Historical Site Assessment of Area IV
Santa Susana Field Laboratory
Ventura County, California

Volume 1 – Methodology

Prepared by Sapere Consulting, Inc. and
The Boeing Company for the Department of Energy
Under Contract DE-AC03-99SF21530

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Executive Summary

This Historical Site Assessment (HSA) is developed to summarize the operational history of Area IV for both the Department of Energy (DOE) and The Boeing Company (Boeing) from a radiological perspective. This activity is undertaken to identify areas of radiological operations, compile prior radiological cleanups and releases and to identify further actions needed to ensure that the radiological cleanup of Area IV is completed.

Nuclear-related operations were conducted at Santa Susana Field Laboratory (SSFL) Area IV from 1953 until 1988, with non-nuclear operations continuing through 1998. The DOE has focused on completing radiological cleanup since 1989. Over the period of Area IV operations, buildings and land in the radiological areas have been decommissioned, and if necessary, remediated, surveyed, verified and released for reuse by the appropriate regulatory agency (i.e., Energy Research and Development Administration (ERDA), DOE, Nuclear Regulatory Commission (NRC) and the California Department of Health Services (DHS)). Buildings and soil have been decommissioned and released using appropriate regulatory standards as authorized by Congress and the State of California.

Based on this history, portions of Area IV have been identified as *radiologically impacted*[1] or *radiologically non-impacted*,[2] consistent with applicable California[3] and Federal[4] regulations, and based on guidance from the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

The DOE and Boeing evaluated 272 numbered structures (collectively referred to as "sites")[5]and any other areas of radiological contamination that existed in Area IV since its establishment in 1953. This was to ensure all areas where any types of operations were performed in Area IV were evaluated for radiological impact.

To evaluate each site, a site summary was prepared using operational records, incident reports, site maps, decommissioning reports and personnel interviews. The site summaries include information about historical and current use and any information about the management and use of regulated radiological materials at the site. Volume 2 of the Area IV HSA contains all the site summaries that were developed.

Based on the information presented in the site summaries, all sites were classified either as radiologically impacted or non-impacted. Sites that had any indication of management or use of regulated radiological material were classified as impacted. All impacted sites were further

[1] "Radiologically impacted" sites are those with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout levels.
[2] "Radiologically non-impacted" sites as those where there is no reasonable possibility (extremely low probability) of residual contamination.
[3] State of California Regulations (Title 17, Sections 30253 and 30256(k)(3)
[4] Code of Federal Regulations (10CFR20.1501) and DOE Order 5400.5
[5] Boeing and its predecessors assigned a unique number to each engineered item (e.g., building, electrical substation, guard shack, parking lot, lean-to, etc.) within Area IV. By defining a site as a numbered structure and its associated areas, the Area IV HSA is a temporally comprehensive evaluation of Area IV from its initial development to the present.

evaluated to determine if the site had been released for unrestricted use by the appropriate regulatory agency. Sites that had been released went through a decision process to determine if additional soil surveys were necessary.

Impacted sites which have not been released were classified consistent with MARSSIM guidelines based on the degree of radiological impact. The three classifications of radiological impact were defined as:

- Class I sites potentially have or had radioactive contamination above the Derived Concentration Guideline Levels (DCGLs), i.e., release criterion.
- Class II sites potentially have or had radioactive contamination below DCGLs, but above 20% of the DCGLs.
- Class III sites potentially have or had radioactive contamination above background but below 20% of DCGLs.

As Area IV continues to undergo cleanup and remediation, the DOE is using the Area IV HSA to ensure all the sites in Area IV have been reviewed for potential radiological impacts and all impacted areas have been either:

- Surveyed and released and require no further action, or
- Identified as impacted and have not been released.
    - These sites require further action, per their MARSSIM classification.

Evaluations performed for the 272 sites in Area IV determined a total of 95 sites were distinguished as impacted or potentially impacted by radiological materials. Of the 95 impacted or potentially impacted sites, 68 have been previously released by the appropriate agency and require no further action, 27 sites require additional actions.

The review of historical activities involving radioactive materials within the Santa Susana Field Laboratory Area IV is documented in this HSA to assist in determining what actions are necessary to allow for the future unrestricted use of the site. This document represents an important step toward ensuring the radiological cleanup of Area IV is completed using the accepted regulatory processes.

SANTA SUSANA FIELD LABORATORY
AREA IV
HISTORICAL SITE ASSESSMENT

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Acronyms and Abbreviations

Acronym	Meaning
AEA	Atomic Energy Association
AEC	Atomic Energy Commission
AERD	Atomic Energy Research Department
AETR	Advanced Epithermal Thorium Reactor
AI	Atomics International
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
ARAR	Applicable or Relevant and Appropriate Requirement
ASER	Annual Site Environmental Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Contaminant of Concern
D&D	Decontamination and Decommissioning
DCC	Dose Compliance Concentration
DCGL	Derived Concentration Guideline Level
DHS	(California) Department of Health Services
DHS-EMB	Department of Health Services, Environmental Mgmt. Branch
DHS-RHB	Department of Health Services, Radiologic Health Branch
DOD	(United States) Department of Defense
DOE	(United States) Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
EPA-ORIA	EPA, Office of Radiation and Indoor Air
ERDA	Energy Research and Development Administration
ETEC	Energy Technology Engineering Center
FFTF	Fast Flux Test Facility
FSDF	Former Sodium Disposal Facility
GRC	Groundwater Resources Corporation
HA	Haley and Aldrich
HEPA	High-Efficiency Particulate Air
HMRFSR	Heavy Metal Reflected Fast Spectrum Reactor
HSA	Historical Site Assessment
KEWB	Kinetics Experiment Water Boiler
LLNL	Lawrence Livermore National Laboratory
LMEC	Liquid Metal Engineering Center
LMIC	Liquid Metal Information Center
LMFBR	Liquid Metal Fast Breeder Reactor
LMR	Liquid Metal Reactor
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MOU	Memorandum of Understanding
NAA	North American Aviation

Acronym	Meaning
NaK	Sodium Potassium Alloy
NMDF	Nuclear Materials Development Facility
NPDES	National Pollutant Discharge Elimination System
NRC	(United States) Nuclear Regulatory Commission
OCY	Old Conservation Yard
OMR	Organic Moderated Reactor
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
POTW	Publicly Owned Treatment Works
PRG	Preliminary Remediation Goal
R&D	Research and Development
RESRAD	Residual Radioactivity
RHB	(California) Radiologic Health Branch
RMHF	Radioactive Materials Handling Facility
ROC	Radionuclide of Concern
RSRMS	Radiation Safety Records Management System
RWQCB	Regional Water Quality Control Board
S2ER	SNAP 2 Experimental Reactor
S2DR	SNAP 2 Demonstration Reactor
S8DR	SNAP 8 Development Reactor
S8ER	SNAP 8 Experimental Reactor
S10FS	SNAP 10 Flight System Reactor
SER	SNAP Experimental Reactor
SGR	Sodium Graphite Reactor
SNAP	Systems for Nuclear Auxiliary Power
SRE	Sodium Reactor Experiment
SSFL	Santa Susana Field Laboratory
STIR	Shield Test and Irradiation Reactor
STR	Shield Test Reactor
UMTRA	Uranium Mill Tailings Remedial Action
WBNS	Water Boiler Neutron Source

Units

Unit	Meaning
cm	centimeter
cpm	counts per minute
cts/min	counts per minute
degrees F	degrees Fahrenheit
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
gm	gram
kWth	kilowatt thermal
mg/cm^2	milligrams per square centimeter
µCi	microcurie
$µCi/cm^3$	microcuries per cubic centimeter
µCi/ml	microcuries per milliliter
µrad/hr	microrad per hour
µR/hr	microroentgen per hour
mCi	millicuries
mrem/hr	millirem per hour
mrem/yr	millirem per year
MWth	megawatts
pCi/cc	picocuries per cubic centimeter
pCi/g	picocuries per gram
pCi/L	picocuries per liter
sq ft	square feet

Section 1.0 – Introduction

1.0 Background

The SSFL is located in eastern Ventura County, California, and borders Los Angeles County.[1] The SSFL is 2,850 acres and divided into four administrative and operational portions based on ownership and operations and two non-industrial portions (i.e., undeveloped sites); Area IV is the 290-acre westernmost administrative and operational portion (Figure 1-1).

