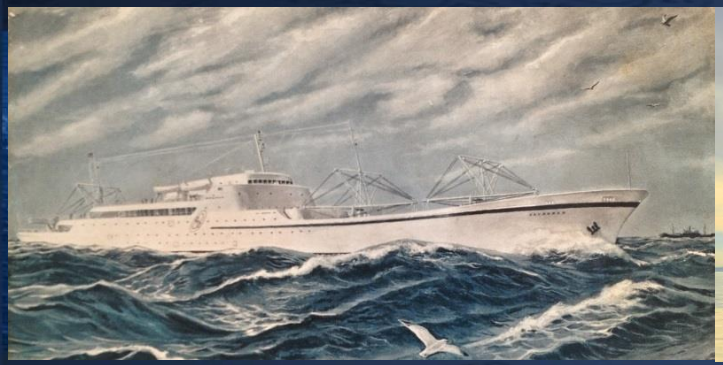

N.S. *SAVANNAH*
License Termination Plan Meeting #3
Dose Modeling Workshop

November 17, 2021

Erhard W. Koehler
Senior Technical Advisor, NS *SAVANNAH*
Maritime Administration

1200 New Jersey Ave, SE | Washington | DC 20590 -0001
www.dot.gov

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Agenda

- **Introductions**
- **Recap of June 30, 2021, LTP Pre-submittal meeting #2**
- **Project Update**
- **Status of LTP Development**
- **Discussion of Dose Modeling**
  - End-State Objectives and Considerations
  - Characterization
  - Parameter Assumptions and Resulting DCGLs
- **Summary and Closing**
- **Next Steps**

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Introductions

- MARAD and Contract Staff
- NRC staff

Meeting Purpose

The N.S. *SAVANNAH* decommissioning is unique in that it seeks to preserve as much historic fabric of the facility as practicable, with as many SSCs installed as allowed by the NRC's decommissioning process.

The purpose of this presentation is show how we plan to make that possible.

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Recap of June 30, 2021 Meeting

- Provided update from November 2019 mtg # 1
- Discussed Administrative Matters
  - LTP to be submitted as LAR vice UFSAR Supplement
  - No partial submission / early chapter review
- Discussed End-State Scenarios and Systems Proposed to Remain
  - Office Worker (Preservation) vs Shipbreaking
  - CV, CRDM Tower, Steam Generators, DB Waste Tanks
- Discussed LTP Process Tools developed by MARAD
  - High interest in LTP Acceptance Review Criteria Matrix
- Described Plans for Dose Modeling and Final Status Surveys

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Project Update

- **Mobilization and Outfitting Complete**
  - Large Personnel and Material Handling Access provided between RCLL and CH 4 Tank Top
  - Solid and Liquid Waste Handling Systems Installed
  - Revised RCA Boundaries in-effect
- **Dismantlement in-Progress inside CV**
  - Small bore piping; electrical and ventilation ductwork; other interference removals – to end of CY 2021
- **Advance Planning for Next Steps**
  - NST, CRDM Tower, RPV removal; Pressurizer
  - Solid and Liquid Waste Transfers early 2022.
- **Monthly Status Meetings with NRC**

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Status of LTP Development

- **Completed Remaining Process Tools**
  - **CR-127, LTP RAI Process**
  - **CR-128, LTP Acceptance Criteria Review**
- **Submitted Updated PSDAR Schedule**
  - **LTP Submittal Anticipated July 2022**
- **Developed Dose Modeling and Draft DCGLs**
- **Chapters continue to be developed**

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Status of Developing LTP Chapters

- Chapter 1: >90% Complete
- Chapter 2: >85% Complete
- Chapter 3: 50% Complete
- Chapter 4: 50% Complete
- Chapter 5: 50% Complete
- Chapter 6: 5% Complete
- Chapter 7: Not Started
- Chapter 8: Not Started
- Chapter 9: 95% Complete

