140N/DT304 probe and the IM-253/PD and solid material samples would be taken.

- Areas that may have had levels of contamination greater than 1000 pCi/100cm^2 would be gridded off based on history of use, a sample of inaccessible areas made accessible, and surveyed with the E140N/DT304 probe and an IM-253/PD. Solid material samples would be taken. For example, gridding the sample counting room at Building 222 into 3' x 3' sections (approximately, no grid larger than 9 square feet) up to a height of 6 feet, then in 6' grids to the ceiling. Each grid would be surveyed with E140N/DT304 probe, and an IM-253/PD. Paint samples would be taken from every grid. Solid material samples would be taken from the crevices between the wall and floor.

- Areas that have had levels much greater than 1000 pCi/100cm^2 would have all inaccessible areas made accessible for survey - a 100% survey with E140N/DT304 probe, and an IM-253/PD. Solid material would be taken from each grid. Extensive surveys would be taken in each of these areas based on history of use, and surveys performed during removal of permanent equipment and systems.

6. Mapping results and evaluating survey data for release:

   - Detailed contamination surveys would be taken with E-140/DT304 probe and an IM-253/PD, and paint and solid material from over 2.8 million square feet of shipyard property.

   - Walk-through surveys would be taken from over 1.8 million square feet of shipyard property.

   - Careful study would be performed of all survey results to ensure all areas are surveyed per the closure plan, all survey results meet the release criteria, and action is taken on unusual results or trends.

7. Investigating unusual results, removing radioactivity, and resurveying:

   - Unusual results would be expected because of instrument sensitivity and the nature of natural background radiation. Each of these instances must be explained by the performance of additional surveys and a detailed investigation.

RADIOLOGICAL DECOMMISSIONING STRATEGY

- It was recognized that some of these investigations would lead to the discovery of previously unknown radioactivity. All NNPP radioactivity found must be removed and the areas resurveyed. Discovery of additional radioactivity would require re-evaluation, entailing additional surveys for adequate release of the area.

8. Preparing final summary and providing detailed records:

- All areas require before and after photographs, a detailed graphical representation of the result of every survey taken, and a data base of survey results documenting the successful completion of radiological clearance process.

- This information could be used by the EPA, state, and local agencies to evaluate the Navy's closure effort in CNSY.

Several projects were established to accomplish nuclear base closure work. These included:

1. Building 79A. Work directed toward making this facility ready for "free release" surveys began on 1 August 1994. Prior to this beginning, a number of "Quick Start" (i.e., where little or no engineering was required) items were completed. This consisted of removal of a never used evaporator (which was sent to Norfolk Naval Shipyard) and the dismantling and disposal of machining and lathe tents, argon piping systems, unused portions of ventilation systems, and jib cranes.

    a. Building 79A was stripped of all internal facilities, services and enclosures. The initial emphasis included the removal of temporary enclosures (i.e., work room and tents); disposing of stored waste and obsolete equipment. All material removed was treated as potentially contaminated.

2. Building 222. The schedule start date for decommissioning this facility was May 4, 1994. Strategy guidelines were established. Priorities were established with the thought that the most complex work requiring the more skilled/ knowledgeable workers and engineers would be done first because of the anticipated attrition of personnel.

    a. Items identified and labeled as "Quick Start" in this project included the roof ventilation and the Waste Curie Monitor enclosure which was located in the shipping and receiving area. The strategy goals for this project prior to start up were:

RADIOLOGICAL DECOMMISSIONING STRATEGY

- Tank house removal.

- Removal of refueling equipment from the fenced area and the staging/storage room.

- Removal of non-essential equipment.

- Start work on pure water tanks 1 and 2 along with associated water level control piping.

- Start removal of inactive radiological waste piping associated with the receipt of discharges from ships located in drydocks.

- Removal of fabrication rooms sinks and associated radiological waste piping.

b. Preparation for the final "free release" survey included:

- Removal of the radioactive waste water system as well as the pure water system.

- Disassembly of the Decontamination Room along with its associated radioactive systems and equipment.

- Disassembly of all other spaces where radioactive work had been performed.

- Disassembly of the elevator (after its need was completed).

- Removal of the building's electrical system to the extent necessary to facilitate radiological surveys.

3. Portable Nuclear Facilities and Associated Equipment. This project included shipyard portable nuclear facilities and equipment to service and refuel various reactor plants. Also included for disposition were barges, facilities, and equipment used for reactor servicing work, as well as miscellaneous equipment such as tanks, shields and covered passageways.

a. The "Quick Start" execution of this project was primarily concerned with non-contaminated shipyard furnished refueling equipment and miscellaneous nuclear support/test equipment disposition.

b. Strategy guidelines established for this project concluded that:

- Portable facility disposal would support the shipyard's plan for the inactivation of permanent nuclear facilities.

- Radiologically contaminated equipment would have priority over non-contaminated equipment where possible to support early release of nuclear work/storage facilities such as Buildings 79A, 222, and 101.

- The "need dates" for equipment/facilities, as requested by other shipyards/activities would be honored as much as possible.

- The disposition of certain refueling facilities would have first priority since the facilities would be reused as new servicing facilities in other shipyards.

c. This project began in May 1994 and completed on 13 June 1995.

4. Refueling Equipment. The closure of CNSY required the disposal of nuclear refueling equipment.

a. The primary "Quick Start" effort of this project involved the shipping of specific reactor servicing equipment. This work had begun prior to base closure so most engineering efforts had been completed. A second area identified for "Quick Start" involved the packaging of non-contaminated reactor servicing material.

b. This project's strategy concluded that:

- Refueling equipment disposal would support the shipyard's plan for the inactivation of nuclear facilities.

- As much as possible, project emphasis would be placed on the early disposal and/or removal of equipment from portable facilities/satellite areas.

RADIOLOGICAL DECOMMISSIONING STRATEGY

- Radiologically contaminated equipment would have priority over non-contaminated equipment, where possible, in order to support early release of nuclear work/storage facilities such as Buildings 222, 79A, and 101.

- The disposition of some reactor servicing equipment would have first priority since it would continue to be used at other facilities.

- The "need dates" for equipment, as requested by other servicing facilities/activities, would be honored as much as possible.

c. The first shipment of refueling equipment (to Pearl Harbor Naval Shipyard) was completed on May 10, 1994 and the project completed on December 23, 1994.

5. Another project for CNSY closure involved the disposal of the YFNX-23 Decontamination Barge. This vessel was received into the shipyard in 1965 as the YFNX-29 from another facility where it had been used for the decontamination of a reactor plant. CNSY used the YFNX-23 in the decontamination of two reactor plants (SSN 585 and SSBN 610). Since then (mid to late 1960s) it had been inactive and for the greater part of the time had been in dry storage in Drydock #4. The non-contaminated sections of the barge were cut away and disposed of as non-radioactive waste. The remainder was disposed of as low-level radioactive waste.

CLASSIFICATION AND SURVEY PROCEDURE

A. Introduction

The extent of the surveys and sampling performed for the unrestricted release of CNSY areas and facilities was commensurate with the history and radiological contamination potential of each specific item of interest. Those having a high potential were surveyed more extensively than those having less potential. All areas having either a recent or past history of association with the NNPP were surveyed.

In some cases, particularly involving portable facilities, the shipyard determined it to be more advantageous to disassemble and dispose of as radioactive waste rather than survey and release them for unrestricted use. In those cases, all potentially contaminated portions of the facility were removed and disposed of as radioactive waste. Although the remaining parts of the facility had little or no radiological history, appropriate surveys were performed in order to ensure that no residual radioactive contamination existed.

It is also noted that some of the facilities that were subject to radiological monitoring in the release survey of CNSY were transferred to other activities. In all cases where such facilities were subjected to other than unconditional release from radiological control, the receiving activity was authorized to handle radioactive material associated with the NNPP. A report documenting radiological surveys of those transferred facilities has been provided the receiving activity and, as information, to NNPP headquarters.

B. The Investigatory Process

The pathways, targets, and potential release mechanisms were used to guide preparation of the CNSY decommissioning plan and, therefore, the classification and survey procedures formulated to carry out the radiological functions of that plan.

Historical records were reviewed to ensure an accurate accounting of past requirements and practices. Available records were reviewed to determine: where radiological work was performed; what the environmental impact of radiological operations has been; and the history of radioactive waste disposal. Records were reviewed to determine if any inadvertent releases to the environment were not immediately remediated. Records of areas formerly used for radiological work were reviewed to determine whether all such areas had been appropriately released from radiological controls in accordance with applicable requirements.

Discussions with long-term and previous employees were conducted to examine whether the body of documented records was complete. No cases of unreported environmental releases of radioactivity or unauthorized disposal of radioactive material were identified nor were any past radiological practices reported different from that previously documented.

C. Area/Facility Classification and Unrestricted Release Procedures

The area/facilities "grouping" categories and related procedures for the unrestricted radiological release of CNSY properties were as follows:

1. Group 1: Industrial facilities not included in other categories.

    a. Facilities were not required to be gridded.

    b. No housing buildings, primary education buildings or public access buildings were surveyed.

    c. Walk-through surveys were conducted in accordance with the requirements of NNPP Technical Instructions. All areas of the buildings specified were surveyed.

    d. Buildings covered by these surveys were specified in Section VIII of the survey plan. The shipyard scheduled these surveys such that all the buildings that needed this search received it coincident with the completion of work involving nuclear personnel in the building.