A broad range of energy-related research, testing and development projects have been conducted at Area IV. From the 1950s until the late 1980s these activities conducted for the DOE by Atomics International (AI)[2] included nuclear power development. Phasing out nuclear operations began during the mid-1960s. By 1988 all nuclear reactor operations in Area IV had ceased[3].

As Area IV continues to undergo cleanup and remediation, the DOE is using the Area IV HSA to ensure all the sites in Area IV have been reviewed for potential radiological impacts and all impacted areas have been either surveyed and released, or identified with the remaining work to be completed.

1.1 Area IV HSA Purpose

The overall purpose of the Area IV HSA is to identify any potential areas of radiological contamination. These sites have been identified using historical information about operations and programs in Area IV. As a result of the identification process, the Area IV HSA is a compendium of previous information that had been provided on a facility-by-facility basis (e.g., demolition reports, final status surveys) and other site-wide information collection efforts (e.g., Area IV Characterization Survey) conducted previously.

The specific objectives of the Area IV HSA are as follows:

[1] Santa Susana Field Laboratory is located in the south-easterly region of Ventura County, State of California, being a portion of Tracts A and P of the Rancho Simi, and portions of Sections 19, 20, 21, 28, 29, 30, 31, 32 and 33, Township 2 North, Range 17 West, San Bernadino Base Line and Meridian; and portions of Sections 25 and 36 Township 2 North, Range 18 West, San Bernadino Base Line and Meridian.

[2] AI was a discrete division of the North American Aviation (NAA) from 1955 to 1984. In 1984, Rocketdyne, a division of Rockwell, absorbed AI. Boeing subsequently purchased Rockwell in 1996, and Rocketdyne remains a division of Boeing.

[3] Nuclear support operations ended in 1996, with the exception of the Radioactive Materials Handling Facility (RMHF). The RMHF is designated as a radiological facility and remains operational as part of ongoing cleanup activities to provide chemical and radiological waste treatment and packaging for off-site disposal.

- Identify potential, likely, or known sources of regulated radiological material or contamination based on the operational history of Area IV. This includes a comprehensive review of all sites that exist or have existed in Area IV. This is summarized in Section 2.0-Area IV History, and detailed in Volume 2, Area IV Site Summaries.
- Describe the methodology used to evaluate sites to assess the need for further action, including assessment for likelihood of contaminant migration, development of DCGLs (i.e., the release criterion), and background data set. This information is provided in Section 3.0- Area IV HSA Methodology.
- Provide classification of sites as radiologically impacted[4] or non-impacted.[5] These classifications are based on guidance from MARSSIM, NUREG 1.86 and DOE Order 5400.5 (Reference 6 and 12). This information is provided in Section 4.0-Results.
- Provide release status of impacted sites, and MARSSIM classification of impacted sites not yet released. This information is provided in Section 4.0-Results.

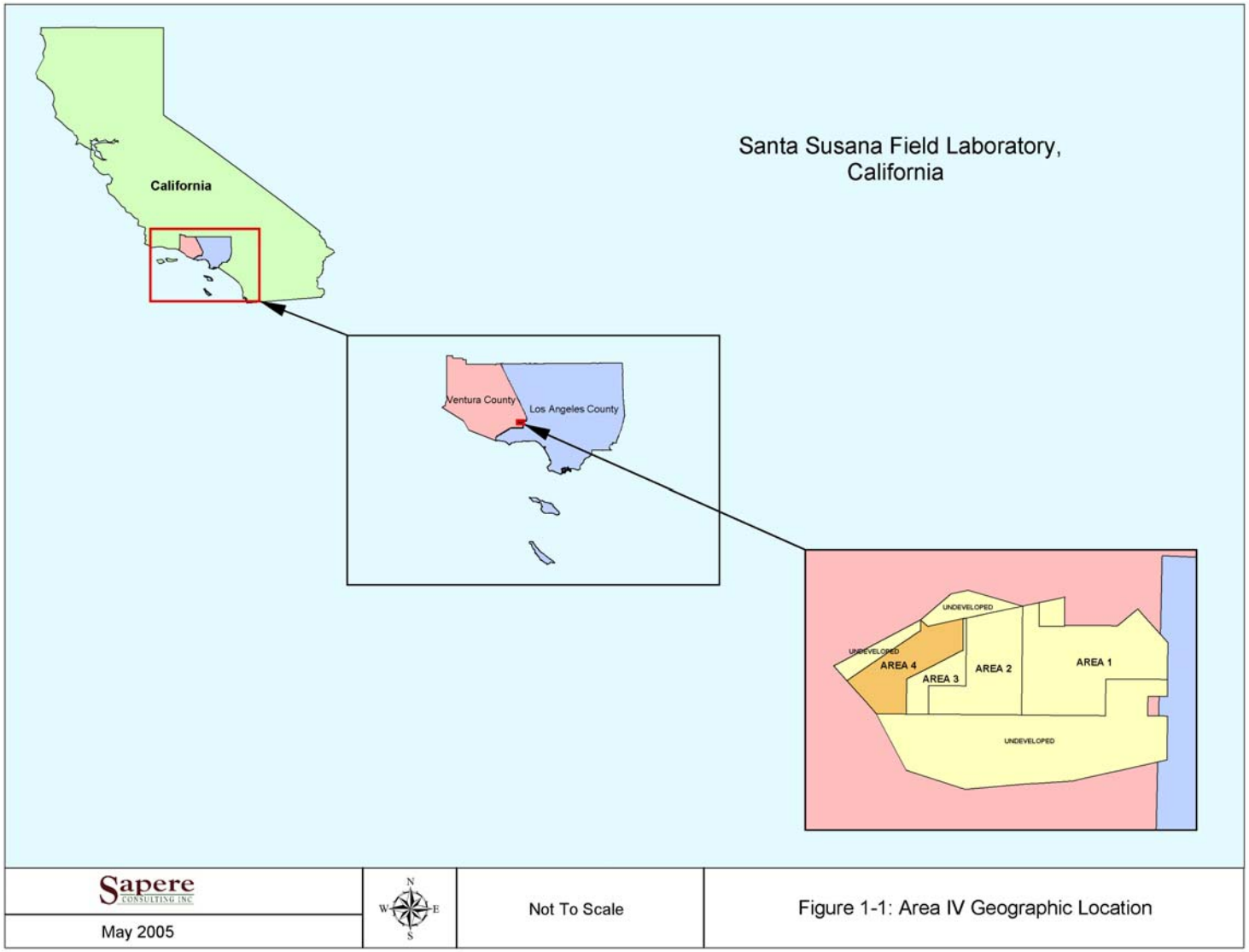
1.2 Multi-Agency Radiation Survey and Site Investigation Manual Overview

The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) was developed collaboratively by the four federal agencies that have primary responsibility for controlling radioactive materials—the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Department of Defense (DOD). It provides detailed guidance for planning, implementing and evaluating environmental and facility radiological surveys conducted to demonstrate compliance with a dose- or risk-based regulation (Reference 12). The guidance was developed for surveys of building surfaces and surface soils. The MARSSIM process consists of four general phases: Site Identification, Site Characterization, Site Remediation and Site Release.