Dose Modeling

- **End-State Objectives and Considerations**
  - MARAD expects and is striving for unrestricted license termination.
  - NSS is a National Historic Landmark (NHL) and Signature Remnant of the Atoms for Peace Program.
  - As an NHL, it is important to Maintain the Physical Integrity of NSS.
  - NSS is a site where keeping as many structures, systems and components (SSCs) - as possible - in their original configuration has public value if the ship is preserved.
  - Consistent with being an NHL, MARAD hopes to provide for future use of the site.
- **Parameter Assumptions and Resulting DCGLs**
  - No Groundwater or Soil
  - Significant Decay Time from 1970
  - No Interim Nuclear Fuel Storage on Site

Dose Modeling Considerations
NSS Disposition Alternatives (After LT)

- **Preservation:**
  - Any prospective use of the ship that involves unrestricted public access (museum, conference center, entertainment venue or educational facility) – the “Office Worker” scenario from Mtg #2.
  - Preservation scenarios are not indefinite, and will at some future date result in shipbreaking
- **Shipbreaking**
  - At the end of the life of the ship, the process by which the steel structure is broken down and recycled.
  - Results in the destruction of the site.
  - Shipbreaking will be performed by MARAD through its Ship Disposal Program.

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Dose Modeling Overview

- Identify potentially exposed individuals in the preservation and shipbreaking scenarios, and eliminate insignificant exposure scenarios
- Identify radionuclides remaining on the ship
- Select exposure parameters and models for each scenario
- Calculate effective dose rate coefficient factors in mrem/y per dpm/cm^2
- Calculate DCGLs based upon release criteria

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Preservation Exposure Scenarios			
Ship Status	**Description**	**Exposed Individual**	**Significance**
Preservation	Office Worker/Tour Guide	Adult Worker	Significant
Preservation	Housekeeping	Adult Worker	Insignificant
Preservation	Minor repairs/ maintenance	Adult Worker	Insignificant
Preservation	Tours and meetings on ship	Members of the Public	Insignificant

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Shipbreaking Exposure Scenarios			
Ship Status	**Description**	**Exposed Individual**	**Significance**
Pre-Shipbreaking	Housekeeping	Adult Worker	Insignificant
Pre-Shipbreaking	Minor repairs/ maintenance	Adult Worker	Insignificant
Shipbreaking	Remediation of hazardous materials on ship	Adult Worker	Significant
Shipbreaking	Component removal/metal cutting on ship	Adult Worker	Significant
Shipbreaking	37 steel scrap recycling and reuse scenarios defined in NUREG-1640	Adult Worker	Significant

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Identify Radionuclides - Characterization Surveys

- A significant characterization effort was undertaken in 2019 in the Reactor Compartment (RC) and Containment Vessel (CV)
- Thousands of measurements were obtained
- Composite smears from the most contaminated locations and systems were obtained.
- Twelve (12) locations were sent for offsite analysis for gamma spectrometry. Five (5) of those samples were also analyzed for Hard to Detect (HTD) radionuclides.