2. Group 2: Areas associated with radiological work facilities which were not used for radioactive work, radioactive material storage, radioactive material transfer, or had no radiological history; or the outside perimeters (up to twenty feet) of radiological work facilities.

    a. Areas were divided into grids. The deck was divided into approximately 10' x 10' grids.

    b. Each grid contained two 3' x 3' subsections. These subsections were located in areas of highest potential for contamination. These subsections represented a minimum of 18% of the grid.

    c. Each grid and subsection were identified with a unique designation.

    d. One subsection of each grid received a 100% survey with an IM-247/PD.

    e. The other subsection of the grid received a 100% survey with an IM-253/PD in the HV-1 PHA mode.

CLASSIFICATION AND SURVEY PROCEDURE

f. Solid material samples were taken from each grid that showed greater than 450 pCi/probe with an IM-247/PD or greater than twice background with an IM-253/PD.

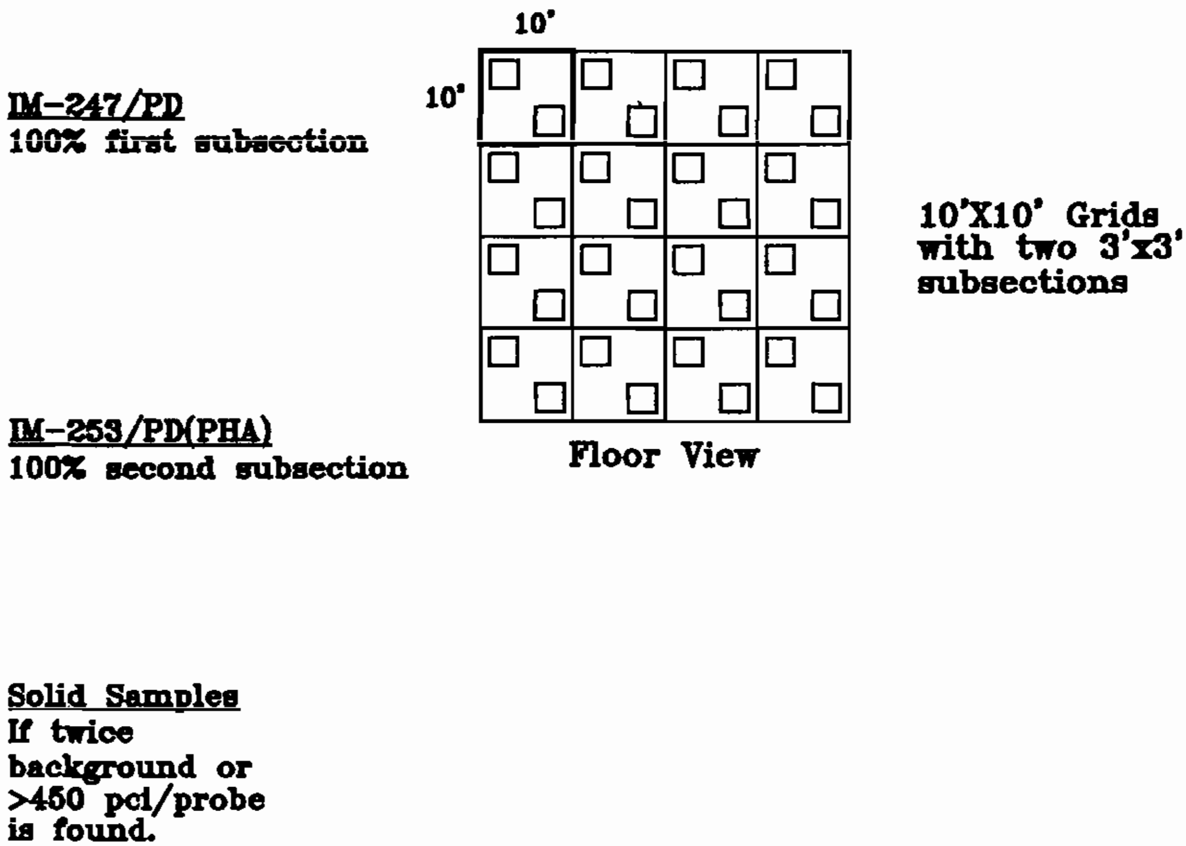
g. Removal of light fixtures, electrical cabling and services, fixed cabinets, and other fixed equipment was not required.

h. Areas were mapped showing the location and configuration of grids and all survey results.

i. Areas on the perimeter of radiological work facilities where radioactive material was routinely handled, such as rollup doors that provide access to radiological work facilities or laydown areas for radiological material, were treated as Group 3 areas.

CLASSIFICATION AND SURVEY PROCEDURE

Figure VI.1
Typical Group 2 Grid



CLASSIFICATION AND SURVEY PROCEDURE

3. Group 3: Radioactive material storage areas and areas with potential for low levels of contamination less than 1,000 pCi/100 cm^2.

   a. Floor/ground covering were divided into approximately 5' x 5' grids.

   b. Walls were divided into grids approximately 5' wide by 6' high of one grid in height.

   c. Each grid was identified with a unique designation.

   d. A 100% survey was performed of each floor and wall grid with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of the grids was performed with an IM-253/PD in the HV-2 GROSS mode.

   e. Solid material samples were taken from the area of highest potential from each grid; a minimum of one sample per wall. Samples were not required from non-painted metal surfaces.

   f. Accessible portions of sanitary sewer system sinks and drains were surveyed with an IM-253/PD in the HV-2 GROSS mode.

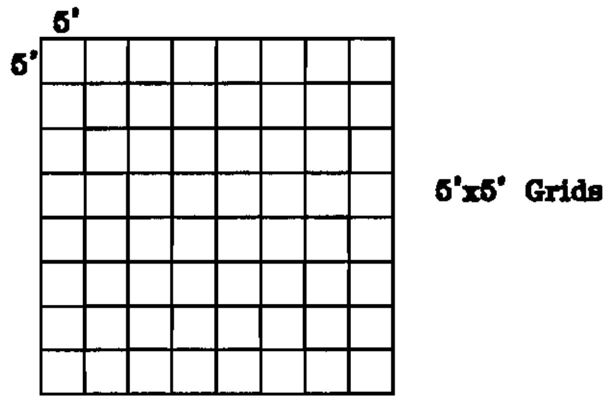
   g. Areas were mapped showing the location and configuration of grids and all survey results.

   h. Removal of light fixtures, electrical cabling and services, fixed cabinet, and other fixed equipment was not required.

CLASSIFICATION AND SURVEY PROCEDURE

Figure VI.2
Typical Group 3 Grid

<u>IM-247/PD</u>
100% grids

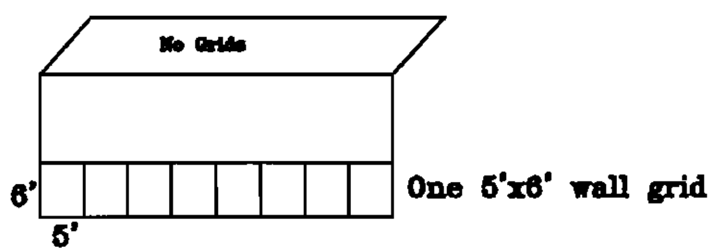


Floor View

<u>IM-253/PD(PHA)</u>
100% grids

<u>IM-253/PD(GROSS)</u>
25% grids

<u>Solid Samples</u>
Each grid



Wall and Ceiling View

CLASSIFICATION AND SURVEY PROCEDURE

4. Group 4: Radiological work areas or other areas where radiological history indicates that a potential existed for contamination levels of 1,000 pCi/100 cm^2 - 10,000 pCi/100 cm^2.

   a. Floor/ground covering were divided into approximately 3' x 3' grids. A minimum of twenty-five percent of the floor coverings (e.g., tile) was removed prior to conducting surveys.

   b. Walls and ceilings below 12' high were divided into approximately 3' x 3' grids. Walls and ceilings above 12', which had a potential to have been exposed to contamination levels of 1000 - 10,000 pCi/100 cm^2 were also divided into approximately 3' x 3' grids. Walls and ceilings above 12', excluding areas already gridded, were gridded into approximately 9' x 9' sections.

   c. Each grid was identified with a unique designation.

   d. A 100% survey of each 3' x 3' floor, wall, and ceiling grid was performed with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of the grids was performed with an IM-253/PD in the HV-2 GROSS mode.

   e. A survey of 25% of the 9' x 9' ceiling and wall grids was performed with an IM-247/PD and an IM-253/PD in the HV-1 PHA and HV-2 GROSS modes.

   f. Solid material samples were taken from the area of highest potential from each 3' x 3' grid on the floor, wall and ceiling. Solid material samples were taken from 25% of the 9' x 9' ceiling and wall grids. A minimum of one sample per wall was taken. Samples were not required from non-painted metal surfaces.

   g. Solid material samples were taken from crevices in floor grids and wall grids below the 6' level and those areas with a potential to have been exposed to contamination levels of 1000 - 10,000 pCi/100 cm^2.

   h. Twenty-five percent of all wall joints along heavy traffic routes and at previous work stations were opened up and exposed for surveys with an IM-247/PD and an IM-253/PD in the HV-1 PHA and HV-2 GROSS modes, and/or by analysis of solid material samples.

   i. Areas were mapped showing the location and configuration of grids and all survey results.

CLASSIFICATION AND SURVEY PROCEDURE

j. For Group 4 areas light fixtures, electrical cabling and services, fixed cabinets, and other fixed equipment were evaluated for radiological potential and removed to expose inaccessible surfaces based on this evaluation.