A Historical Site Assessment (HSA) is used to document the results of the first MARSSIM phase, Site Identification. The HSA is an investigation to collect information describing a site's history from the start of site activities to the present time.[6] The purpose of the HSA is to identify potential, likely or known sources of radioactive material and radioactive contamination based on operational information and provide initial classification of the site

[4] These guidelines suggest "radiologically impacted" sites are those with a reasonable possibility of containing residual radioactivity in excess of natural background or fallout levels.
[5] These guidelines suggest "radiologically non-impacted" sites are those where there is no reasonable possibility (extremely low probability) of residual contamination.
[6] MARSSIM defines a site as "any installation, facility, or discrete, physically separate parcel of land, or any building or structure or portion thereof, which is being considered for survey and investigation." At Area IV a "site" refers to any numbered structure.

Figure 1-1. SSFL and Area IV Location Map



as impacted or non-impacted. Impacted sites are further divided into three classifications, Class I, Class II or Class III. The classification process is used to place more rigorous survey efforts on sites that have the highest potential for contamination. Class I sites have the greatest potential for contamination based on the quantity of radioactive materials used and therefore receive the most rigorous survey effort. Non-impacted areas do not receive any level of survey coverage.

The classification process considers the possibility that adjacent areas, including soil, may be impacted. As a part of the classification process, potentially impacted soil adjacent Class I and II sites are designated "buffer" areas. The buffer area is also surveyed to provide more assurance that radiological contamination has not spread from the impacted site to the adjacent soil (e.g., footprint or adjacent land). Buffer areas may be classified and surveyed as Class II or Class III.

The Derived Concentration Guideline Levels (DCGLs) are also established as part of the Site Identification phase. The DCGLs are constituent-specific release criteria, i.e., the maximum allowable level of residual radioactive material that can exist following remediation. All release surveys will compare measured levels of radioactivity to DCGLs to determine if the site meets release criteria.

Figure 1-2 is an overview of the MARSSIM process.

Based on the results of an HSA, impacted sites may have one or more surveys (i.e., data collection efforts) conducted to answer specific questions:

- Characterization surveys may be conducted to determine if remediation is necessary at Class I, II or III sites or adjacent soil. Characterization surveys are also conducted to help select, and also to plan remedial action necessary at an impacted site (i.e., determine nature and extent of radiological contamination).

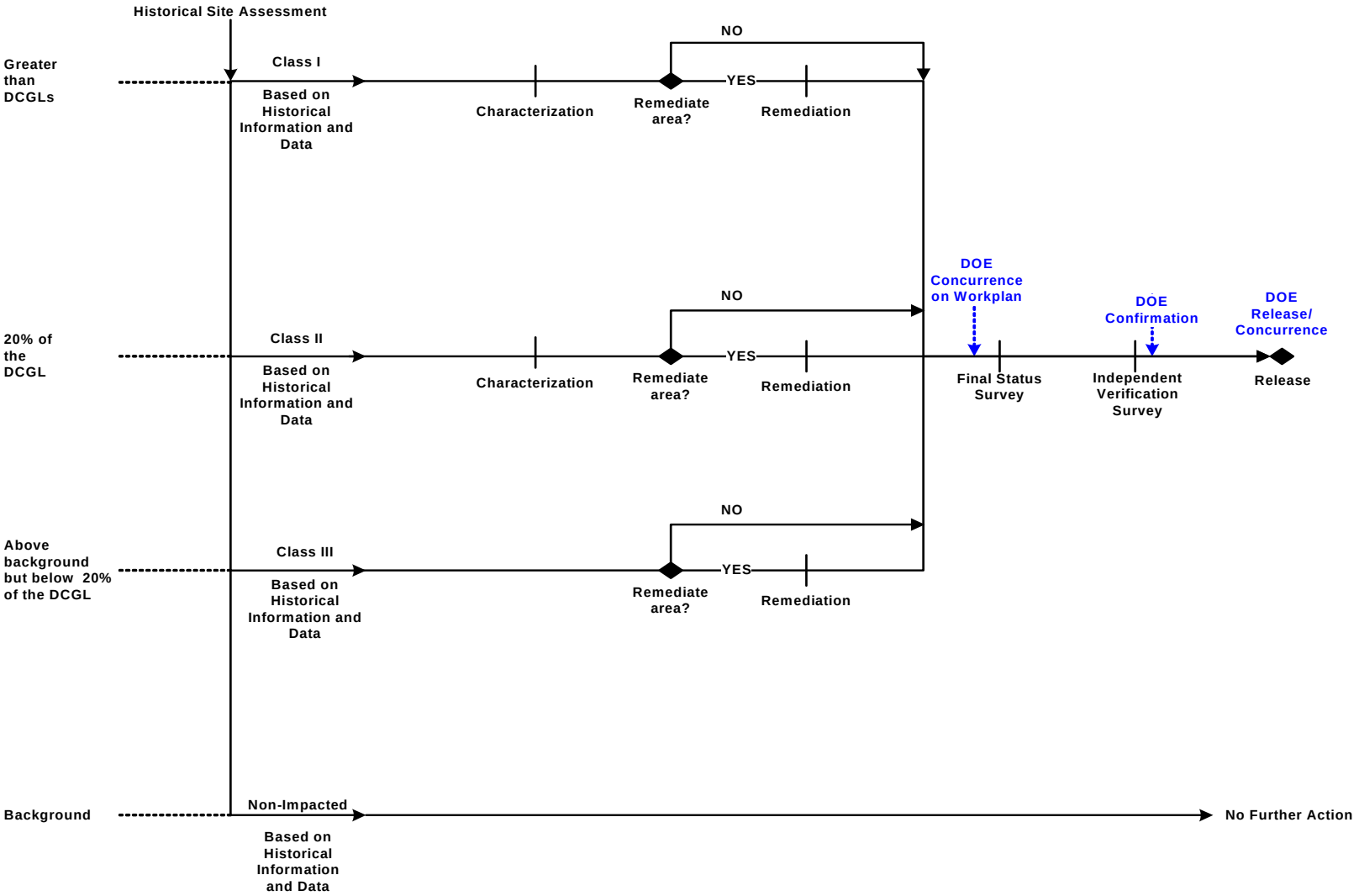
- Sites requiring remediation will often use a remedial action support survey to guide the cleanup process.

- Following any necessary remediation, the site will undergo a final status survey to determine if the site has met the DCGLs and can be released. The final status survey is used by regulatory agencies to make final release decisions.

- In addition to the final status survey, the responsible regulatory agency or an independent third party may also conduct an independent verification survey to confirm the results of the final status survey.

The MARSSIM guidance was adopted by Federal Agencies in 1998 and implemented by the DOE at the Santa Susana Field Laboratory (SSFL) in 1999.

