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NUCLEAR CLOSURE OF CHARLESTON AND MARE ISLAND CNC CHARLESTON SC
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NAVAL NUCLEAR PROPULSION PROGRAM

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NUCLEAR CLOSURE OF CHARLESTON AND MARE ISLAND NAVAL SHIPYARDS

NAVAL NUCLEAR PROPULSION PROGRAM
DEPARTMENT OF THE NAVY
WASHINGTON, DC 20362

EXECUTIVE SUMMARY

This report provides an overview of the process to complete nuclear closure of Charleston and Mare Island Naval Shipyards and to release their facilities for unrestricted civilian use with respect to radioactivity from nuclear propulsion plant work regulated by the Naval Nuclear Propulsion Program.

In September 1993, Congress approved the recommendation of the Base Realignment and Closure Commission and President Clinton to close Charleston Naval Shipyard in Charleston, South Carolina, and Mare Island Naval Shipyard in Vallejo, California. The Department of the Navy established April 1, 1996 as the closure date for both shipyards.

These nuclear-capable shipyards performed work on every class of nuclear-powered ship since the 1950's. This work included construction, repair, and overhaul of nuclear-powered ships as well as refueling ship nuclear reactors. Each shipyard had specialized facilities and equipment to support the various types of nuclear work.

To release these shipyards for unrestricted civilian use, all Naval Nuclear Propulsion Program radioactive material needed to be removed, and all areas verified to be below Program radiological limits to ensure no significant risk to the public or the environment. Accordingly, the Navy developed radiological survey plans to verify Program radioactivity had been removed. The shipyards performed radiological surveys using sensitive instruments and took solid samples in all areas where Program radioactive equipment and material had been or may have been worked on, stored, or transported.

The extent of survey and sampling of each area was based on the radiological history of the area and the potential for finding radioactivity. The shipyards used detailed written instructions to survey each area and record the results. In the process, the shipyards removed all radioactivity above Program radiological limits and verified removal by performing additional surveys.

The shipyards documented the results of these surveys for each area in detailed release reports. To ensure the validity of survey data recorded, the shipyards implemented a rigorous quality assurance program. Each shipyard surveyed over 5,000,000 square feet of area in buildings, drydocks, and berths and analyzed over 40,000 solid samples. For perspective, the estimated total amount of Program radioactivity removed from remediated areas at each shipyard was about as much radioactivity as in one household smoke detector (2-3 microcuries).

Each shipyard completed the nuclear closure work on schedule. The cost of the survey effort at each shipyard (including solid samples and remediation) was about $26 million.

The Navy worked closely with state and federal environmental regulatory agencies who provided independent oversight throughout the closure process. These agencies agreed, that under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and implementing State requirements where applicable, all facilities at both shipyards were acceptable for release to the local communities for unrestricted use with respect to Naval Nuclear Propulsion Program radioactivity.

This overview demonstrates that facilities used to maintain and repair Naval nuclear-powered ships for over 40 years can be decommissioned and released for unrestricted public use with a reasonable effort and cost and within a short period of time. The Program's strict control of radioactivity is the basis for this achievement. The closure process involved straightforward planning and engineering, using off-the-shelf technology. The cooperation and support from the States of South Carolina and California, and from the local regions of the Environmental Protection Agency, were major elements in successfully completing this process on schedule and within budgeted costs.