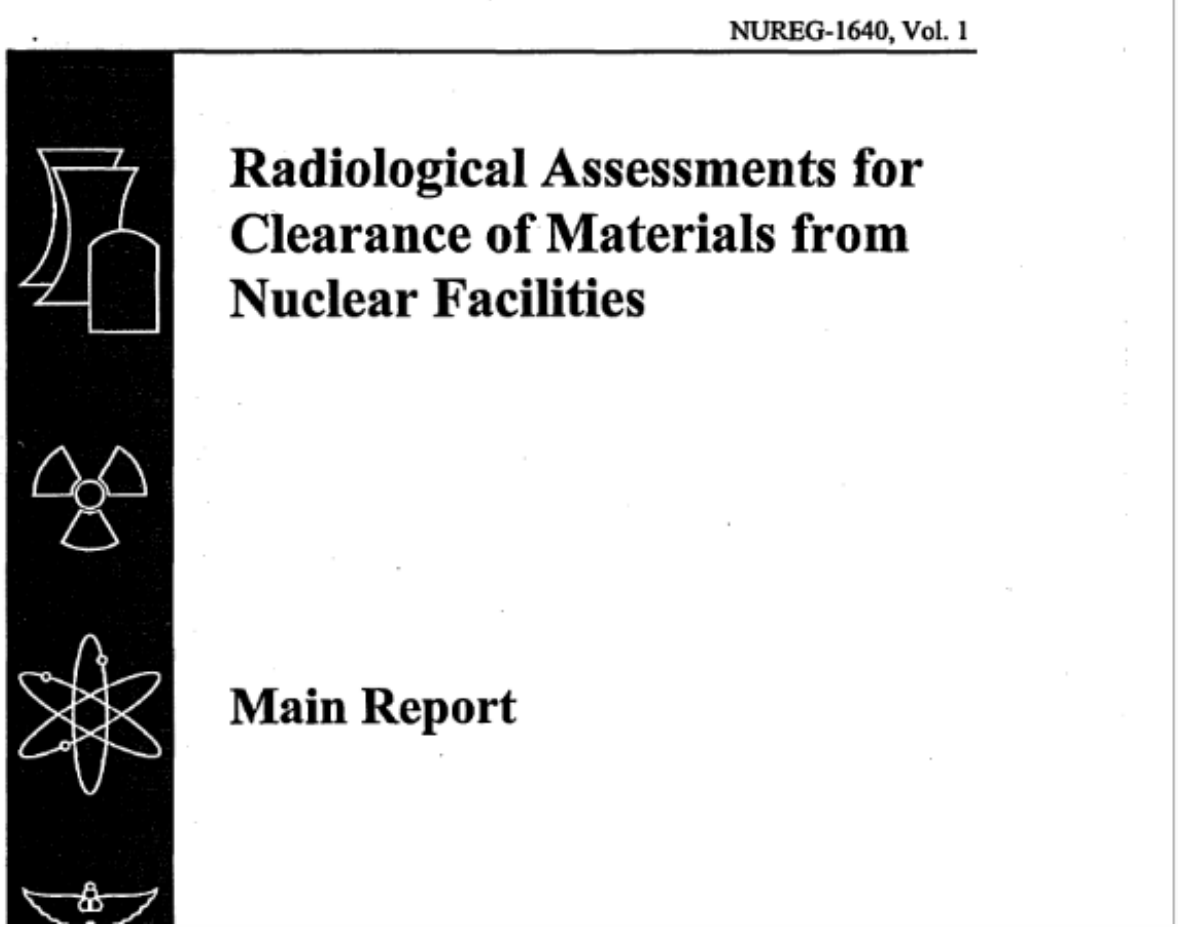
Characterization - Smear Locations for HTD Analyses

- **Locations selected because of high gamma activity that are most likely to have detectable HTD radionuclides**
- **Locations of composite smears for Hard to Detect (HTD) radionuclide analyses**
  - Ion Exchange Piping
  - Containment Drain Tank PD-T4
  - Pressurizer
  - Steam Generator
  - Ventilation System

Characterization - Radionuclides Identified

- **Positively Identified Radionuclides from the Offsite Analyses of the Composite Smears**
  - C-14
  - Co-60
  - Ni-63
  - Sr-90
  - Tc-99
  - Ag-108m
  - Cs-137
- Note: H-3 detected in several water and sludge samples. Water and sludge will be removed during decommissioning.