Figure 1-2. Overview of the MARSSIM Process



1.3 Real Property Ownership

From the time of its establishment in 1953, Area IV hosted a combination of Federal Government and commercial research and development activities. The Federal Government has funded activities throughout Area IV since its establishment. Approximately 90 acres of the 290 acres in Area IV were set aside for Government-financed projects. Within this set-aside area the Government has held title to real property improvements and personal property. As a result, Area IV is a combination of Federally-owned and Boeing-owned structures, all of which reside on Boeing-owned land.

1.4 Adjacent Land Uses

Area IV is adjacent to undeveloped Boeing-owned property on the north, east and south (Figure 1-1). To the west, Area IV borders undeveloped land.

Adjacent land uses to Boeing's undeveloped areas are agricultural grazing and recreation to the west, and residential to the north, south and east.

Section 2.0 – Area IV History

2.1 Area IV Programs and Operations

Figure 2-1 summarizes the primary research and development (R&D) programs and operations conducted in Area IV.[1]

Following World War II, the potential of atomic energy captured the interest of the United States Government and many companies. This created the need for nuclear R&D facilities. North American Aviation (NAA) created the Atomic Energy Research Department (AERD) in 1948 to manage its government and commercial nuclear R&D activities.

The SSFL was initially established by the NAA in 1947 to meet the requirements for a field test laboratory to static-fire large rocket engines but also met the NAA's need for a nuclear research facility. Area IV was established at the SSFL in 1953 as a nuclear research and development facility. Since then, the SSFL has housed both nuclear development and rocket development groups, although in distinct and separate locations. The rocket development group conducted operations in the SSFL's Area I, II and III. The AERD conducted operations in the SSFL's Area IV. In December 1955, these two NAA groups were transformed into separate divisions: AI and Rocketdyne.

Several corporate mergers and organizational changes subsequently occurred. In 1967 NAA merged with Rockwell Standard to become North American Rockwell. In 1973 the corporate name changed to Rockwell International. Throughout this period AI and Rocketdyne continued to exist as independent divisions.

Two distinct groups of AI were housed in Area IV and supported by the DOE: one focused on development of civilian nuclear power, and the other was a center of excellence for research and testing of non-nuclear components related to liquid metals. These groups were referred to as AI and the Liquid Metal Engineering Center (LMEC), respectively.

The group focused on developing and commercializing reactor technology was AI. Nuclear research and development activities in Area IV increased rapidly from 1953 into the late 1960s. As time passed, nuclear R&D activities steadily declined. As a result of this decline, AI was merged into Rocketdyne in 1984.

The LMEC was created in 1966 as a government-owned, contractor-operated organization to provide development and non-nuclear testing of liquid metal reactor (LMR) components and to establish the Liquid Metal Information Center (LMIC) for the Atomic Energy Commission's (AEC's) Liquid Metal Fast-Breeder Reactor (LMFBR) Program. The LMEC was renamed the Energy Technology Engineering Center (ETEC) in 1978 to reflect the DOE's desire to broaden its mission beyond the LMFBR Program.

[1] Program duration was decided using the following criteria: beginning dates mark the earliest date the program was referenced; end dates denote reactor operation or support building activities have ceased.

Most nuclear research programs and operations ceased in 1988 and all non-nuclear research ended in 1998.[2] Beginning in the 1990s, activities in Area IV have focused on decontamination and decommissioning (D&D), and remediation. In 1996, Rocketdyne merged into The Boeing Company in a corporate acquisition of the aerospace divisions of Rockwell International.

Prior to termination of remaining research activities in 1998, three primary types of operations were conducted at Area IV summarized in the following sections:

Development and testing of nuclear reactors (Section 2.2). By 1960 eight major programs that focused on the development and testing of nuclear reactors were being conducted in Area IV. These programs were a potential source of radiological contamination in Area IV, and all eight were terminated by 1980.

Nuclear support operations (Section 2.3). Starting in 1956 several operations were conducted in Area IV to support nuclear programs. These included the manufacture, management and disassembly of fuel for reactor operations, and the operation of nuclear waste management facilities for off-site disposal. All operations – with the exception of the Radiation Materials Handling Facility (RMHF), Fuel Storage Facility, and the Radiation Instrument Calibration Laboratory – were terminated by 1988. These programs were also potential sources of radiological contamination in Area IV.

Non-nuclear energy research and development (Section 2.4). Throughout its existence, Area IV supported non-nuclear research and development programs. Primarily, these programs focused on testing liquid metal processes and developing liquid metal components (e.g., pumps, sodium water heat exchangers) and weld testing. This research supported the design of the Hallam Nuclear Power Facility, the Piqua Nuclear Power Facility, the Fast Flux Test Facility (FFTF) and the Clinch River Breeder Reactor. This research used hazardous materials such as sodium and solvents. With the exception of sealed sources used for calibration and testing,[3] radioactive materials were not handled or produced in these facilities. All programs were terminated by 1998. These programs were not sources of potential radiological contamination in Area IV.

In total, 272 sites (i.e., numbered structures[4]) were built in Area IV between 1953 and 1995. To be comprehensive, the Area IV HSA evaluated each of these numbered structures to confirm the types of operations conducted within Area IV. All current and historical operations were identified to determine areas where radiologically regulated materials were

[2] Other support operations, including the Fuel Storage Facility and the Radiation Instrument Calibration Laboratory did not cease until 1996. The RMHF is designated as a radiological facility and remains operational as part of ongoing cleanup activities to provide chemical and radiological waste treatment and packaging for off-site disposal.

[3] A sealed source is radioactive material contained in a sealed capsule, sealed between layers of non-radioactive material. The confining barrier prevents dispersion of the radioactive material. A sealed source can be a calibration source, check source, an internal standard or an irradiator.

[4] Throughout Area IV's operational history, a unique number was assigned to each engineered structure or item including parking lots, substations and buildings.

used. Volume 2 of the Area IV HSA provides a detailed description of each site.[5] Figure 2-2 provides a historical location of all 272 sites both company and government owned.

2.2 Development and Testing of Nuclear Reactors

Between 1954 and 1980, several nuclear reactors were built, tested, and operated in Area IV. These included both nuclear reactors and critical test assemblies.[6] Table 2-1 lists the specific nuclear reactor operations conducted in Area IV, the building(s) where the operation took place, time period of operations and potential radiological contaminants as a result of the operation. The potential radiological contaminants are those expected at the site as a result of the types of operations performed there. Potential contaminants vary depending on fuel type and operational power levels.

2.2.1 Nuclear Reactors

Nuclear reactor programs focused on the development and operation of homogeneous water boiler-type reactors;[7] sodium-cooled, graphite-moderated reactors and uranium-zirconium hydride reactors.

Homogeneous Water Boiler-type Reactors

These low-energy (i.e., 1 kilowatt thermal (kWth) to 3 kWth) reactors were used to conduct reactor safety tests and to train reactor operators. For fuel, the water boiler-type reactors in Area IV used a water solution of enriched uranyl sulfate.

Two water boiler reactors were located in Area IV:

The Kinetics Experiment Water Boiler (KEWB) reactor was located in Building 4073 and operated from 1956 until 1966. The KEWB reactor operated at a power production level of approximately 1 kWth.

- Removal of the fuel was completed in 1968. Decontamination and demolition activities for the KEWB reactor were completed by 1975.