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1.0 INTRODUCTION

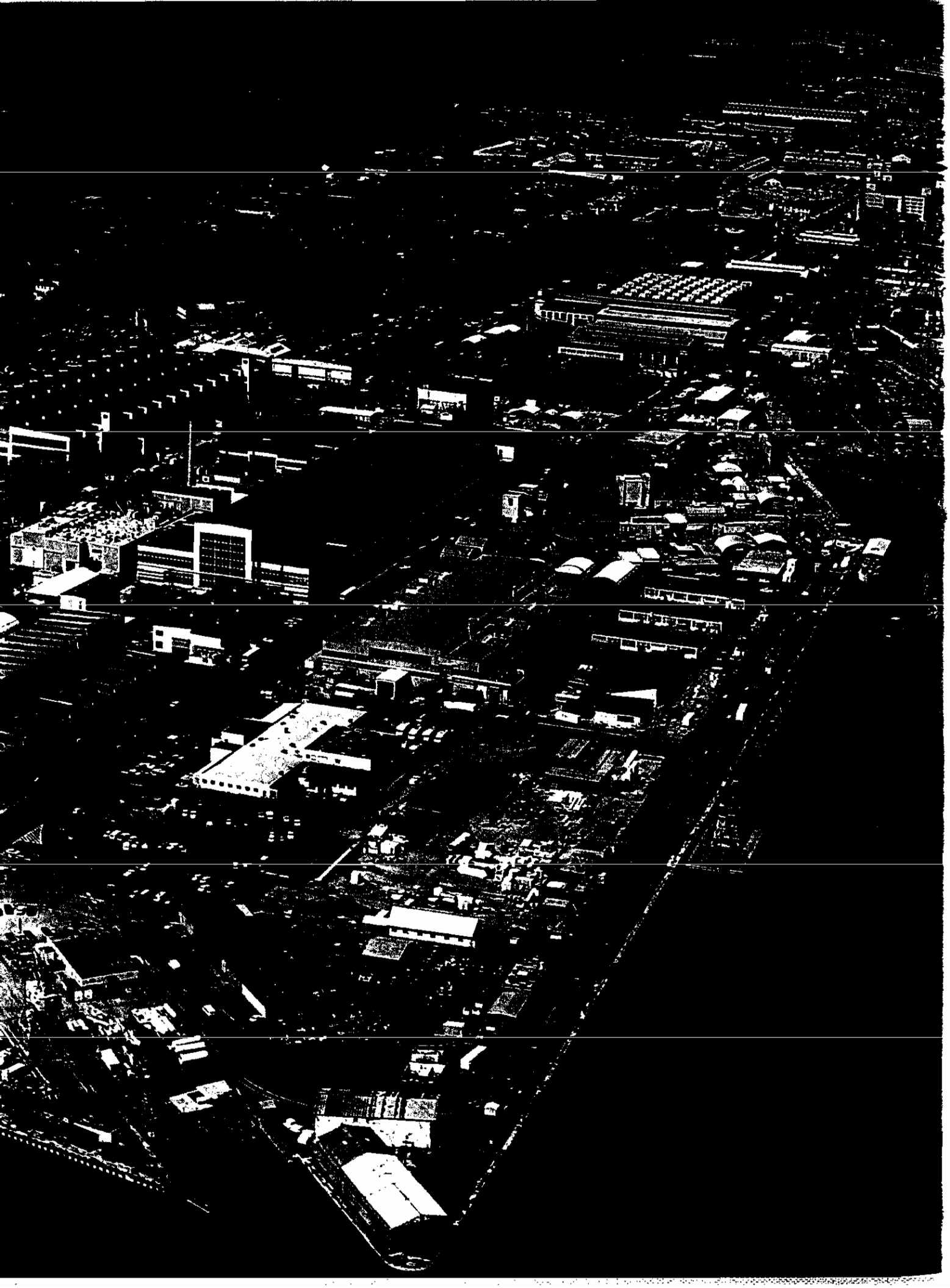
This report provides an overview of the process to complete nuclear closure of Charleston and Mare Island Naval Shipyards and to release their facilities for unrestricted civilian use with respect to radioactivity from nuclear propulsion plant work regulated by the Naval Nuclear Propulsion Program.

In September 1993, Congress approved the recommendation of the Base Realignment and Closure Commission and President Clinton to close Charleston Naval Shipyard in Charleston, South Carolina, and Mare Island Naval Shipyard in Vallejo, California. The Department of the Navy established April 1, 1996 as the closure date for both shipyards.

Charleston Naval Shipyard in Charleston, South Carolina performed maintenance and repair work on nuclear-powered ships and submarine tenders from 1962 to 1994. Charleston overhauled 33 nuclear-powered submarines of which 27 were refueled. Eight other nuclear-powered submarines were defueled, inactivated, and prepared for towing to Puget Sound Naval Shipyard for disposal. Charleston also performed work during many shorter maintenance availabilities on nuclear-powered ships, and supported special Fleet operations related to handling, processing, and disposal of radioactive resin and low-level waste. This type of work required special facilities, support systems, and trained personnel.

Similarly, Mare Island Naval Shipyard in Vallejo, California performed maintenance and repair work on nuclear-powered ships from 1957 to 1995, including the construction of seventeen nuclear-powered submarines from 1957 to 1971. Also, Mare Island Naval Shipyard performed work during numerous overhauls and shorter maintenance availabilities on nuclear-powered submarines, cruisers, and aircraft carriers. During the period from 1957 to 1995, Mare Island overhauled 52 nuclear-powered submarines and surface ships of which 31 were refueled. An additional 14 submarines were defueled, inactivated, and prepared for towing to Puget Sound Naval Shipyard for disposal.