CLASSIFICATION AND SURVEY PROCEDURE

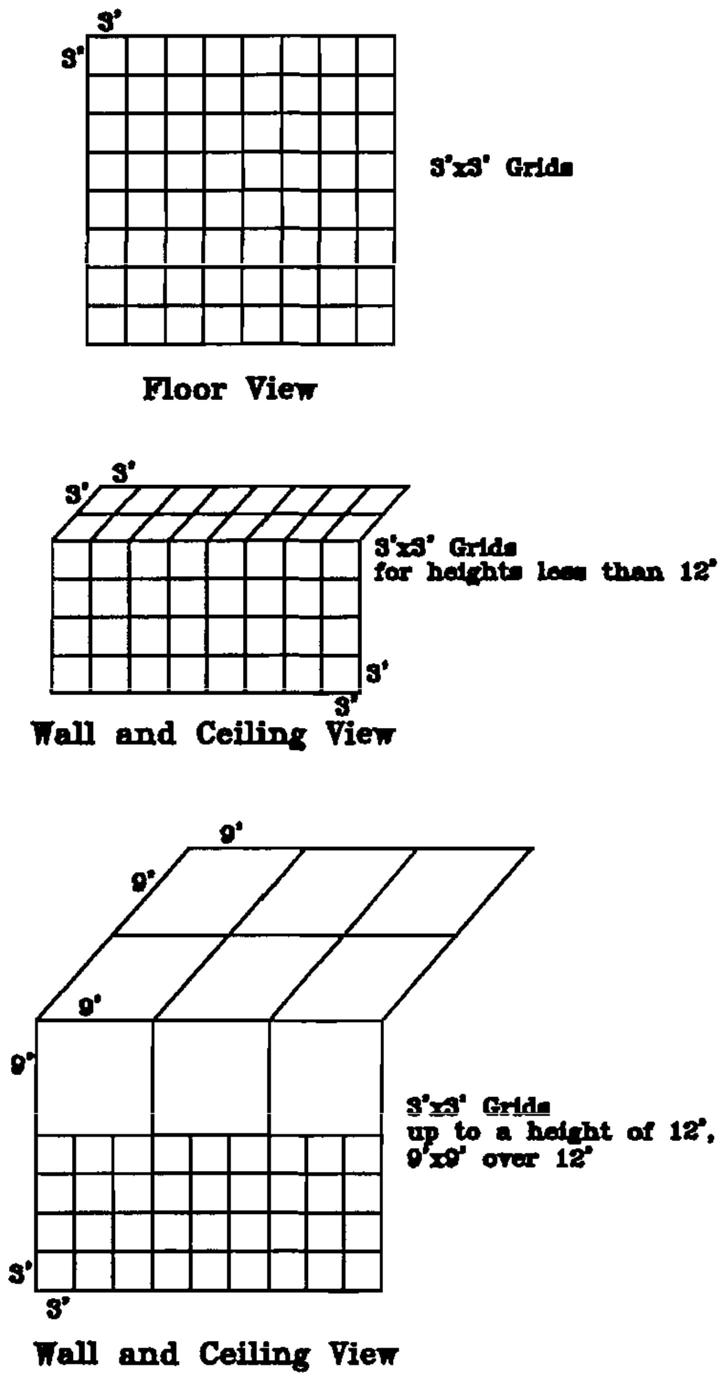
Figure VI.3
Typical Group 4 Grid

<u>IM-247/PD</u>
100% of 3'x3' grids
25% of 9'x9' grids

<u>IM-253/PD(PHA)</u>
100% 3'x3' grids
25% of 9'x9' grids

<u>IM-253/PD(GROSS)</u>
25% of all grids

<u>Solid Samples</u>
Each 3'x3' grid
25% 9'x9' grids



CLASSIFICATION AND SURVEY PROCEDURE

5. Group 5: Radiological work areas or other areas where radiological history indicates that a potential existed for high levels of contamination (i.e., greater than 10,000 pCi/100 cm^2) to be deposited.

   a. Stripped all floor coverings other than coverings without crevices, such as stainless steel. Opened up and exposed all floor, wall, and ceiling crevices and joints in order to perform surveys.

   b. Floor/ground covering were divided into approximately 3' x 3' grids.

   c. Walls and ceiling within 6' of roof hatches were divided into approximately 3' x 3' grids.

   d. Walls and ceilings below 12' high were divided into approximately 3' x 3' grids. Walls and ceilings above 12', which had a potential to have been exposed to contamination levels greater than 10,000 pCi/100 cm^2 was also divided into approximately 3' x 3' grids. Walls and ceilings above the 12' level, excluding areas already gridded, were gridded into approximately 6' x 6' grids.

   e. Each grid was identified with a unique designation.

   f. A 100% survey of each 3' x 3' floor, wall and ceiling grid was performed with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of the 3 ' x 3' floor, wall and ceiling grids was performed with an IM-253/PD in the HV-2 GROSS mode.

   g. A survey of 25% of the 6' x 6' ceiling and 50% of the 6' x 6' wall grids was performed with an IM-247/PD and an IM-253/PD in the HV-1 PHA and HV-2 GROSS modes.

   h. Performed a survey of grids containing roof hatches with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. Performed a 25% survey of these grids with an IM-253/PD in the HV-2 GROSS mode.

   i. Solid material samples were taken from each 3' x 3' floor, wall and ceiling grid. Samples were taken from every other 6' x 6' wall grid. Samples were taken from 25% of the 6' x 6' ceiling grids.

CLASSIFICATION AND SURVEY PROCEDURE

j. All crevices and joints between the floor, wall, and ceiling were opened up and exposed for surveys with an IM-247/PD and an IM-253/PD in the HV-1 PHA and HV-2 GROSS modes and/or by analysis of solid material samples.

k. Solid material samples were taken from each door jam, window casing and roof hatch.

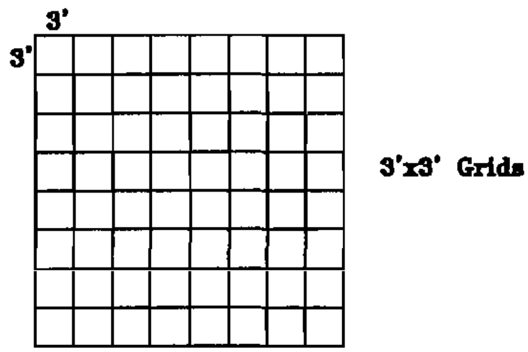
l. Areas were mapped showing the location and configuration of grids and all survey results.

m. For Group 5 areas all light fixtures, electrical cabling and services, fixed cabinets, and other fixed equipment were removed and controlled as radioactive material.

CLASSIFICATION AND SURVEY PROCEDURE

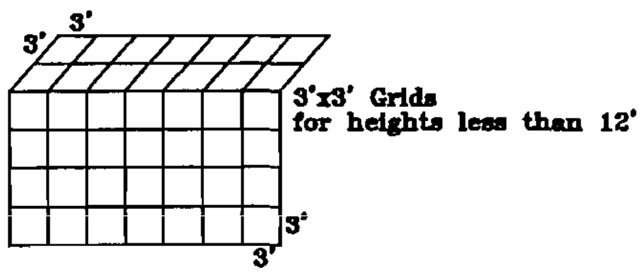
Figure VI.4
Typical Group 5 Grid

IM-247/PD
100% 3'x3' grids
50% 6'x6' wall grids
25% 6'x6' ceiling grids



Floor View

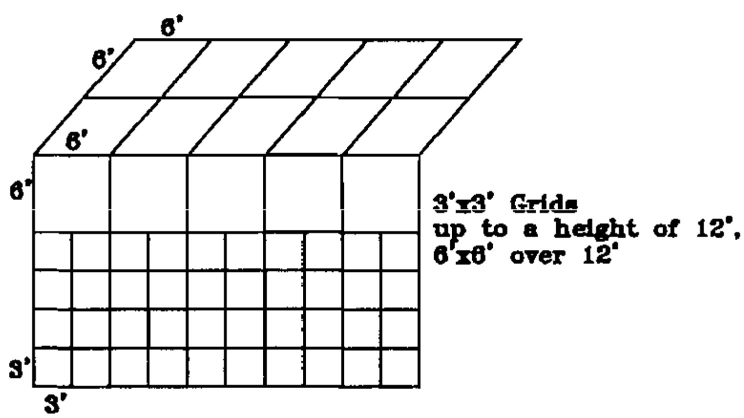
IM-253/PD(PHA)
100% 3'x3' grids
50% 6'x6' wall grids
25% 6'x6' ceiling grids



Wall and Ceiling View

IM-253/PD(GROSS)
25% 3'x3' grids
50% 6'x6' wall grids
25% 6'x6' ceiling grids

Solid Samples
100% 3'x3' grids
50% 6'x6' wall grids
25% 6'x6' ceiling grids



Wall and Ceiling View

CLASSIFICATION AND SURVEY PROCEDURE

6. Group 6: Areas designated as having a potential for alpha contamination (e.g., alpha source storage areas).

   a. Each area classified as Group 6 areas were also classified as a Group 3, 4, or 5 area.

   b. The area was grid in accordance with the Group 3, 4, or 5 gridding requirements.

   c. A survey of 25% of the floor grids was performed with an AN/PDR-56.

   d. Areas were mapped showing the location and configuration of grids and all survey results.

7. **Radioactive Piping Trenches:**

   a. Trenches formerly used to carry radioactive piping were divided into approximately 5' long grids.

   b. Each grid was identified with a unique designation.