Steel Scrap Recycling Scenarios



NUREG-1640, Vol. 1

Radiological Assessments for Clearance of Materials from Nuclear Facilities

Main Report

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Steel Scrap Recycling Scenarios

- **37 Scenarios Evaluated in NUREG-1640**
  - Handling and Processing (7 scenarios)
  - Transportation (5 scenarios)
  - Product Use (12 scenarios)
  - Landfill Disposal (7 scenarios)
  - Groundwater Leachate (5 scenarios)
  - Atmospheric Release (1 scenarios)
- **Evaluations based on some of the steps that would most likely be involved in recycling scrap into consumer or industrial products, or in disposing of this scrap in an industrial or municipal landfill.**

Steel Scrap Recycling Scenarios – NUREG 1640

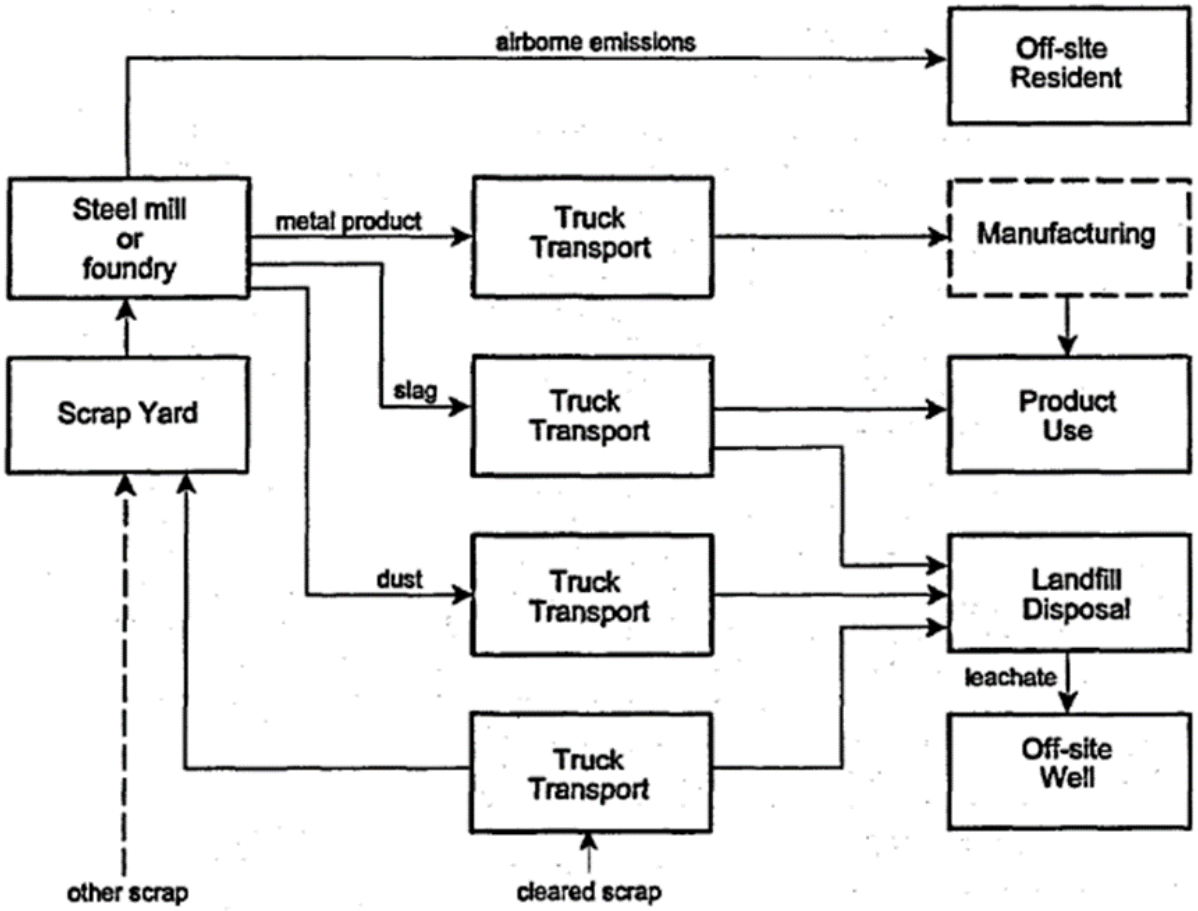

Figure 3.1 Flow of steel scrap

NUREG-1640 Recycling / Disposal of Steel Scrap

- **Normalized surficial effective dose rates to critical groups for steel are presented in Table 3.24**
- **Four values presented**
  - Mean, 5th, 50th and 95th percentiles
- **Chose the most conservative 95th percentile for the effective dose rate coefficient for evaluations**