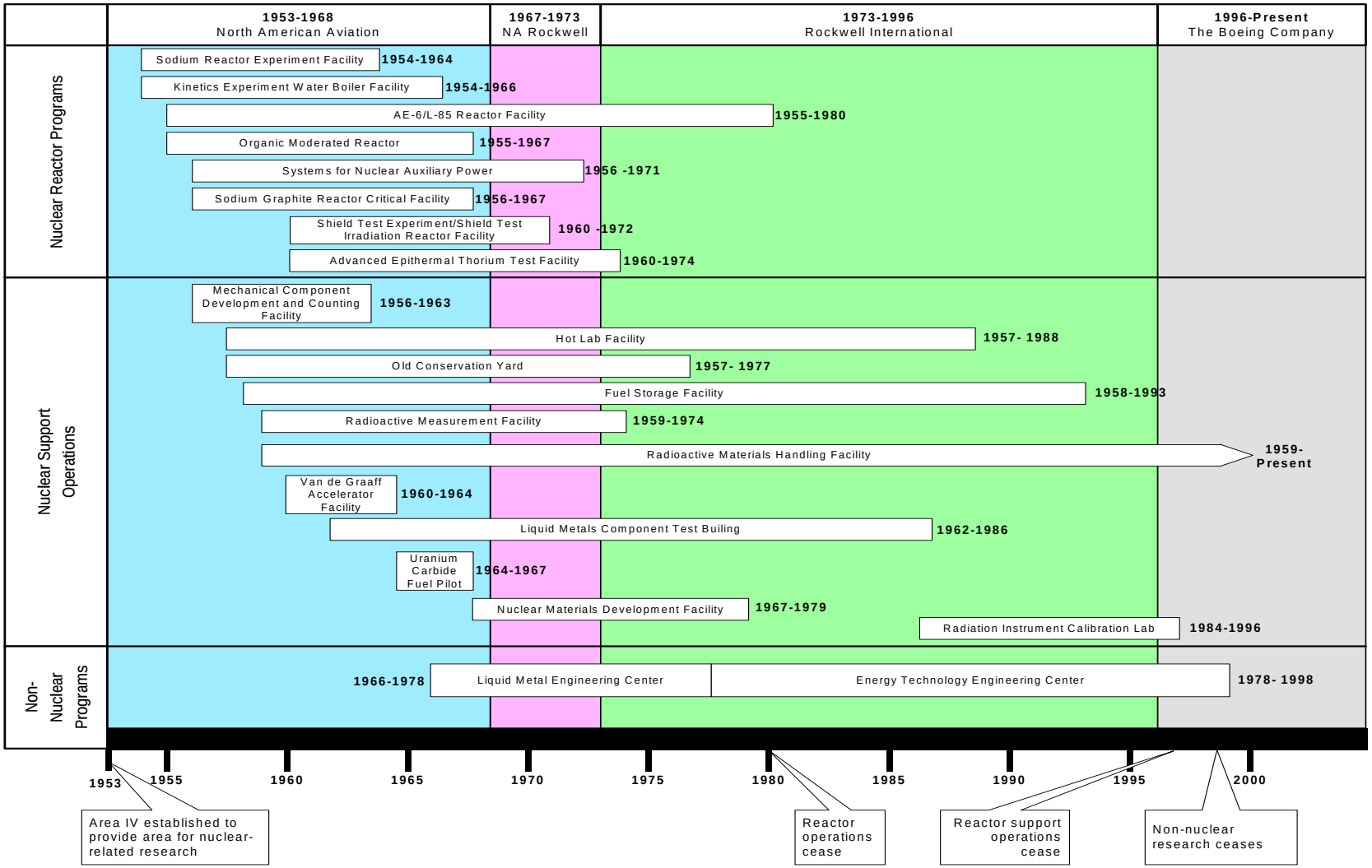
The Water Boiler Neutron Source (WBNS), located in Building 4093, operated from 1956 until 1980. From 1956 until 1972 the reactor was referred to as the AE-6. In 1972 the reactor name was changed to the L-85. The AE-6/L-85 operated at a power production level of 3 kWth.

[5] An individual site summary was developed for each site within Area IV. The site summaries consist of operational history, current status and other available information (e.g., radiological surveys, decontamination and demolition reports, industrial planning maps, aerial photographs, etc.) relevant to each site.

[6] A critical test assembly is a very low-power reactor that does not require an active cooling system. Frequently the assembly would require a separate neutron source to maintain critical neutron flux.

[7] The water boiler reactors used a 93% enriched uranyl sulphate solution held in a critical configuration in a spherical vessel. The solution did not boil; rather, neutron and gamma flux caused radiolytic decomposition of water into hydrogen and oxygen in the form of tiny bubbles that gave the impression of boiling.

Figure 2-1. Summary of Primary Area IV Programs and Operations



- Removal of the fuel was completed in 1982 and the building was decontaminated by 1987. Demolition activities for the AE-6/L-85 were completed by 1995.

Sodium-cooled, Graphite-moderated Reactors

Design of the Sodium Reactor Experiment (SRE) started in Area IV in 1954 to demonstrate the feasibility of high-temperature, sodium-cooled, graphite-moderated reactors as an energy source for power stations.

In 1957 as part of the demonstration, the SRE provided electricity to the City of Moorpark. The SRE reactor, located in Building 4143, operated at a maximum power level of 20 megawatts (MWth) from 1957 until 1964. In 1959, the SRE reactor experienced a coolant failure that resulted in damage to fuel elements including melting of cladding on 13 fuel assemblies. The reactor was shut down for repair on July 27, 1959, and restarted on September 5, 1960. The reactor operated without further incident until 1964 when the DOE terminated the SRE. Volume 2 provides a detailed description of incidents in Building 4143 that could have resulted in a release of radioactive contamination to the environment.

- Decontamination of Building 4143 began in 1974 and continued through 1983. The building was used as a storage facility from 1983 to 1999, when it was demolished.

Systems for Nuclear Auxiliary Power (SNAP) Reactors

The SNAP Program operated from 1956 to 1971. The purpose of the SNAP program was development and testing of small reactors designed to provide power for research missions in space. The SNAP reactors were uranium-zirconium hydride reactors that used fully enriched uranium dispersed in fuel rods containing zirconium hydride. Seven SNAP reactors were tested and operated in Area IV. These included:

The SNAP Experimental Reactor (SER), also known as the SNAP 2 Experimental Reactor (S2ER), was a prototype for the basic SNAP reactor. Operated in Building 4010 at a power level of 50 kWth, the SER was used for power demonstration and endurance tests. The SER operated from September 1959 to December 1960.

- Upon completion of the SER/S2ER operations, the reactor was removed from the building and sent offsite for disposal. Decontamination and demolition of Building 4010 was completed in 1978.

The SNAP 2 Development Reactor (S2DR), a prototype for the SNAP 2 Reactor, operated in Vault 1 of Building 4024 at a power rating of 50 kWth. The S2DR operated from April 1961 to December 1962.

- Following completion of the S2DR, the reactor was removed from the building and sent offsite for disposal. The D&D activities of Building 4024 were completed in 1978. At that time the non-vault portions of the building were declared suitable for release for unrestricted use. The test vaults remain restricted

and have been in surveillance and maintenance mode since 1978. Additional decontamination and demolition is scheduled to occur in 2005.

The Shield Test Reactor (STR) located in Building 4028 was used primarily for shielding tests of the SNAP reactors. The STR operated from 1961 through 1964 at a power rating of 50 kWth. The STR was modified in 1964 to achieve a power rating of 1 MWth and renamed the Shield Test and Irradiation Reactor (STIR). The STIR operated from 1964 through 1972.

- The reactor was removed from the building in 1976 and sent offsite for disposal. Decontamination and demolition activities for Building 4028 were completed in 1998.