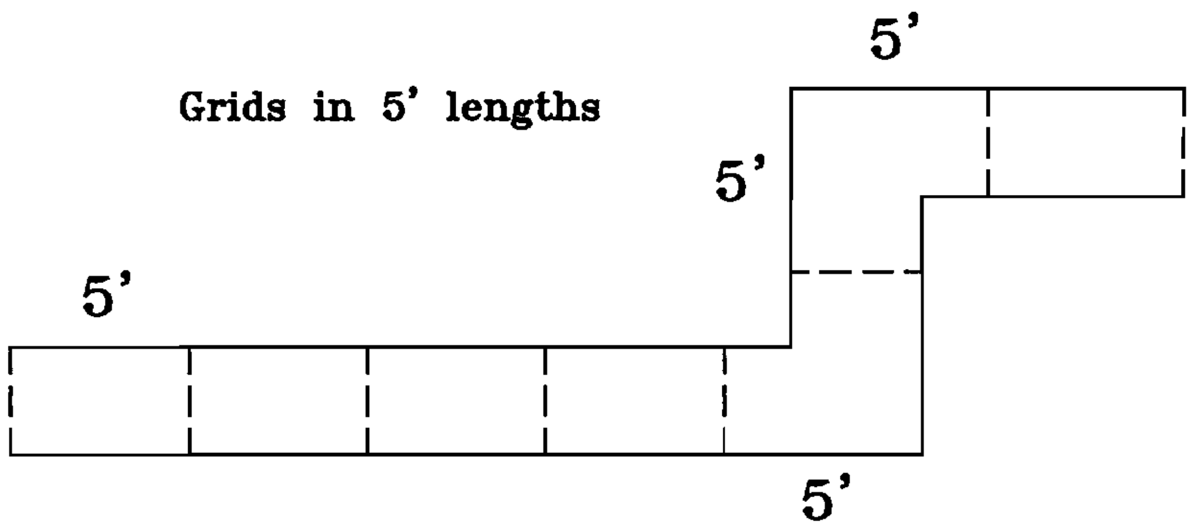
   c. A 100% survey was performed of each 5' grid with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of the grids was performed with an IM-253/PD in the HV-2 GROSS mode.

   d. Solid material samples were taken from each grid.

   e. Solid material core samples were taken from 25% of the grids. Each core sample contained at least one inch of top soil.

   f. Areas were mapped showing the location and results of these surveys.

Figure VI.5
Typical Trench Grid



<u>IM-247/PD</u> **100% every grid**	**<u>Solid Samples</u>** **each of the grids**
<u>IM-253/PD(PHA)</u> **100% every grid**	**<u>Solid Material Core Samples</u>** **25% of the grids**
<u>IM-253/PD(GROSS)</u> **25% of the grids**	

CLASSIFICATION AND SURVEY PROCEDURE

8. **Drydocks:**

   a. Areas of the drydock floor, walls, and caissons with a low potential for contamination were divided into approximately 20' x 20' grids. Each 20' x 20' grid had two subsections measuring approximately 3' x 3' placed in the area of highest potential for contamination. Areas of the drydock which were known storage areas for portable effluent tanks or other radioactive material, known spill areas, or areas underneath contaminated sea chests when ships or submarines have been docked received approximately 5' x 5' grids.

   b. Each grid was identified with a unique designation.

   c. Each 3' x 3' subsection was surveyed with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. 50% of the 3' x 3' subsections was performed with an IM-253/PD in the HV-2 GROSS mode.

   d. Each 5' x 5' grid received a 100% survey with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of the grids were performed with an IM-253/PD in an HV-2 GROSS mode.

   e. A solid material sample was taken from each 5' x 5' grid. A solid material sample was taken from each 20' x 20' floor grid.

   f. A sediment sample was taken from the drydock sump.

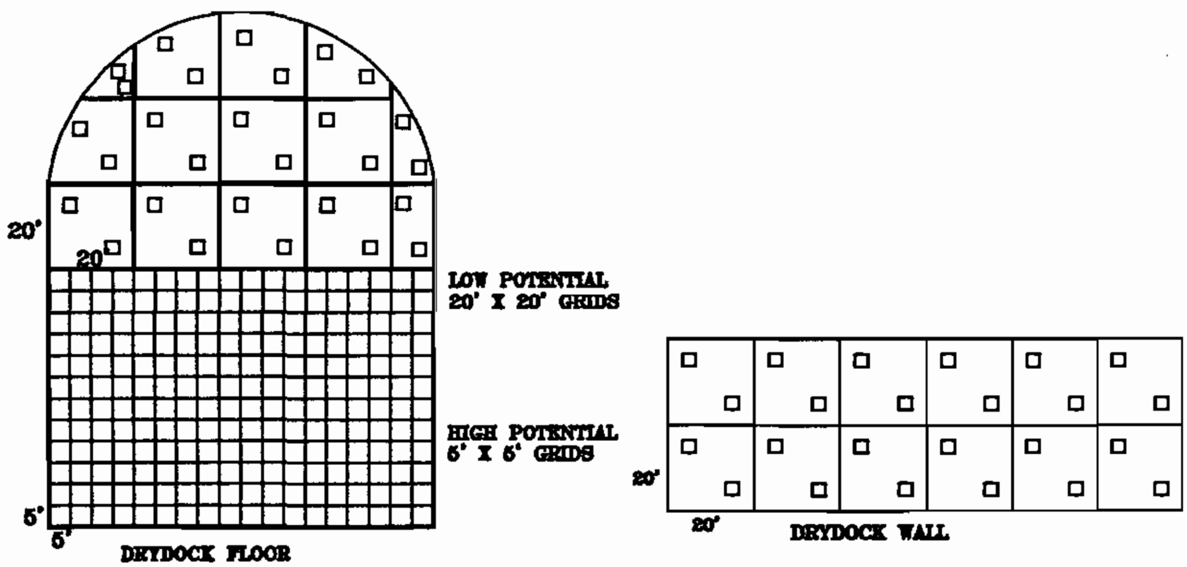
   g. Ten percent of the drydock keel blocks had all accessible surfaces surveyed with an IM-247/PD. Half of the keel blocks surveyed had solid material samples taken.

   h. Areas adjacent to drydocks, unless the area was otherwise categorized, was treated as ship berthing areas.

   i. Areas were mapped showing the location and configuration of grids and all survey results.

CLASSIFICATION AND SURVEY PROCEDURE

Figure VI.6
Typical Drydock Grid



<u>IM-247/PD</u>
LOW POTENTIAL
100% each 3'x'3' sub-grid
HIGH POTENTIAL
100% each 5'x5' grid

<u>IM-253/PD (PHA)</u>
LOW POTENTIAL
100% each 3'x3' sub-grid
HIGH POTENTIAL
100% each 5'x5' grid

<u>IM-253/PD (Gross)</u>
LOW POTENTIAL
50% 3'x3' sub-grids
HIGH POTENTIAL
25% 5'x5'grids

<u>Solid Samples</u>
Each floor grid

CLASSIFICATION AND SURVEY PROCEDURE

9. **Nuclear Ship Berthing Areas:**

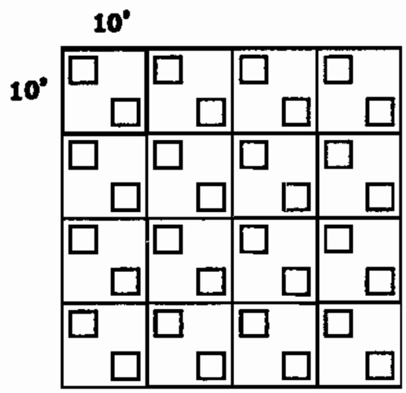
   a. Group 2 surveys were performed on the pier and to extend forty feet beyond the end of the pier. Additionally, a solid material sample of the ground covering was taken from a minimum of 50% of the 10' x 10' grids. Group 3 surveys were performed in those areas where portable effluent tanks or other radioactive material were known to have been stored.

   b. Areas were mapped showing the location and configuration of grids and all survey results.

CLASSIFICATION AND SURVEY PROCEDURE

Figure VI.7
Typical Pier and Berthing Area Grid

<u>IM-247/PD</u>
100% first subsection



Floor View

10'x10' grids with 3'x3' subsections out to a distance of 40' from the berth's end

<u>IM-253/OTHER</u>
100% second subsection

<u>Solid Samples</u>
50% of grids

CLASSIFICATION AND SURVEY PROCEDURE

10. **Radioactive Material Transfer Routes:**

a. Radioactive material transfer routes where radioactive material was packaged in accordance with Department of Transportation requirements and the route was used only for transport of radioactive material onto or off of the shipyard did not require survey.

b. Locations where two radioactive material transfer routes intersect had one 10' x 10' grid layed out.

c. Each grid contained two 3' x 3' subsections. These subsections were located in areas of highest potential for contamination. These subsections represented a minimum of 18% of the grid.

d. Each grid and subsection was identified with a unique designation.

e. One subsection of each grid received a 100% survey with an IM-247/PD.