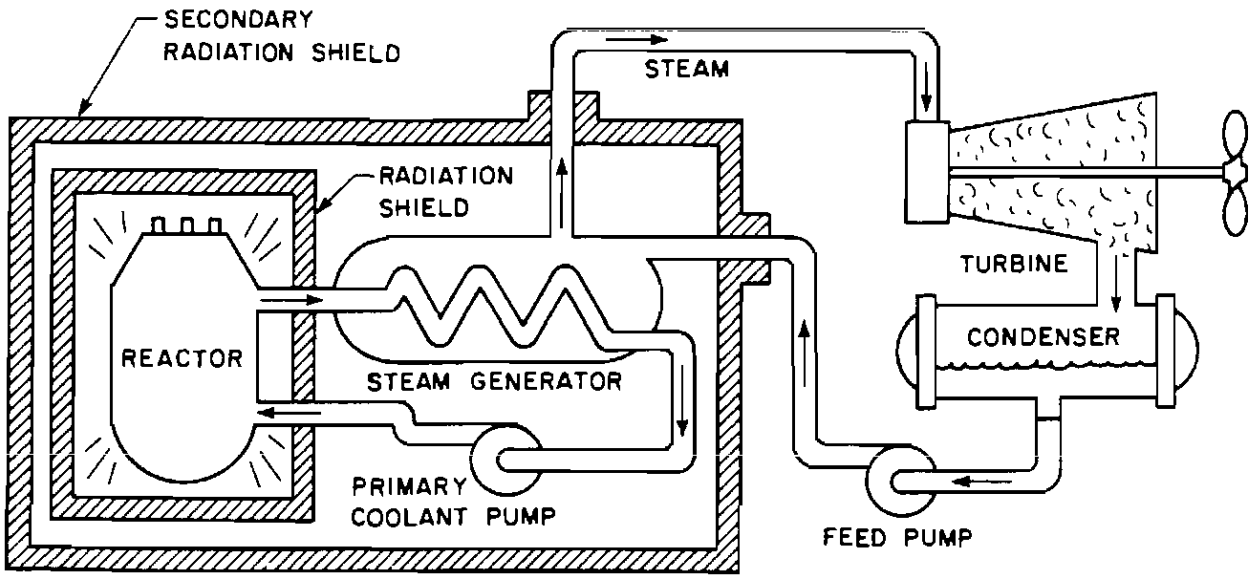
◀Aerial View of Mare Island Naval Shipyard



2.0 NAVAL NUCLEAR PROPULSION PROGRAM RADIOACTIVITY

U.S. Naval nuclear propulsion plants use a pressurized water reactor design which has two basic systems: the primary system and the secondary system. The primary system circulates water in an all-welded, closed loop consisting of the reactor vessel, piping, pumps, and steam generators. The heat produced in the reactor core is transferred to the water, which is kept under pressure to prevent boiling. The heated water passes through the steam generator where it gives up its energy. The water is then pumped back to the reactor to be heated again.

Inside the steam generators, the heat from the primary system is transferred across a water-tight boundary to the water in the secondary system, also in a closed loop. The secondary water, which is at relatively low pressure, boils, creating steam which is then used as the source of power for the propulsion plant as well as for auxiliary machinery.



Pressurized Water Reactor Plant
Simplified Sketch

Trace amounts of corrosion and wear products from reactor plant metal surfaces which contact the primary water are the principal sources of radioactivity encountered during shipyard maintenance and repair work on nuclear-powered ships. 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 predominant of these radionuclides and has the most restrictive concentration limits as listed in the Code of Federal Regulations, Title 10 (Nuclear Regulatory Commission), Part 20 (Standards for Protection Against Radiation). Therefore, cobalt-60 is the primary radionuclide of interest for Naval nuclear propulsion plants.

Radioactivity is present in reactor plant components that have been exposed to primary water. This radioactivity must be properly controlled and managed during shipyard maintenance and repair work. The potential existed for this radioactivity to have been transferred to facilities and equipment at Charleston and Mare Island Naval Shipyards during repair and maintenance of reactor plant components. To minimize the potential for the spread of radioactivity, the shipyards limited the areas where work was performed to a small number of specially designed and operated facilities.

This report uses the curie (Ci) as the unit of radioactivity. A curie is the amount of any radionuclide that undergoes exactly 37 billion disintegrations per second. This report uses submultiples of the curie, such as microcurie (one millionth of a Ci, or μCi) and picocurie (one trillionth of a Ci, or pCi), to express radioactivity. For perspective, the concentration of naturally occurring radioactivity in ordinary dirt is several picocuries per gram.