The SNAP 8 Experimental Reactor (S8ER) was a prototype for the SNAP 8 reactors. The S8ER operated in Building 4010 (former location of the SER) from May 1963 to April 1965 at a power level of 600 kWth.

- Following completion of the S8ER operations, the reactor was removed from the building and sent offsite for disposal. Decontamination and demolition of Building 4010 was completed in 1978.

The SNAP 8 Development Reactor (S8DR) was tested in a vacuum chamber to simulate the space environment. It was the second SNAP 8 prototype, and operated in the vault in the basement of Building 4059 from June 1968 to December 1969 at a power level between 600 kWth and 1 MWth.

- Following completion of the S8DR operations, the reactor was removed from the building and sent offsite for disposal. The D&D activities for Building 4059 were completed in 1989. The test vault was restricted and under surveillance and maintenance until demolition in 2004.

The SNAP 10 Flight System Reactor (S10FS-3) was a SNAP 10A reactor used to test the reliability and performance of the reactors in space. Between January 1965 and March 1966, the Reactor operated continuously for 10,000 hours at 37 kWth in the west cell of Building 4024.

- Following completion of the S10FS-3 operations, the reactor was removed from the building and sent offsite for disposal. The D&D activities for Building 4024 were completed in 1978. At that time the non-vault portions of the building were declared suitable for release for unrestricted use. The test vaults remain restricted and have been in surveillance and maintenance mode since 1978. Additional decontamination and demolition is scheduled to occur in 2005.

2.2.2 Critical Test Facilities

Several programs used critical test facilities (i.e., low-power reactors) in Area IV. Use of these low-power reactors began in 1954 and continued until 1974.

SNAP Development Test Facilities

Test facilities in Area IV for the SNAP program included:

The SNAP Critical Test Facilities were located in Buildings 4373 and 4012. Building 4373 was used to test five SNAP reactor critical assemblies between 1957 and 1963. In 1962, Building 4012 replaced 4373 as the SNAP Critical Test Facility and SNAP reactor critical assembly testing occurred there until 1968. From 1970 through 1972, Building 4012 was used to house a critical assembly for the Heavy Metal Reflected Fast Spectrum Reactor (HMRFSR).

- The D&D activities in Building 4373 were completed in 1995. Demolition of the building was completed in 2003.
- Initial demolition efforts in Building 4012 were completed in 1986 to accommodate construction of a non-nuclear building. Final D&D in the remaining portion of the building was performed in 1995. Demolition of the building was completed in 2003.

The SNAP Flight System Critical Facility, located in Building 4019, was used to conduct critical acceptance tests of SNAP reactors before they were delivered to clients for launch as space power systems. Three reactors (FS-1, FS-4 and FS-5) were assembled and tested from 1964 to 1965.

- The D&D activities for the SNAP Flight System Critical Facility were completed in 1965. Following additional decontamination in 1998, the building was released. The building remains standing and is inactive.

The SNAP Transient Test Facility was located in Building 4024 and only operated in 1971. This facility tested the SNAP reactors for rapid changes in drum control position.

- Following completion of the SNAP operations, the assemblies were removed from the building and sent offsite for disposal. The D&D activities in Building 4024 were completed in 1978. At that time the non-vault portions of the building were declared suitable for release for unrestricted use. The test vaults remain restricted and have been in surveillance and maintenance mode since 1978. Additional decontamination and demolition is scheduled to occur in 2005.

Civilian Nuclear Power Test Facilities

Critical test facilities supporting the development of civilian nuclear power included:

The Organic Moderated Reactor (OMR) Critical Facility, located in Building 4009, was built as a low-power critical experiment facility to test reactors moderated and cooled by organic liquids. It supported the development and construction of the Piqua Nuclear Power Facility. The OMR Critical Facility operated from 1958 to 1967.

- The D&D activities for the OMR Critical Facility were completed in 1967. Building 4009 is currently being used for non-nuclear R&D.

The Sodium Graphite Reactor (SGR) Critical Facility, located in Building 4009, was a low-power critical experiment facility used to determine the operating characteristics of reactors with cores cooled by sodium and moderated with graphite. It supported the development and construction of the Hallam Nuclear Power Facility. The SGR Critical Facility operated from 1958 to 1967.

- The D&D activities for the SGR Critical Facility were completed in 1967. Building 4009 is currently being used for non-nuclear R&D.

The Advanced Epithermal Thorium Reactor (AETR), located in Building 4100, was built to study and test reactor core configurations for thorium and uranium-fueled reactors. It supported the development of reactors for the Southwest Atomic Power Association. The reactor operated from 1960 to 1974.

- The D&D activities for the AETR were completed after the program was terminated in 1974. Building 4100 currently houses the radiation safety group's counting and instrument calibration laboratory and a Computer Aided Tomography system.

2.3 Nuclear Support Operations

Several facilities were designed and built in Area IV to handle or manage radioactive material in support of nuclear reactor programs. These operations included fuel fabrication, fuel storage, radioactive measurement and calibration, and radioactive waste management.

All nuclear support operations were terminated by 1988, with the exception of operations in support of closure and cleanup activities. These exceptions included the Fuel Storage Facility, Radiation Instrument Calibration Laboratory, and the RMHF. Operations were terminated at the Fuel Storage Facility and Radiation Instrument Calibration Laboratory in 1993 and 1996, respectively. Radiation instrument calibration is currently performed in Building 4100. The RMHF continues to operate in support of the DOE's cleanup effort and will be terminated as the facility goes into closure.

Table 2-2 lists specific nuclear support operations conducted in Area IV, building(s) where the operation took place, and potential radiological contaminants as a result of the operation. A summary of all nuclear support operations can be found in Volume 2. The activities for the four major support operation facilities, the RMHF, Fuel Storage Facility, Hot Laboratory and the Nuclear Materials Development Facility (NMDF) are summarized below.

2.3.1 Radioactive Materials Handling Facility

The RMHF was constructed in 1959 to process radioactive waste from on-site programs. It consists of several facilities that are used to process radioactive waste materials for packaging and disposal. During operation, the facility was fenced and manned by a guard to prevent unauthorized access. The facility is active and continues to be used as a storage area for wastes from decommissioning activities throughout Area IV.

Table 2-1. Potential Radionuclides in Area IV Resulting from Reactor Operations

Power Output	Period of Operations[8]	Facility	Radionuclides
KEWB Reactor/ 1 kWth	1956-1966	Building 4073	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241
L-85 Reactor/ 3 kWth	1956-1980	Building 4093	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241
SRE Reactor/ 20 MWth	1957-1964	Building 4143	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, Th-232, H-3
SER/ 50 kWth	1959-1960	Building 4010	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, H-3
S8ER/ 600 kWth	1963-1965		
S2DR/ 50 kWth	1961-1962	Building 4024	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, H-3
S10FS/37 kWth	1965-1966		
SNAP Transient Test Facility	1971		
STR/ 50 kWth	1961-1964	Building 4028	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, H-3
STIR/ 1 MWth	1964-1972		
S8DR/ 600 kWth - 1 MWth	1968-1969	Building 4059	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, H-3
SNAP Critical Test Facility	1962-1968	Building 4012	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241
HMRFSR	1970-1972		
SNAP Critical Test Facility	1957-1963	Building 4373	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241
SNAP Flight System Critical Facility	1964-1965	Building 4019	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241
OMR Critical Facility	1958-1967	Building 4009	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154
SGR Critical Facility	1958-1967		
AETR Test Facility	1960-1974	Building 4100	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Th-232

[8] Refers to operation of the reactor rather than program duration dates provided in Figure 2-1.