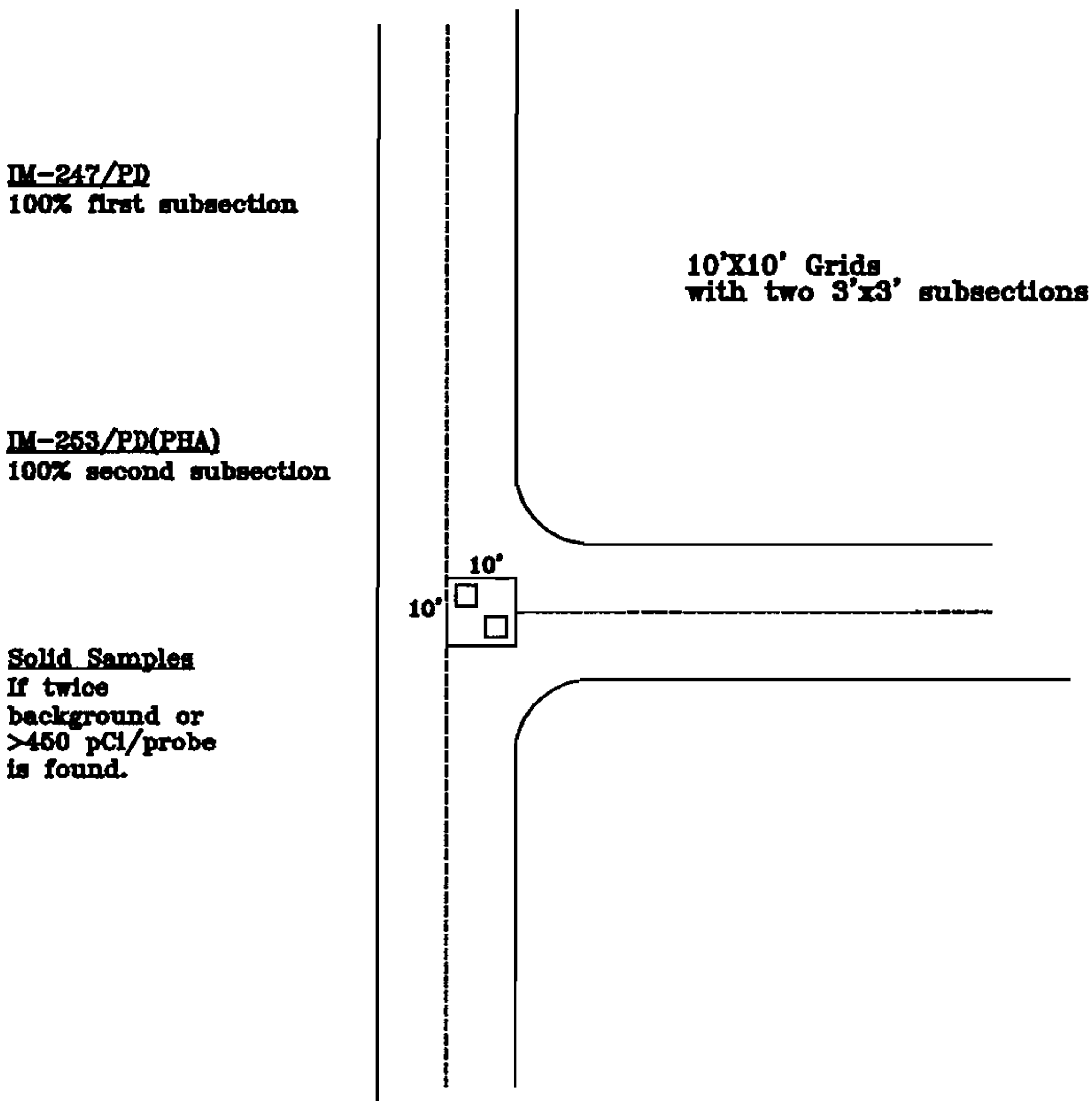
f. The other subsection of the grid received a 100% survey with an IM-253/PD in the HV-1 PHA mode.

g. Solid material samples were taken from each grid that showed greater than twice background with an IM-253/PD or greater than 450 pCi/probe with an IM-247/PD.

h. Areas were mapped showing the location and configuration of grids and all survey results.

Figure VI.8

Typical Transfer Route Grid



CLASSIFICATION AND SURVEY PROCEDURE

11. **Ventilation Systems:**

a. HEPA filters and HEPA filter housings in Group 3, Group 4, and Group 5 ventilation exhaust and recirculation systems were removed and dispose of as radioactive waste.

b. Group 4 and Group 5 ventilation exhaust and recirculation systems upstream of ventilation HEPA filters were removed and disposed of as radioactive waste, or surveyed for release from radioactive material controls.

c. Group 4 and Group 5 ventilation exhaust and recirculation systems downstream of ventilation HEPA filters, Group 4 and Group 5 ventilation supply systems, and Group 3 ventilation exhaust and recirculation systems upstream and downstream of ventilation HEPA filters were surveyed as follows: Accessible internal areas of the ventilation system remaining after HEPA filter, filter housing, and duct removal were surveyed with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of these areas was performed with an IM-253/PD in the HV-2 GROSS mode. Accessible internal areas of the ventilation system at exhaust sites were surveyed with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of those areas was performed with an IM-253/PD in the HV-2 GROSS mode. Ventilation ducts were breached approximately every twenty feet at accessible handhole openings, access ports, flow restrictors (e.g., reducers, etc.). Portions of the ventilation system accessible from these breach points were surveyed with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% of these areas was performed with an IM-253/PD in the HV-2 GROSS mode.

d. If contamination was found during ventilation system release surveys, additional surveys were performed in all suspect ventilation ducting to determine the extent of the contamination.

e. In Group 4 and Group 5 areas, where a potential existed for higher levels of contamination, a 100% survey was performed of all areas on and around intake registers, housings and/or ventilation supply registers with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A survey of 25% was performed of these areas with an IM-253/PD in the HV-2 GROSS mode. Unless these areas were otherwise gridded, the survey included all areas within 6' of intake registers, housings and/or ventilation supply registers, and were divided into 3' x 3' grids.

CLASSIFICATION AND SURVEY PROCEDURE

f. In Group 3 areas, where a potential existed for higher levels of contamination, a 100% survey was performed of all areas on and around intake registers, housings and/or ventilation supply registers with an IM-247/PD and an IM-253/PD in the HV-1 PHA mode. A 25% survey was performed of these areas with an IM-253/PD in the HV-2 GROSS mode. Unless these areas were otherwise gridded, the survey included all areas within 3' of intake registers, housings and/or ventilation supply registers, and were divided into 3' x 3' grids.

g. Areas and ventilation systems were mapped showing the location and configuration of grids, survey locations, and survey results.

12. **Environmental Sampling:**

a. Ground water samples were taken from areas surrounding facilities or areas where radioactive liquid was processed or stored. Sampling locations were located outside the facility of interest and selected on the basis of available data on ground water flow underneath the facilities of interest.

b. Sediment samples were taken from storm drains in the vicinity of Group 3, 4, and 5 areas, in the vicinity of drydocks and nuclear ship berthing areas, and from 20% of the storm drains along radioactive material transfer routes.

c. The preceding storm drain sampling was timed so that they were coincident with the nuclear closure of the facilities of areas from which the storm drains originate.

d. The following surveys were conducted after the departure of the last nuclear ship.

- Environmental water samples were taken from the river at nuclear ship berthing areas, at the drydock pump outfalls, and storm drain outfalls.

- Environmental sediment samples were taken from the river at nuclear ship berthing areas, drydock pump outfalls, and storm drain outfalls.

- Environmental shoreline surveys were performed in areas that the shipyard normally performed biannual shoreline surveys.

CLASSIFICATION AND SURVEY PROCEDURE

- Environmental marine life sampling was performed in areas that the shipyard normally performed biannual marine life sampling.

- A solid material core sample was taken from the river ship berthing areas and drydock outfalls.

e. Areas were mapped showing the location and configuration of grids and all survey results.

AREAS AND FACILITIES REQUIRING RADIOLOGICAL SURVEYS

A. INTRODUCTION

Initial radiological survey planning for the decommissioning of CNSY included the identification of areas within the shipyard that had been exposed to NNPP radiological work or radioactive material storage. This also included making an educated determination of the maximum radioactive contamination level to which each could have potentially been exposed.

B. RELEASE OF FACILITIES AND EQUIPMENT PREVIOUSLY USED FOR RADIOLOGICAL WORK

The NNPP requires that activities engaged in Naval nuclear propulsion plant work compile and maintain lists of facilities, areas, and equipment that have been used in support of radiological work. Further, extensive radiological surveys are required when these radiological work or storage areas will no longer be used or when the area, facility, or equipment is being released from radiological control.

Such surveys include those using a gamma scintillation type meter, and beta-gamma frisk surveys. Solid material samples are analyzed with a high-purity germanium detector coupled to a 4096-channel analyzer. Samples are taken in defined grids. Radioactivity detected by surveys or samples above permissible limits is removed and the area resurveyed or resampled until levels comparable to background are attained. Release criteria are provided in Table III-1 of Section III of this volume.

Results of surveys and sample analysis are formally documented and archived. For those areas being permanently released, a written report describing the area, radiological history, surveys and sampling protocol, tabulated results, and conclusions is forwarded to NNPP headquarters.

Several facilities at CNSY have had clearance surveys performed and documented. Those surveys were reviewed, as a part of the base closure process, against closure procedures to ensure all areas are released in a consistent manner. If considered to be appropriate, those areas were resurveyed. Table VII-1 lists previous radiologically controlled facilities that have been released for unrestricted use prior to the CNSY decommissioning process.