3.0 CONTROL OF NAVAL NUCLEAR PROPULSION PROGRAM WORK AT CHARLESTON AND MARE ISLAND NAVAL SHIPYARDS

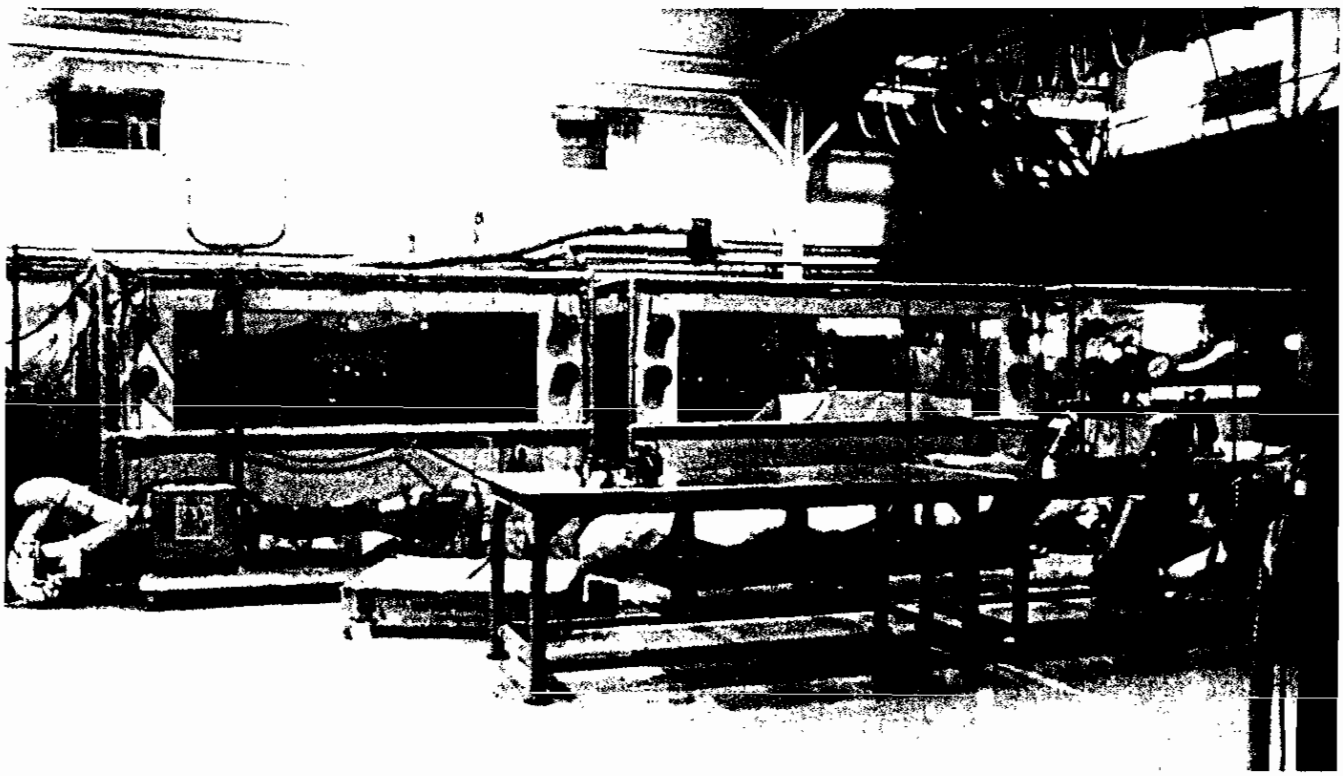
Protection of the environment has always been a high priority in the Naval Nuclear Propulsion Program. The Program maintains the same rigorous standards toward the control of radioactivity and protection of the environment that it does toward reactor plant design, testing, operation, and maintenance. The major parts of the radiological controls program are radiation exposure reduction, radioactive surface contamination control, airborne radioactivity control, control of radioactive material, and environmental monitoring.

Both Charleston and Mare Island performed a wide range of radiological work associated with Naval nuclear propulsion plants, including refueling reactors. Refueling involves removal of spent fuel for transfer into special shipping containers and installation of new fuel. Both shipyards shipped all spent fuel to the Idaho National Engineering Laboratory; neither Charleston nor Mare Island Naval Shipyard processed any spent nuclear fuel.

Radioactive materials encountered during radiological work at these shipyards included primary water 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 solid low-level radioactive waste such as rags, plastic bags, tape, and plastic bottles. The shipyards strictly controlled this radioactive material to prevent loss. Shipyard controls included accountability procedures which required serialized tagging and marking by radiologically trained personnel.

Inside radiological work facilities were Radiologically Controlled Areas that were physically separated from the rest of the building. Access to these areas was by a control point manned by radiologically trained personnel. Personnel exiting a Radiologically Controlled Area were surveyed to ensure no radioactive contamination was taken outside the area. Similarly, any material to be removed from a Radiologically Controlled Area was either controlled as radioactive material or surveyed to ensure no radioactive contamination was present.

Both shipyards maintained all areas within Radiologically Controlled Areas within Program limits except for those areas designated and specially controlled as Controlled Surface Contamination Areas. Controlled Surface Contamination Areas consisted of engineered glovebags and tents with ventilation systems containing high efficiency particulate air filters. Radiologically trained personnel frequently surveyed Radiologically Controlled Areas and



Typical Work Tents in Radiologically Controlled Area inside a Radiological Work Facility at Charleston Naval Shipyard

Controlled Surface Contamination Areas to ensure that radioactive contamination levels were appropriately controlled.

To provide additional assurance that procedures to control radioactivity were adequate, each shipyard conducted extensive environmental monitoring dating from the initiation of Program work at that shipyard. This monitoring program involved harbor monitoring (including water and sediment sampling), monitoring of air discharged from radiological work facilities, and posting of thermoluminescent dosimeters around the radiological work facilities and shipyard boundaries to measure radiation levels.

References (1) through (5) detail additional information related to the Naval Nuclear Propulsion Program and the Program's radiological controls and environmental monitoring programs.

4.0 NUCLEAR CLOSURE

Both Charleston and Mare Island prepared detailed radiological survey plans to radiologically release shipyard facilities. The detailed documentation of facilities used to support the Program's radiological work was key in developing the radiological survey plans. The shipyards based this documentation on review of past records and interviews of former and current employees. Also, each shipyard prepared a comprehensive Historical Radiological Assessment to further document historical environmental practices and results [references (4) and (5)], pursuant to the requirements in Environmental Protection Agency regulations implementing the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Additionally, both shipyards reviewed other standards for closing radiological facilities that are presently under development by the Environmental Protection Agency, Nuclear Regulatory Commission, and Department of Energy. Each shipyard's plan met the quality control/quality assurance provisions in these standards.