2.3.2 Fuel Storage Facility

The Fuel Storage Facility was located in Building 4064 and was constructed in 1958. Building 4064 was a vault, built to provide secure storage for non-irradiated fissionable fuel material (enriched uranium and plutonium) used to make reactor fuel. The building was constructed above ground out of concrete and concrete blocks to meet the AEC criteria for vaults for storage of fissionable material. It was equipped with intrusion alarms. Closed containers of radioactive waste were also stored outside on a concrete pad within the locked and fenced facility perimeter.

Following removal of all fissionable material in the mid-1980s, miscellaneous equipment and containers of radioactive waste (principally soil) were stored in the building. The building was emptied of all contents by 1993.

- Decontamination and demolition activities for Building 4064 were completed in 1997.

2.3.3 The Hot Laboratory

The Hot Lab facility operated in Building 4020 from 1959 to 1988. It was a 16,000 sq ft facility with four large hot cells with remote manipulators and cranes, a mock-up area, operating area, and decontamination areas. During reactor test operations, it was often necessary to examine reactor fuel assemblies and other test specimens to determine how they were performing. This involved handling and examining highly radioactive items. These operations were done remotely in the heavily shielded Hot Laboratory, built for this purpose.

The Hot Lab was used to examine fuel and/or components from the SRE, SER, S2DR, S8DR, and S10FS-3 reactors operated at Area IV. The Hot Lab has also been used for work on radioactive material generated outside Area IV. This material has consisted in large part of used reactor fuel from other nuclear reactors. The fuel elements were shipped into the Hot Lab, disassembled or separated from their cladding material, and the separated materials then shipped offsite for disposal.

Decontamination and demolition activities in Building 4020 were completed in 1999.

2.3.4 The Nuclear Materials Development Facility

The NMDF was located in Building 4055 and constructed in 1967. It operated until 1979. The NMDF was built specifically for development work involving plutonium and supported several research programs.

- The D&D activities were completed by 1987 and the building was released (i.e., suitable for use without restrictions). The building is currently standing and is used for non-radiological research.

Table 2-2. Potential Radionuclides in Area IV Resulting from Nuclear Support Operations

Operation	Period of Operations	Facility	Radionuclides
SRE Support Complex	1954-1964	Buildings 4003, 4163, 4041, 4654, 4689, 4653, 4606, 4773	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, Th-232
Uranium Carbide Fuel Pilot Plant	1964-1967	Building 4005	U-234, U-235, U-238
Radiation Instrument Calibration Laboratory	1984-1996	Building 4011	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, Th-232
Van de Graaff Accelerator	1960-1964	Building 4030	H-3
Hot Laboratory	1957-1988	Building 4020	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, Pm-147
Liquid Metals Component Test Building	1962-1986	Building 4023	Sr-90, Cs-137, Co-60, Eu-152, Eu-154
Radioactive Measurement Facility	1959-1974	Building 4029	Ra-226
NMDF	1967-1979	Building 4055	U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241
Fuel Storage Facility	1958-1993	Building 4064	Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154
RMHF	1959-present	Buildings 4021/4022	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, H-3
Mechanical Component Development and Counting Building	1956-1963	Building 4363	Sr-90, Cs-137
Radiation Instrument Calibration and Radiological Sample Counting Laboratory	1985-present	Building 4100	Sr-90, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Co-60, Eu-152, Eu-154, H-3

2.4 Non-Nuclear Energy Research and Development

Although several non-nuclear energy research programs were conducted in Area IV, the primary non-nuclear R&D activities were performed by the LMEC.

The major research programs of the LMEC/ETEC from 1966 through 1998 included:

- Support of the DOE's effort to design and construct the FFTF at the Hanford site in Washington State [1966 until 1978].
- Support of the effort to design and develop the first full-size breeder reactor at Clinch River, Tennessee [1978 to 1984].
- Support of other DOE energy development programs including: molten-salt technology development, operation of a 6 MWth atmospheric fluidized bed combustion facility, operation of a solar concentrator facility and development and testing of the Kalina Cycle Power Plant [1984 until 1998].

The LMEC/ETEC energy-related research and testing activities ceased in 1998, when the DOE contract expired. These program operations were reviewed and found not to be potential sources of radiological contamination in Area IV.

2.5 Areas of Known Contamination

Through incident reports and site surveys, three areas not designed to handle radiological materials were identified as contaminated. These areas were contaminated as a result of radiological activities in Area IV:

- The 17th Street Drainage is a drainage channel and holdup pond located south of the intersection of "G" and 17th Streets (Figure 2-2). Contamination in the area likely resulted from runoff from the SNAP facilities. Characterization surveys performed in 1997 and 1998 identified levels of Cs-137 and Th-228 above the DCGLs. As a result, remediation began in 1998, and a final status survey was performed in 1999. The site was released for unrestricted use in 2004.
- The Old Conservation Yard (OCY) was used to store salvageable materials from nuclear-related facilities at the SSFL from the late 1960s to the late 1970s. In 1976 a radioactive spill was detected in the OCY. The area was remediated and a final status survey indicated the area was acceptable for release. The site was released for unrestricted use in 1995.
- From 1956 to 1978, the Former Sodium Disposal Facility (FSDF-Building 4886) was used to clean non-radioactive metallic sodium and sodium potassium alloy (NaK) from various scrap-test components before they were disposed. In the 1970s, storage drums at the site were found contaminated with residual radioactivity. The site was remediated, re-vegetated and released for unrestricted use in 1998.

2.6 Other Areas

In the 1960s, tests were conducted at the Area IV to determine how deeply falling radioisotope heat sources would penetrate the soil. During one of these tests a 1-kg slug of depleted uranium was lost after being dropped from a helicopter. No documentation was found to suggest the slug was ever recovered. The area where the slug was dropped has been surveyed several times and contamination has not been detected. Further reconnaissance is planned to recover the missing slug.

2.7 Future Operational and Research Programs

All the DOE Area IV operational and research programs were completed in 1998. The DOE has no future research programs planned for Area IV. Since 1998, all the DOE-directed activities in Area IV have focused on closure activities including assessment and cleanup of radiological and chemical contamination of facilities and environmental media.

Section 3.0 – Area IV HSA Methodology

3.1 Regulatory Framework

The Area IV HSA was developed to meet the objectives identified in Section 1.1 based on the requirements of the DOE and the California Department of Health Services-Radiation Health Branch (DHS-RHB). All radiological activities conducted in Area IV were either performed under contract to the DOE under the authority of the AEC, or were licensed by the Nuclear Regulatory Commission and the DHS-RHB using the Atomic Energy Act (AEA) authority as commercial nuclear activities conducted by AI.

Department of Energy

The DOE has authority to regulate federal (i.e., non-commercial) nuclear programs and special nuclear materials. Within Area IV, the DOE is responsible for cleanup and release of radiologically impacted facilities. The DOE is completing the radiological cleanup within Area IV to meet a cleanup standard for unrestricted, residential use. The conservative cleanup level was established to allow industrial, recreational or residential land use.

The DOE sponsored many of the programs and operations and is the owner of most structures in Area IV. The DOE has accepted responsibility for completing the radiological cleanup of Area IV to levels that are protective of human health and the environment consistent with reasonably anticipated land uses. The DOE is using the Area IV HSA to determine if it has appropriately addressed all radiologically impacted areas and to identify any remaining activities. The Area IV HSA is a compilation of information that has been developed on a facility-by-facility basis. The Area IV HSA enabled the DOE to look at Area IV as a whole and identify any facilities impacted by radiological material not previously addressed.