AREAS AND FACILITIES REQUIRING RADIOLOGICAL SURVEYS

Table VII-1

Previous Radiological Facilities Unconditionally
Released From Radiological Controls

FACILITY	RADIOLOGICAL USE
Field Repair Superintendent Trailer	Radiological control counting laboratory and radioactive material storage
Building 69 "K" Condition Storage Area	Radioactive material storage
Building 1169 Caged Storage Area	Radioactive material storage
Building 13 Annex - Ground Level	Radiochemistry laboratory
Former Radiochemistry Laboratory (Building 13, 1st Floor)	Radiochemistry laboratory
Building 35 Radioactive Material Receipt Area	Storage for radioactive material initially entering the shipyard
Building 1317	Radiochemistry analysis (used for only one week during a reactor plant decontamination)
Building 1156 Enclosed Storage Area	Radioactive material storage
Building 1013B	Radioactively contaminated valve refurbishment, radioactive material storage and anti-contamination clothing laundering
Building 96	Radioactive material storage
Building 1267	Radioactive material storage
Building 79A Mock Up	Radiation worker training using controlled equipment and radioactive material storage
Building 79A Instrument Room	Storage area for radiac instruments and response sources
Building 80	Inadvertent storage of radioactive material
Building 58 Room 201	Analyzing contained samples and storage of sealed radiac sources
Refueling Training Mock Up Facility	Refueling hands-on training utilizing low potential radioactive material
Building 79 Radiac Instrument Storage Area	Storage area for radiac instruments considered to be radioactive material
Training Facility Support Structure	Training area for the mock up of work to be done in radiological areas utilizing low potential radioactive material
Refueling Storage House #1	Staging and storage of refueling items having a radiological history
Refueling Storage House #2	Staging and storage of refueling items having a radiological history

Note: Two radiological repair barges have also been released from radiological controls.

AREAS AND FACILITIES REQUIRING RADIOLOGICAL SURVEYS

Pier and wharf areas adjacent to berths where nuclear ships are moored were used to locate portable radioactive liquid waste collection tanks, and occasionally served as temporary radioactive material storage areas. Radioactive liquid waste tanks were controlled by technical work documents approved by Radiological Engineering management. All temporary radioactive material storage areas required the written approval of the shipyard's Director, Radiological Control Office.

When a radioactive liquid waste tank was relocated or a temporary radioactive material storage area was disestablished, beta-gamma radiological surveys are performed prior to removing signs and barriers. The area must meet the NNPP limits of less than 450 pCi/100 cm^2 swipe sample, or less than 450 pCi/20 cm^2 scanning probe, to be released for general use. Even then, the area is included on the list of those areas requiring permanent release as described above.

Radiological equipment, including portable work and storage enclosures, are maintained under the control of radiological control personnel until permanently released as described above.

Other than active radiological work and storage areas within the shipyard as of the beginning of shipyard closure efforts, there were no areas within CNSY where radioactivity existed above natural background levels. Those work and storage areas are identified in Table VII-2. Note that this table lists only the dominate facility at a given location. The list does not include the satellite modules/facilities in the immediate vicinity of the major facility in the area. Those have been included in the individual release reports and can be found in Volume II of this final report.

AREAS AND FACILITIES REQUIRING RADIOLOGICAL SURVEYS

Table VII-2

Radiological Work and Storage Areas Requiring
Unconditional Release From Radiological Controls
at Beginning of Base Closure

Facility	Radiological Use
Building 222	Radiological Repair Facility
Building 79A	Radiological Repair Facility
Building 13A (Radiochemistry and Counting Labs, Radiography Areas)	Radioactive Material Storage Areas and Sample Processing
Building 101	Radioactive Material Storage Area
Building 1426	Radioactive Material Storage Area
Building 58	Radioactive Material Storage Area
Piers A, C, D, E, F, G, H, and J	Radioactive Material Storage Areas, Sample Processing and in-Transit Radioactive Material Transfer Routes
Drydocks 1, 2, 3, 4, and 5	Radiological Repair Facility, Radioactive Material Storage Areas, and In-Transit Radioactive Material Transfer Routes
Building 241	Temporary Storage of Fuel Transfer Railcars during Hurricane "Hugo"
Building 246	Radioactive Material Storage Area (Mixed Hazardous Waste)

Note: (a) In addition to the above shore-based areas, one Radiological Control Barge, typically stored in Drydock #4 was decommissioned.

The individual release reports for CNSY areas and facilities (including narratives, grid maps, and photos) are provided in Volume II of this report.

DISPOSITION OF RADIOLOGICAL FACILITIES EQUIPMENT

A. FACILITY/EQUIPMENT DISPOSITION

1. Refueling Equipment

    a. At the time the base closure process was initiated CNSY possessed various pieces of reactor servicing equipment. The shipyard's inventory of equipment also included three railroad car mounted temporary storage containers (associated with specific refueling material). Disposal of this equipment was made in accordance with the authorization provided by NNPP headquarters.

    b. The shipyard conducted hazardous material reviews of all radiological refueling equipment that was to be scrapped. If a determination was made that the item(s) contained hazardous material, it was either shipped to Norfolk Naval Shipyard for recycling or further review made to determine final disposition.

2. All equipment, having a radiological history removed from Buildings 222, 79A, and 13 (Radiochemistry Laboratory) was disposed of as low-level radioactive waste at the Chem Nuclear System Inc. site in Barnwell, SC. Tanks, and piping along with other selected items were sent the Scientific Ecology Group (SEG) in Oak Ridge, Tennessee, for further processing/reduction prior to final disposal.

3. Portable Facilities and Associated Equipment

    a. Over 11,700 line items of miscellaneous equipment used in support of nuclear work were depositioned. Items ranged from Special Maintenance and Reusable Support Equipment (SMARSE), to support/test gear, to cleanliness plugs. An inventory of potentially available equipment was forwarded to other naval shipyards and activities designated by NNPP headquarters for reuse screening.

    b. Numerous facilities were disposed of. Table VIII-1 provides a listing of these.

DISPOSITION OF RADIOLOGICAL FACILITIES EQUIPMENT

Table VIII-1
Nuclear Portable Facilities Disposition

FACILITY	DISPOSITION
1. M-130 House #3 2. Reactor Access Enclosure (RAE) #3 3. Contaminated Storage Enclosure 4. Training Facility Support Stand 5. Dockside Refueling Enclosure (DRE) #1, #2 6. RAE Annex #1 7. Vertical Stairwell - 55' 8. Change Houses (2) 9. Covered Brows 10. Steam Generator Cleaning (SGC) Barge YNFB-39 11. Portable Radioactive Liquid Waste Tanks	Shipped to Norfolk Naval Shipyard
1. Off Hull Refueling Enclosure 2. S6G Training Base 3. Depot Modernization Period (DMP) Hull House 4. M-130 House #4 5. RAE #4 6. RAE Annex #2 7. Vertical Stairwells - 33', 55', 45' 8. Frisk Enclosures (2)	Shipped to Pearl Harbor Naval Shipyard
1. M-130 House #1, #2 2. RAE #1, #2 3. Portable Radioactive Liquid Waste Tanks (Those not shipped to Norfolk) 4. Covered Brows (33 ea. not shipped to Norfolk) 5. Dockside training Support Enclosure 6. Nucleonics Labs 7. RC Ventilation and Service Penetration Hullcut Cofferdams	Disposed of as radioactive material or recycled as shielding material. The majority of these enclosures would likely have been releaseable from radiological controls. Processing of this equipment was quicker and less expensive than the surveys required to release the enclosures.
1. SGC Enclosure 2. 635 Pierside Cofferdam 3. Fuel Transport Trailers	Disposed of as Non-Radioactive Material (Unrestricted Use)
1. New Fuel Enclosure (NFE)/Inspection Assembly Facility (IAF) Enclosure 2. Core Barrel Thermal Shield Storage Enclosure 3. Steam Generator Inspection (SGI) Training Enclosure	Surveyed/provided unrestricted use release/abandoned
1. SGI Barge YFNX-20	Transferred to NPTU CHAS

DISPOSITION OF RADIOLOGICAL FACILITIES EQUIPMENT

c. A decision was made to dispose of three capital structures which had originally been designated for survey, free release, and abandonment. These were the M130 House #2, the Steam Generator Chemical Cleaning Enclosure, and the Dockside Training Support Enclosure. That decision was based on knowledge that the structures were obsolete, deteriorating, and contained both asbestos and lead paint. Thirty-three obsolete covered brows were also scrapped for the same reason.

4. The YFNX-23 Decontamination Barge was disposed of in accordance with the authorization provided by NNPP headquarters.

a. The disposition of this vessel employed a method similar to that used by Puget Sound Naval Shipyard to dispose of reactor compartments. The barge was cut away from the Containment Tank, the Effluent Pump Room, the Pump Room, and the Lower Level Chemical Mixing Tank Room. These remaining areas, taken collectively were the "disposal package" which was shipped to the burial site. A more detailed discussion of this disposition is provided by Section IX of this Volume.

SOLID RADIOACTIVE WASTE GENERATED DURING RADIOLOGICAL FACILITIES DECOMMISSIONING

A. BACKGROUND

1. It was recognized in the planning process that the decommissioning of CNSY would result in a large amount of material requiring processing as potential radioactive or mixed waste. The stringent time constraints placed on CNSY to complete the work compounded the problems caused by the large volume of material. Therefore, it was recognized very early that historical practices used in the past for processing and disposing of low-level radioactive waste would not support the amount expected from the rehabilitating and free release of CNSY permanent and portable nuclear facilities and equipment.

B. ORGANIZATION AND STRATEGY

1. The Radioactive Waste and Equipment Shipout (RAWES) Project was created as the vehicle to support the disposal of the anticipated large volume of material. The project provided for:

   - Using shipyard personnel most experienced and knowledgeable in Title 49, Code of Federal Regulations (CFR), Title 10 CFR, NNPP headquarters requirements, and State and local regulations governing the packaging, transportation, contracting and disposal of radioactive materials.

   - Utilizing the Nuclear Material Manager as the Project Manager. This individual was well versed in the responsibilities and expected function of the project.

   - Using the technical code expertise of the Radiological Engineering Division.

   - The availability of personnel from all shops/codes on an as-needed basis.

2. The strategy guidelines were established at the beginning of the project. They would:

   - Plan and execute the waste disposal such that its repetitive handling would be eliminated.