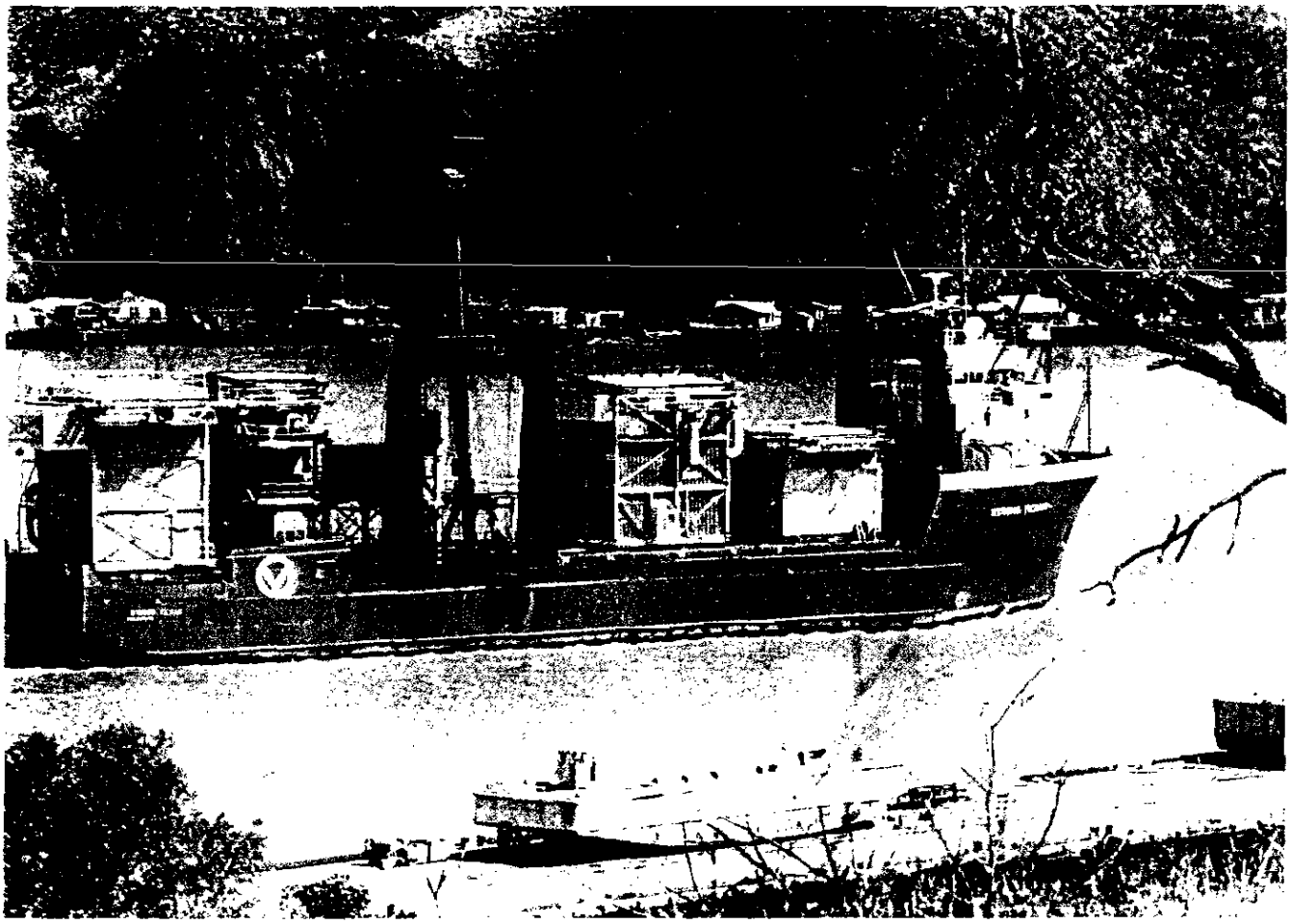
The Naval Nuclear Propulsion Program headquarters approved the final plans, and the cognizant state and federal environmental regulatory agencies agreed with the final plans. The basic steps of each plan were:

1. Completing assigned work and removing Naval Nuclear Propulsion Program radioactive material and equipment.
2. Conducting surveys and obtaining solid material samples of designated areas of buildings, piers, and drydocks to verify the removal of Program radioactivity.
3. Documenting the results of surveys and obtaining Program headquarters approval and state and federal environmental regulatory agencies' agreement that the facilities could be released for unrestricted civilian use.

STEP 1:
COMPLETING ASSIGNED WORK AND REMOVING NAVAL NUCLEAR PROPULSION PROGRAM RADIOACTIVE MATERIAL AND EQUIPMENT

In addition to removing and disposing of radioactive material and equipment, this step involved completing assigned work and transferring unique functions and useful material and equipment to other organizations in the Naval Nuclear Propulsion Program.

Charleston and Mare Island performed unique functions (e.g., reactor plant engineering support functions) for the Program which were turned over to other activities using detailed plans to ensure no loss of service to the Fleet.