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Preservation Dose Modeling – Significant (*Office Worker / Tour Guide*)

- Model built in RESRAD-Build Version 3.5
- Assumed similar size to CV
- Assumed 5 large area sources (5m radius) in the 4 walls and floor
- Receptor standing on the floor source
- Assumed areal activity of each source at 1 dpm/m^2
- Assumed 2000 hours occupancy
- Annual calculated dose includes external, inhalation and ingestion

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Shipbreaking Dose Modeling – Significant (*Remediation & Component Removal Workers*) External Exposure Model

- Model built in MicroShield Version 8.03
- Used the cylinder surface geometry. Created 2”, 4” and 12” diameter Schedule 40 pipe geometries, 10’ long with dose point at 3’ from center
- Assumed areal activity of each source at 1 Bq/cm^2 on the inside of the pipe
- Multiplied the highest (12” diameter) Antero-posterior effective dose coefficient by 2
- Assumed 2000 hours occupancy

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Shipbreaking Dose Modeling – Significant (*Remediation & Component Removal Workers*) Internal Exposure Model

- **Used same equations in NUREG-1640**
  - Modified to obtain dose rates, convert gm to cm^2 and for varying surface contamination levels
- **Used same inhalation and ingestion dose coefficients in NUREG-1640**
- **Used same breathing rates, secondary ingestion rates and same distributions in NUREG-1640**
- **Assumed 2000 hours occupancy**

DCGL Calculations - Remediation and Component Removal Workers

- **Used a computerized risk analysis modeling tool, "ModelRisk 4.0", developed by Vose software**
- **This analysis tool is a 3rd party add-on to Microsoft's Excel spreadsheet program**
- **This tool allows for a variety of analysis and distribution propagations including:**
  - Monte Carlo Simulations of the sampling and propagation of a variety of distributions,
  - Correlations of parameter values from data sets,
- **Each simulation set was run with 10,000 iterations**
- **Chose the 95th percentile for the effective dose rate coefficient for evaluations**

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The surficial effective dose rate coefficients in mrem/y per dpm/cm^2

Radionuclide	Tour Guide	Comp Removal Worker	Remediation Worker	NUREG-1640 Table 3.24	Maximum	Source of Maximum
Ag-108m	2.42E-10	2.20E-04	8.78E-05	3.42E-02	3.42E-02	NUREG-1640 Table 3.24
C-14	2.60E-12	2.22E-05	1.63E-05	2.48E-05	2.48E-05	NUREG-1640 Table 3.24
Co-60	3.15E-10	2.05E-04	9.86E-05	6.31E-02	6.31E-02	NUREG-1640 Table 3.24
Cs-137	1.03E-10	4.66E-04	3.71E-04	1.49E-02	1.49E-02	NUREG-1640 Table 3.24
Ni-63	8.38E-13	4.21E-06	2.65E-06	4.50E-07	4.21E-06	Comp Removal Worker
Sr-90	8.35E-11	6.22E-04	5.43E-04	3.60E-05	6.22E-04	Comp Removal Worker
Tc-99	5.21E-12	4.21E-05	2.25E-05	4.50E-03	4.50E-03	NUREG-1640 Table 3.24

Proposed DCGLs

Nuclide	Maximum (mrem/y per dpm/cm²)	25 mrem/y (dpm/100 cm²)
Ag-108m	3.42E-02	7.30E+04
C-14	2.48E-05	1.01E+08
Co-60	6.31E-02	3.96E+04
Cs-137	1.49E-02	1.68E+05
Ni-63	4.21E-06	5.94E+08
Sr-90	6.22E-04	4.02E+06
Tc-99	4.50E-03	5.55E+05

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Discussion Period

Questions

Comments

Closing and Summary

Next Steps