   - Realize the economies of scale by using large disposal containers thereby significantly reducing the administrative burden of shipping

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documentation, packaging documentation, contracting, truck loading, and quality control reviews.

- Prior to closure the primary radioactive waste disposal container had been the 95 cubic foot "B-25" box.

- For closure much larger disposal containers proved to be major labor savers. The 525 cubic foot "S-144" container as well as the 1280 cubic foot "Conex" boxes were used and proved to be advantageous.

- Capture significant cost savings by obtaining contracts for state of the art volume reduction.

  - CNSY capitalized on the volume reduction potential of a considerable amount of low-level waste (mostly tanks, piping systems, etc.) by utilizing the metal melting services of Scientific Ecology Group, Inc. at its site in Oak Ridge, Tennessee. Considerable volume reduction was realized. The six 3000 gallon waste processing tanks that had been housed in Building 222 underwent this process.

- Complete shipment of all radioactive equipment by August 1995.

- Complete shipment of all radioactive waste by February 1996.

C. SPECIFIC RADIOACTIVE WASTE GENERATING PROJECTS

1. Building 79A. This project included the partial dismantlement of buildings 79, 79A, 101, 1426, 1760, 1711, and the Reactor Compartment Mock-Up Facility. Building 79A was by far the most complex part of the entire project. It was a 13,000 square foot nuclear work facility attached to the rear of Building 79. Its historical background included:

   - The refurbishing of large reactor components.

   - The processing of radioactive waste (both liquid and solid).

   - The shipping and receiving of radioactive components and materials.

   - The decontamination of equipment and components.

   - The storage of numerous and varied nuclear components.

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Building 79A was one of two major radiological work facilities at CNSY. The facility contained numerous work rooms, liquid/solid waste processing areas and a complex environmentally controlled ventilation system that utilized HEPA filtration units.

Building 79A was stripped of all internal facilities, services, and enclosures. Essentially all that was left of that facility was the main structure, roof, some overhead lighting and two large overhead cranes. Practically all equipment and material removed from there was disposed of as low-level radioactive waste.

Buildings 101, 1426, 1760, and 1711 were not normally manned and were primarily storage areas for radioactive material. The Mock-Up facility was a simulated submarine reactor compartment that was used only for rehearsal and planning of complex shipboard jobs. With the exception of 1760, all had their internal equipment and services stripped and unusable material disposed of. Because of its condition and type of construction Building 1760 was dismantled entirely and disposed of as low-level radioactive waste.

The intial shipment of radioactive waste generated by the Building 79A Project was made in April 1994 and the last in May 1995. The actual total shipped was 46,134 cubic feet.

2. Building 222. This project included the two underground tunnels leading from the building to drydocks 1 and 2. The Building 13 Radiochemistry Laboratory was also included in the project. Building 222 was the second of the two major radiological work facilities at CNSY. This is a three story building with a basement. As such:

- The third floor was used as office space.
- The second floor was mostly office space with the exception of an access control point for entry into radiologically controlled areas on the lower floor/basement and another space used as a machinery room containing ventilation system components.
- The first floor was a large general area partitioned off with storage cages, controlled access areas to the drydock tunnels, various storage rooms, gage calibration room, fabrication/work room, radioactive waste

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counting room, large shipping/receiving area, large staging/ storage area used for refueling, and a freight elevator traversing between the first floor and basement.

- The basement consisted of a large general area partitioned off for the radioactive liquid waste processing systems, their filter and demineralizers; a shielded storage enclosure; a controlled pure water caged area with pumps valves, and tanks; a waste packer room; a large stainless steel lined decontamination room; and a tank room containing six 3000 gallon radioactive liquid tanks with associated system piping, and components; and a sump pit with sump tank.

Building 222 and the Building 13 Radiochemistry Laboratory were stripped of all internal facilities, services, and enclosures. Essentially, all equipment and material removed was disposed of as low-level radioactive waste.

The initial shipment of radioactive waste generated by the Building 222 Project was made in April 1994 and the last in March 1995. The actual total shipped was 38,110 cubic feet.

3. Portable Nuclear Facilities and Associated Equipment. At the time the CNSY closure process began the shipyard possessed nuclear facilities to service various reactor plants. In addition this project included, for disposition, barges, facilities, and equipment used for steam generator cleaning and inspection along with numerous pieces of equipment such as tanks, shield blocks, and covered brows. All of this equipment was offered to other activities. Those items not wanted were disposed of in a number of ways. Where disposition of item(s) were dependent on its radiological history, disposal as low-level radioactive waste was one of the alternatives available.

   Residual amounts of radioactive liquid wastes were generated from piping systems and portable tanks. This liquid underwent processing and solidification after which it was disposed of as solid low-level radioactive waste.

   Some 48,038 cubic feet of solid low-level radioactive waste was generated by this project. The initial disposal shipment was made in March 1994 and the last in May 1995.

4. YFNX-23 Decontamination Barge. This project presented a unique set of circumstances in that it involved a barge that had been actively involved in the decontamination of Naval nuclear reactor plants about 25 years ago. The

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barge itself had been in dry storage for the greater part of that time and the only entrances made over those years were for routine inspections and surveys. Since there was no plan to re-activate that system it became cost effective to dispose of it.

The barge was cut away from the Containment Tank, the Effluent Pump Room, the Pump Room, and the Lower Level Chemical Mixing Tank Room. These remaining areas, taken collectively, became the disposal package which was shipped to the burial site. All contaminated piping and ventilation components which were external to the disposal package were removed and placed in the disposal package for burial.

The disposal package and its contents were evaluated to ensure that the requirements for hazardous materials sent to the burial site were met. Such materials (which included about 122 tons of canned lead shielding) were surveyed and released from radiological controls or controlled as mixed waste.

The barge being used to transport the disposal package to the burial site was landed on the floor of the drydock which was then flooded and the package placed on the barge. After the disposal package had been prepared for shipment, the burial site contractor assumed responsibility for its transfer to the place of burial.

36,645 cubic feet of solid low-level radioactive waste resulted from this project. The initial shipment was made in October 1994 and the last in March 1995.

5. Miscellaneous. The closure process involved numerous radiological survey programs over and beyond those discussed in paragraphs C.1 through C.4 above. Although most were minor they did result in the accumulation of low-level radioactive waste. This material along with in-house waste that existed prior to the beginning of the closure resulted in the disposal of 7,271 cubic feet when the last shipment was made on February 13, 1996.

D. MIXED WASTE

1. Mixed waste (that which is both hazardous and contaminated with low-level radioactivity) had been generated at CNSY during overhaul and repair of nuclear-powered ships. Although efforts to minimize the generation of mixed waste had been largely successful, the shipyard had produced small quantities. The ripout of the internal features of the major radiological repair facilities that had been in existence for many years along with the total dismantlement

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of some modules and radiological waste storage areas made the potential for generating mixed waste more pronounced.

2. The Building 79A project served as the coordinator for all mixed waste generated during the closure process. In July 1994 a mixed waste handling area was established within Building 79A. In this connection:

   - The area served as a less than 90 day accumulation site to perform simple treatment of mixed waste. This material had been determined to be hazardous under the Resource Conservation and Recovery Act (RCRA). Material handled in this area included:

     - Flammable debris
     - Lead/chromium paint chips
     - Brass/bronze material
     - Cadmium plated material
     - Lead/chromium contaminated organic debris
     - Elemental lead

   - CNSY incorporated guidelines for mixed waste identification and characterization. These included instructions on how to track each item from its point of origin to its designated satellite accumulation area. It also contained instructions for the <90 day area outlining the method for processing the mixed waste once received from the various shipyard satellite accumulation areas.

   - Every item identified as potentially mixed waste was tracked with a profile sheet through use of a tracking number denoting the satellite accumulation area and item number.

   - The <90-day mixed-waste area operated independently of the 79A project. Mixed waste processing was handled as a smaller separate function. It was serviced by personnel who were qualified radiation workers (with the additional qualifications for handling hazardous waste). That group had direct access to technical support personnel on an as needed basis.

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3. The <90-day area processed over 3,200 items. The majority of the items involved were gamma counted, verified not to be radioactive, and shipped as non-radioactive hazardous waste or recycled (such as brass, bronze, and lead). Items that were not radiologically released underwent decontamination. If initial decontamination efforts were unsuccessful and the determination was made that further efforts to decontaminate would not be worthwhile, the item(s) were sent to Building 246, a RCRA permitted storage area. Actions were taken to ship the waste offsite for treatment and ultimate disposal in accordance with the Federal Facility Compliance Act and the implementing Consent Order. The final mixed waste shipment under the Site Treatment Plan took place on January 19, 1996.

E. CONCLUSION

Table IX-1 provides a tabulation of the radioactive waste generated by the closure process.

SOLID RADIOACTIVE WASTE GENERATED DURING RADIOLOGICAL FACILITIES DECOMMISSIONING

Table IX-1

Status of Radioactive Waste For Closure Projects (Cu. Ft.)