Shipping Refueling Facilities from Mare Island Naval Shipyard to Another Naval Shipyard

Both Charleston and Mare Island had a significant amount of uniquely military material, portable facilities, and equipment that will be used by other Naval activities. The transfer of these items significantly minimized the amount of low-level radioactive waste remaining at the closing shipyards for disposal.

The major radiological work facilities were dismantled to bare walls and floors to allow complete access for surveys. This included removal of liquid and solid waste processing systems, tools, work tables, ventilation systems, sinks, stainless steel decks, and piping systems. Additionally, the shipyards removed non-radioactive systems such as electrical lighting, power circuits, and communication circuits to allow surveys of normally inaccessible areas.

Radioactive material and equipment was either:

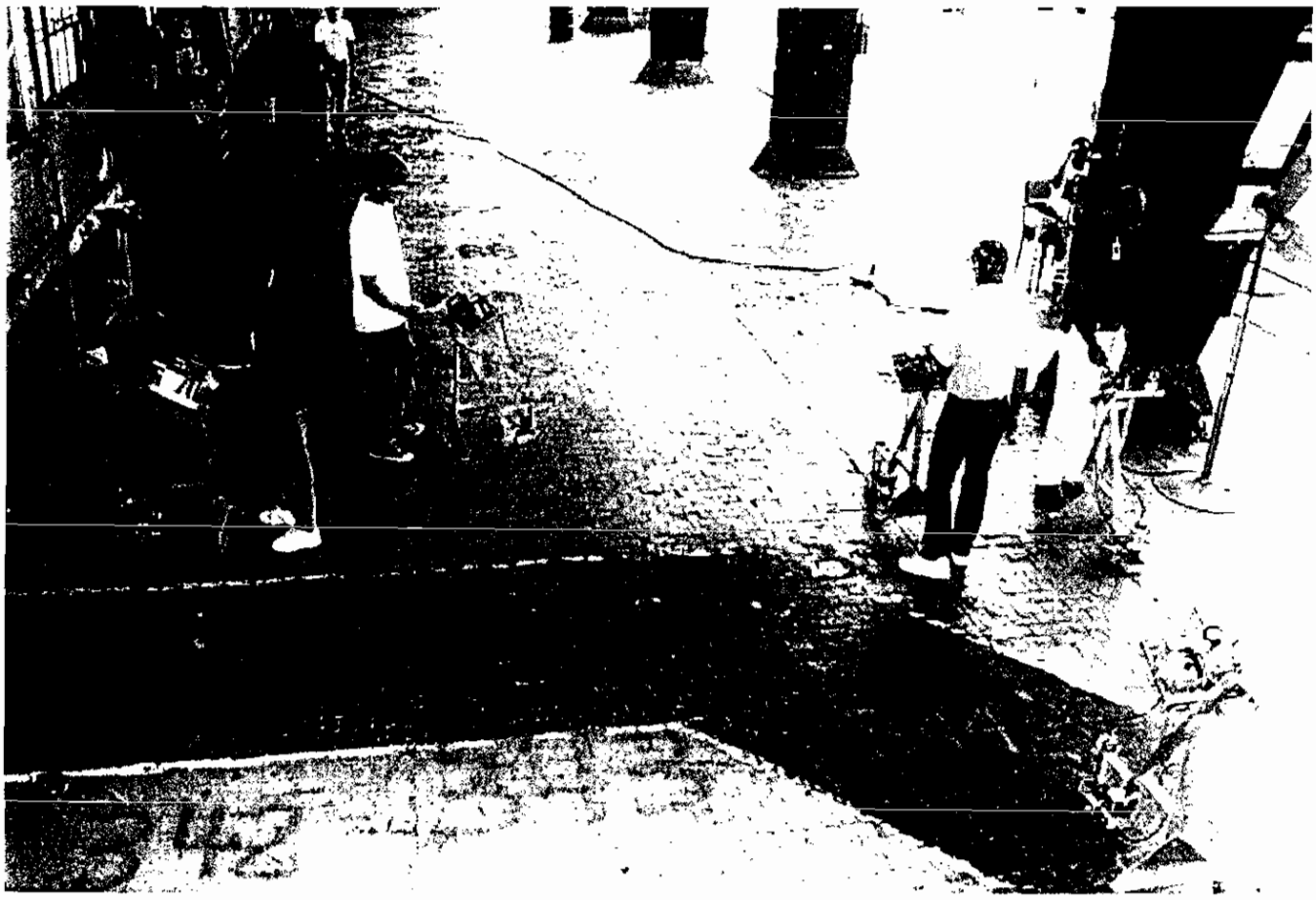
1. surveyed for release from radiological control and disposed of as regular waste,
2. shipped to a waste volume reduction facility for metal melting, supercompaction, or incineration and later disposal, or
3. shipped directly to a low-level radioactive waste disposal facility.

During the closure process, Charleston and Mare Island shipped a total of approximately 450,000 cubic feet of low-level radioactive waste for disposal. Through the use of waste volume reduction facilities, the total volume finally disposed of by licensed radioactive waste burial grounds was only approximately 150,000 cubic feet. Further, the shipyards shipped approximately 1,100 cubic feet of mixed waste for disposal in accordance with approved Site Treatment Plans under the Federal Facility Compliance Act.

STEP 2:
CONDUCTING SURVEYS AND OBTAINING SOLID MATERIAL SAMPLES OF DESIGNATED AREAS TO VERIFY THE REMOVAL OF ALL PROGRAM RADIOACTIVITY

Surveys began after the shipyards removed all known radioactive material and equipment. Although radioactive work was mostly limited to two major facilities in each shipyard, a large number of facilities (including outside areas) were surveyed to verify there was no radioactivity above Program limits.

The shipyards placed work areas, rooms, piers, drydocks, and roads into various survey groups based on their radiological history and the potential for finding Program radioactivity. Surveys focused more extensively on areas with the highest potential for finding Program radioactivity. For example, the shipyards divided areas with the highest potential into 3 foot by 3 foot grids, while dividing areas with a very low potential into 20 foot by 20 foot grids.



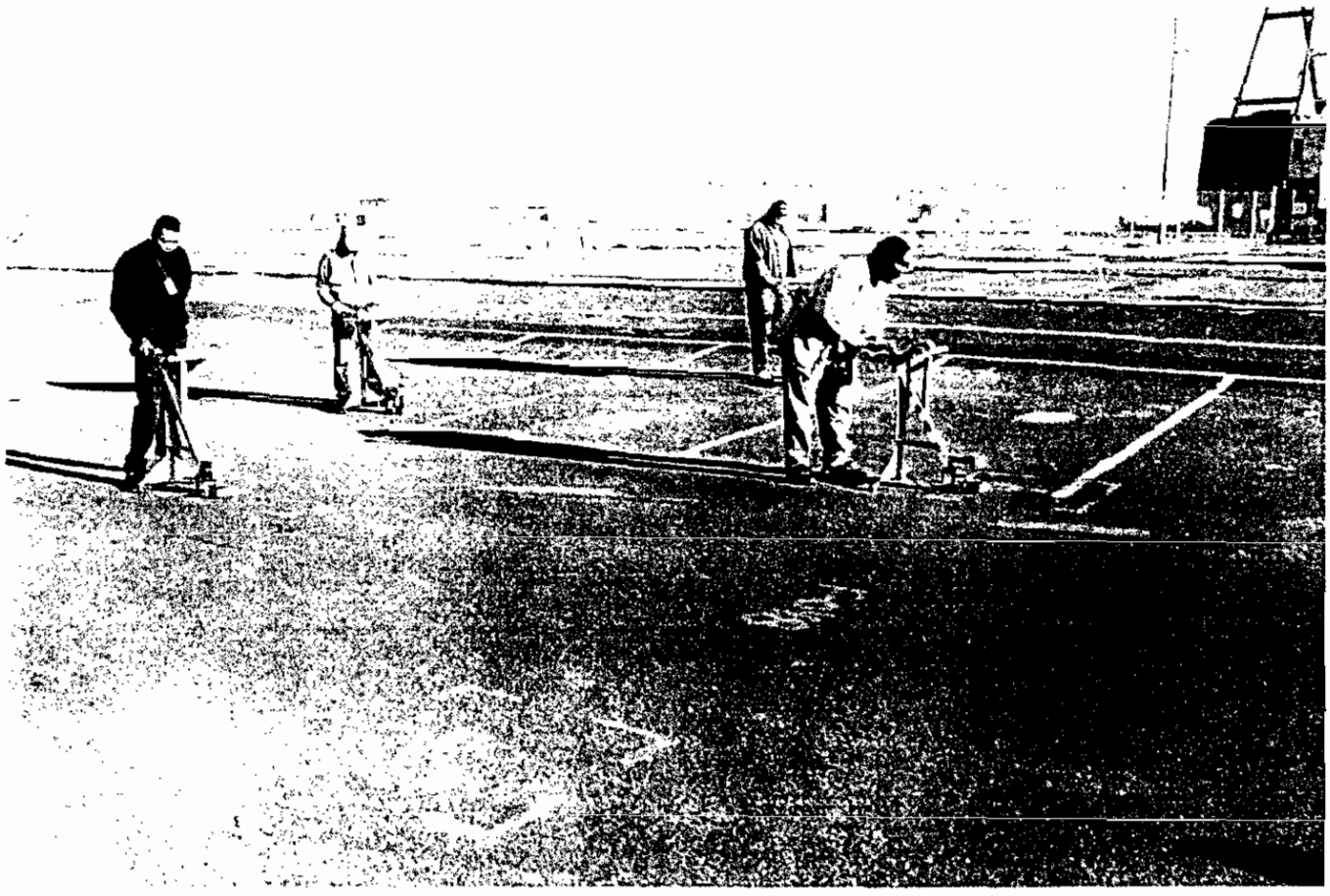
Personnel Surveying inside Building 271 (Radiological Work Facility) at Mare Island Naval Shipyard

The detailed radiological survey plans contained the criteria for the extent of survey and solid material sampling for each group.