Month-Yr	Bldg. 222	Bldg. 79A	Reful. Equip and Port Nuc Fac	YFNX-23	Survey	Totals (Monthly)
Mar-94	0	0	3066	0	0	3066
April	680	320	0	0	0	1000
May	1577	1000	0	0	0	2577
June	2772	1050	0	0	0	3822
July	3852	0	0	0	0	3852
August	3759	1095	9967	0	0	14821
Sept	5940	190	0	0	0	6130
Oct	190	1555	285	380	0	2410
Nov	7955	4525	875	620	1924	15899
Dec	3779	1145	3760	3840	525	13049
Jan-95	2855	8400	2190	1280	0	14725
Feb	3466	7015	6355	0	285	17121
March	1285	8139	3380	30525	0	43329
April	0	8400	3380	0	0	11780
May	0	3300	14780	0	95	18175
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	760	760
Sept	0	0	0	0	1525	1525
Oct	0	0	0	0	0	0
Nov	0	0	0	0	0	0
Dec	0	0	0	0	2061	2061
Jan-96	0	0	0	0	96	96
TOTALS	38110	46134	48038	36645	7271	176198

Note: The total reflected by this table does not compensate for the metal melt and volume reduction services provided by Scientific Ecology Group, Inc. at its site in Oak Ridge, Tennessee. When these services are accounted for, the total amount of radioactive waste disposed of at the Barnwell, South Carolina radioactive waste burial ground was 94,939 cubic feet.

QUALITY CONTROLS PROGRAM

A. Introduction

1. This section of the report summarizes the quality provisions used in this comprehensive survey project to assure surveys were satisfactory for the release of CNSY facilities for unrestricted use by the general public. The radiological control expertise exercised by the shipyard stemmed from a relationship of over thirty years with the NNPP. The same rigorous attitude as applied to reactor operation and design was applied to radiological and environmental controls. The effectiveness of these controls had been demonstrated through the years by over-sight environmental surveys from the U.S. Public Health Services (USPHS prior to the EPA), the USEPA, USDOE contractors and SCDHEC. The quality provisions included: formal personnel training and qualifications, strong technical supervision, multiple reviews of data, strict equipment calibration/daily checks and independent reviews.

2. Standards for closing radiological facilities are presently being developed by the EPA, NRC and DOE. The available drafts were reviewed, and the quality control/quality assurance provisions used by CNSY met or exceeded the requirements of those documents.

B. Project Organization

1. Charleston Naval Shipyard had performed work on nuclear-powered ships for more than thirty years.

2. Much of the CNSY infrastructure (i.e., organization, processes, systems, training, problem reporting, etc.) were applicable to performing final remediation, closure and surveys. As such:

   - Production projects were structured to maintain the independence of engineering, radiological control, environmental and safety and quality control personnel from the personnel responsible for the production effort.

   - Management personnel held similar positions during the overhaul and refueling of nuclear-powered submarines. Many of these persons had been involved in nuclear submarine work from its beginning in the 1960's.

QUALITY CONTROLS PROGRAM

C. Training and Qualification of Personnel

1. Management, engineering, radiological control, quality control and trades personnel involved in the release survey project had previously performed complex overhauls of nuclear-powered submarines. The extent of training and qualification for the project personnel was commensurate with the education, experience and individual proficiency. In most instances, prior qualifications were still valid. Qualification typically included:

   - A course of instruction provided by detailed lesson plans.

     - A written final examination.

     - A practical demonstration performing simulated work.

     - Periodic requalification.

   For example, Radiological Control Technicians were required to complete a course of six months to one year in length in radiological controls with numerous written tests--including a final comprehensive written examination. They were also required to demonstrate practical abilities in work operations and emergency drills as well as pass a comprehensive oral examination. Radiological controls supervisors were required to have the same technical knowledge and abilities as the technicians; however, passing scores for examinations provided for supervisors were higher than for technicians. Requalification was required at least every thirty months. Between qualification periods, these persons participated in periodic training and were subject for selection for impromptu written and practical examinations.

2. U.S. Navy Report, "Occupational Radiation Exposure From U.S. Naval Nuclear Plants and Their Support Facilities, Report NT-95-2" provides additional details on radiological training programs.

D. Work Control

1. The same disciplined work control process used for nuclear submarine work was used for this project. Detailed, written engineered procedures were prepared and used. Each procedure was identified by a unique number. Procedures were followed verbatim. If the procedure could not be performed

as written, a formal change was made. Such procedure changes were numbered and tracked to ensure all required work was accomplished. A separate work packaging and control group tracked the work procedures and verified that all work had been completed.

2. Trained personnel performed the work and assured the accuracy of the data recorded and performed signature certification. Qualified supervisors provided on-site work direction. These supervisors reviewed data as it was collected and performed spot-check surveys to further assure the validity of survey results. Individuals were held accountable for performing tasks as specified.

3. Signature chain-of-custody was maintained on all samples to ensure that the samples taken from a specific location were counted and recorded for the proper location. Sample containers were used only once to eliminate the possibility for contamination of another sample.

E. Survey Data Review

1. There were multiple reviews of survey data for completeness, validity and accuracy. They included a review by radiological controls supervisors or laboratory analysis supervisors, the production work-packaging group, radiological engineering and a team of middle managers called the internal quality assurance group. Guidelines for conducting them were established to ensure that consistent, in-depth analyses were performed.

2. Computer programs were used to check data and to provide verification that all data required by the survey plan had been obtained and was within the required specifications.

3. Selected areas were resurveyed and sampled to validate the survey and sampling results.

4. Finally, all survey data contained in this comprehensive report was reviewed by senior technical personnel.

F. Measuring Equipment Calibration and Checks

1. All measuring and test equipment was maintained and calibrated in accordance with the standard Navy calibration program. Additionally, field radiation

detection equipment was checked on a daily basis to a known quantity of radioactivity (source) traceable to a National Institute of Standards and Technology (NIST) standard. This check, performed by qualified radiological controls personnel, ensured proper instrument response to radioactivity.

2. Laboratory equipment used for solid and water-sample analysis was maintained and calibrated in accordance with detailed written instructions. These instructions included a series of daily checks with NIST traceable standards. On a quarterly basis, the sample counting laboratory provided samples to an independent Department of Energy Laboratory (Knolls Atomic Power Laboratory) for duplicate counting to confirm the adequacy of the Shipyard's results. On a periodic basis the same Department of Energy Laboratory provided blind standards to the Shipyard to confirm the ability on the sample counting laboratory to detect known values of radioactivity.

G. Audits and Reviews

1. Numerous checks, cross-checks and inspections were included as part of the normal work process. In addition to these checks, a strong independent audit program verified compliance with the requirements of the survey plan. This was not a new concept; an audit program has been in existence since nuclear submarine work began. This radiological audit group was independent of the radiological controls and production organizations and its findings were reported regularly to senior management. This group performed continued surveillance of the project. In-depth audits of specific aspects, as well as overall assessments, were performed.

2. A representative of the Director of the Naval Nuclear Propulsion Program had been in place on CNSY since the inception of nuclear work on the Naval base complex. That representative and his staff were dedicated to oversight of this project following the cessation of nuclear submarine work.

3. NNPP headquarters technical personnel conducted periodic inspections of the project. They also reviewed all survey data collected prior to its final distribution.

4. The SCDHEC and USEPA reviewed the survey plan, the drafts of this report and performed independent observations, over-check surveys and sampling of facilities and areas. Their results were consistent with Navy results. Both

QUALITY CONTROLS PROGRAM

agencies concurred with the Navy conclusion that there are no significant radiological hazards from residual radioactive material associated with activities conducted by the Navy in excess of regulatory standards or which would be detrimental to the health and safety of the public or the environment. They also concluded that the facility could be released from radiological controls for unrestricted use.

GLOSSARY OF ACRONYMS

ADP	:	Automated Data Processing.
AEC	:	Atomic Energy Commission.
BRAC	:	Base Realignment and Closure Commission.
CFR	:	Code of Federal Regulations.
CIA	:	Controlled Industrial Area.
CNSY	:	Charleston Naval Shipyard.
cpm	:	counts per minute.
CPW	:	Controlled Pure Water.
curie	:	Abbreviated Ci. A unit of measure of the amount of radioactivity equal to 3.7×10^{10} disentegrations per second or 2.22×10^{12} disentegrations per minute.
DMP	:	Depot Modernization Period.
DOE	:	Department of Energy.
DRMO	:	Defense Reutilization and Marketing Office.
EPA	:	U.S. Environmental Protection Agency.
HEPA filter	:	High Efficiency Particulate Air filter. A filter that can remove 99.97% of 0.3 micron particulates from an air system.
IMANPY	:	Intermediate Maintenance Activity Nuclear Planning Yard.
inac	:	Inactivation.
INEL	:	Idaho National Engineering Laboratory.
IQA	:	Internal Quality Assurance.
KAPL	:	Knolls Atomic Power Laboratory.
kcpm	:	Thousand counts per minute.

GLOSSARY OF ACRONYMS

MCA	:	Multichannel Analyzer.
MDA	:	Minimum Detectable Activity.
MeV	:	Million electron volts.
micro	:	Abbreviated μ. A prefix denoting a one-millionth part (10^{-6}).
milli	:	Abbreviated m. A prefix denoting a one-thousandth part (10^{-3}).
NIST	:	National Institute of Standards and Technology.
NNPP	:	Naval Nuclear Propulsion Program. A joint Navy/Department of Energy program to design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities.
NPTU CHAS	:	Nuclear Power Training Unit Charleston.
NRC	:	U.S. Nuclear Regulatory Commission.
PHA	:	Pulse Height Analyzer.
pico	:	Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).
STP	:	Site Treatment Plan.
RAWES	:	Radioactive Waste and Equipment Shipout.
RCRA	:	Resource Conservation and Recovery Act.
RDA	:	Redevelopment Authority.
RO/RF	:	Regular Overhaul/Regular Refueling.
SCDHEC	:	South Carolina Department of Health and Environmental Controls.
TGI	:	Task Group Instruction.
TLD	:	Thermoluminescent Dosimeter.
TSCA	:	Toxic Substance Control Act.

GLOSSARY OF ACRONYMS

WCM	:	Waste Curie Monitor.
<	:	Less than.
>	:	Greater than.