The shipyards prepared detailed engineering instructions for all work performed. These instructions specified grid patterns, surveys, and sampling locations. Also, procedures specified solid sample handling and counting methods and necessary documentation for the final release reports. All closure work was performed using the same rigor as other Program maintenance and repair work.

As the shipyards cleared areas of radioactive material and equipment, the areas were gridded with designated markings according to the detailed engineering instructions. The shipyards surveyed each grid and took and counted the requisite solid samples for radioactivity using sensitive laboratory instruments. The shipyards used the following instruments to accomplish these surveys and analyze solid material samples:

- Sensitive beta/gamma detection instrument using a flat, thinly shielded Geiger-Müller probe. The shipyards selected this instrument based on its capability to detect low levels of cobalt-60 radioactivity.



Personnel Performing Surveys at Mare Island Naval Shipyard

- Sensitive gamma scintillation detector. The shipyards selected this instrument based on its capability to detect low levels of cobalt-60 radioactivity and versatility in detecting other radioactive isotopes.
- Sensitive alpha survey detector for areas where alpha sources were stored.
- Vault counter system with a multi-channel analyzer. The minimum detectable activity achieved for solid material samples was less than 0.25 pCi/gram.
- Isotopic analysis counting system with a gamma spectroscopy workstation connected to a high purity germanium detector. The minimum detectable activity achieved for solid material samples was less than 0.25 pCi/gram.

Each shipyard surveyed more than 5,000,000 square feet and took more than 40,000 solid samples. The cost of the survey effort at each shipyard was about $26 million. There were a few localized areas where radioactivity was detected above Program limits and remediation was performed. Remediation involved removal and proper disposal of the radiologically contaminated surface material and then re-survey and re-sampling of the affected area to ensure the radioactivity had been removed. Less than 0.2% of the area surveyed required remediation. The estimated total amount of Program radioactivity removed from remediated areas at each shipyard was about as much radioactivity as in one household smoke detector (2-3 microcuries).

STEP 3: DOCUMENTING THE RESULTS OF SURVEYS AND OBTAINING STATE AND FEDERAL ENVIRONMENTAL REGULATORY AGENCIES' AGREEMENT THAT THE AREA WAS RELEASABLE FOR CIVILIAN USE

As surveys were completed, the shipyards prepared individual release reports for each area to document the results and support unrestricted release for civilian use. Naval Nuclear Propulsion Program headquarters reviewed and approved these individual reports. The shipyards forwarded the approved reports to the States of South Carolina and California and the cognizant Environmental Protection Agency regions for review. The Navy resolved all comments, and the States and local Environmental Protection Agency regions performed independent overcheck surveys. The agencies agreed with the Navy's conclusion that each area could be released for unrestricted civilian use with respect to Program radioactivity. For future reference, each shipyard combined its individual reports into a single comprehensive report (references 6 and 7) which formally documents the results of the release surveys.

Charleston and Mare Island worked closely with the state and federal environmental regulatory agencies throughout the closure process. The shipyards kept the local communities involved and informed of the closure process through Restoration Advisory Boards established under Environmental Protection Agency and Department of Defense guidelines.

Charleston and Mare Island Naval Shipyards closed as scheduled on April 1, 1996. Before closure of each of these shipyards, the state and federal environmental regulatory agencies agreed that all facilities at the shipyard were acceptable for release to the local community for unrestricted use with respect to Naval Nuclear Propulsion Program radioactivity.

Drydock 2 at Charleston Naval Shipyard Being Used by the Local Community

5.0 CONCLUSIONS

This overview of the nuclear closure of Charleston and Mare Island Naval Shipyards demonstrates that the facilities used to maintain and repair Naval nuclear-powered ships can be decommissioned and released for unrestricted public use with reasonable effort and cost and within a short period of time. The Naval Nuclear Propulsion Program's strict control of radioactivity is the basis for this achievement. The closure process involved straightforward planning and engineering, using off-the-shelf technology. The cooperation and support from the States of South Carolina and California, and from the local regions of the Environmental Protection Agency, were major elements in successfully completing this process on schedule and within budgeted costs.

Aerial View of Charleston Naval Shipyard

6.0 REFERENCES

(1) U.S. Navy Report, "The United States Naval Nuclear Propulsion Program," June 1996

(2) U.S. Navy Report, "Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities-1995," J. J. Mangeno, J. M. Steele, and K. C. Bernhardt, NT-96-1, March 1996

(3) U.S. Navy Report, "Occupational Radiation Exposure from U.S. Naval Nuclear Propulsion Plants and Their Support Facilities-1995," J. J. Mangeno and C. W. Burrows, NT-96-2, March 1996

(4) Historical Radiological Assessment, Charleston Naval Shipyard, February 1996

(5) Historical Radiological Assessment, Mare Island Naval Shipyard, March 1996

(6) Naval Nuclear Propulsion Program Radiological Final Report for the Decommissioning of Charleston Naval Shipyard, 1 April 1996

(7) Naval Nuclear Propulsion Program Radiological Final Report for the Decommissioning of Mare Island Naval Shipyard, 1 April 1996