Nuclear Regulatory Commission

The NRC has authority to regulate and license commercial nuclear reactors and non-DOE special nuclear materials (e.g., nuclear fuels). At the SSFL, the NRC issued licenses for Buildings 4093, 4100, 4055, and 4020. The NRC terminated licenses for 4093, 4100, and 4055 following release of these buildings. The NRC terminated the license for building 4020 following transfer of the building to the DOE.

The NRC delegated to California the authority to regulate and license the use of by-product radiological material (e.g., calibration sources, mixed fission products, activation products). As such, the NRC no longer has an active role in regulating non-DOE radiological materials within Area IV.

California Department of Health Services-Radiation Health Branch

The DHS-RHB is the California State Agency responsible for executing the NRC's delegated authority. The DHS-RHB licensed AI and Boeing for the commercial use of by-product radiological material at specific facilities within Area IV.

3.1.1 Applicable Regulations

Nuclear-related programs and operations were conducted in Area IV from 1953 until 1988,[1] while non-nuclear operations continued through 1998. Throughout its operational period buildings and land in Area IV were decommissioned, and if necessary, remediated, surveyed, verified and released for reuse by the cognizant regulatory agency (i.e., the Energy Research and Development Administration (ERDA), the DOE, the NRC or the DHS). As a result, buildings and soil were decommissioned using different regulatory standards including DOE Order 5400.5, Chapter 4 and the NRC Regulatory Guide 1.86 (Reference 6 and 13).

In 1998, MARSSIM was developed to provide a process to demonstrate to the appropriate regulatory agency that remediation meets the specific regulatory limit. The DOE implemented MARSSIM at Area IV in 1998. The current regulatory standard implemented at Area IV is DOE Order 5400.5.

The DOE used the Area IV HSA process to:

- Evaluate and classify all sites (i.e., numbered structures) that existed during the operational period of Area IV as impacted or non-impacted.
- Use the operational history of buildings to identify radiologically impacted soils (e.g., building footprint and drainage paths).
- Determine remaining activities for impacted sites to be conducted consistent with MARSSIM guidance.

This process enabled the DOE to provide a comprehensive review of all of Area IV, including sites that already met regulatory standards.

3.1.2 Scope/Boundaries

The scope of the Area IV HSA is all operations that occurred within the 290-acre extent of Area IV within the SSFL (Figure 2-2), inclusive of numbered structures both government and Boeing-owned and adjacent soil.

[1] Other support operations, including the Fuel Storage Facility and the Radiation Instrument Calibration Laboratory did not cease until 1996.

3.1.3 Land Use

No nuclear research has been conducted in Area IV since 1988. The SSFL is currently used as a general aerospace industrial research facility. This land use is allowed under a special land use permit granted in 1954 from Ventura County, replacing a special land use permit issued in 1947. The special land use permit conditions are limited to the duration of ownership by the NAA or its successors (e.g. Boeing). At the time successor company ownership ends, land use zoning reverts to its original land use zoning as RA-5 (a 5-acre rural/agricultural use).

Cleanup standards were developed and approved by the DOE and the DHS, based on a presumed suburban residential land use scenario (Reference 1). The DOE believes the suburban residential scenario is a *reasonably anticipated land use* as defined in the NRC/EPA Memorandum of Understanding on Consultation and Finality of Decommissioning and Decontamination of Contaminated Sites (Reference 2).

3.1.4 Derived Concentration Guideline Levels

The MARSSIM introduces the concept of DCGLs. The DCGLs are constituent-specific release criteria (i.e., the allowable level of residual radioactive material that can exist following remediation that assure residual radioactivity will not result in individuals being exposed to unacceptable levels of radiation or radioactive materials). The DCGLs are the release levels (i.e., cleanup levels) that are determined for each radionuclide of concern (ROC). Appendix C discusses ROCs at Area IV.

The DCGLs are established as a part of planning for an HSA. The results of final status surveys are compared to the DCGLs to determine if the site meets release criteria.

Area IV Soil DCGLs

Table 3-1 provides the constituent-specific DCGLs established for the ROCs in Area IV. These DCGLs were determined for soil using the residual radioactivity (RESRAD)[2] exposure pathway analysis and approved by the DOE and DHS in 1996 (Reference 8 and 9)

These DCGLs are based on a suburban residential land use, a conservative *reasonably anticipated future land use* for Area IV following the cessation of industrial use, and calculated using a 15 mrem/yr exposure goal.[3] Thorium and radium isotopes have promulgated cleanup levels of 5 pCi/g soil based on uranium mill tailings remedial action (UMTRA) legislation. The DCGLs for these isotopes default to their promulgated standard.

[2] The RESRAD is a computer model designed to estimate radiation doses and risks from RESidual RADioactive materials. RESRAD has been widely used by the DOE, its operations and area offices, and its contractors for deriving limits for radionuclides in soil. The EPA, U.S. Army Corps of Engineers, NRC, industrial firms, universities, and foreign government agencies and institutions also use RESRAD.

[3] The NRC issued 10 CFR 20 Subpart E, License Termination Rule, based on a dose of 25 mrem/yr. The EPA currently maintains the position that 15 mrem/yr is fully protective of public health. The DOE has adopted the NRC's 25 mrem/yr standard for other DOE facilities.

Appendix B provides the technical detail and analysis supporting calculation of the Area IV DCGLs, including comparison of default RESRAD parameters to Area IV-specific parameters.

Area IV Non-Soil DCGLs

DCGLs for non-soil sites (e.g., structural building surfaces, pavement, and building interiors) are based on the NRC Regulatory Guide 1.86, DOE 5400.5 and Boeing's N001SRR140131 (References 1, 6, and 13). These DCGLs apply to remaining buildings that have not been released.

3.1.5 Radiological Background

The Bell Canyon data set has been selected as a suitable "MARSSIM reference dataset" for the purposes of the Area IV HSA classification. The Bell Canyon data represent background surface soil values for the Area IV ROCs (Reference 5).

The majority of the ROCs at Area IV have mean background concentrations (represented by the Bell Canyon data) that are small relative to the DCGLs (e.g., Cs-137, Sr-90). This means background measurements do not play a significant role in determining whether the DCGL is met.

Appendix A provides the Bell Canyon reference data set, technical detail and rationale for the use as a background data set for classification of sites in Area IV.

3.2 Approach

In order to determine whether buildings and soils are appropriately and consistently evaluated for radiological impacts, a formal decision process was developed to:

- Identify buildings and soil areas that are potentially impacted based on historical operations (Figure 3-1).

- Determine status, and remaining activities required for release of each impacted area (Figure 3-2 and Figure 3-3).

The decision process was applied to all sites[4] that existed in Area IV since its establishment in 1953, as well as to any other known areas of contamination. Starting with existing site lists and verifying and adding sites based upon employee interviews, historical documentation (demolition records, environmental surveys, etc.) and available industrial maps, individual site summaries were developed for each site to describe operational history and current status.

[4] Boeing and its predecessors assigned a unique number to each engineered item (e.g., building, electrical substation, guard shack, parking lot, lean-to, etc.) within Area IV, excluding groundwater wells (groundwater wells, which are numbered, are not sites). By defining a site as a numbered structure and its associated areas, the Area IV HSA is a temporally comprehensive evaluation of Area IV from its initial development to the present.

Table 3-1. Area IV DCGLs[5]

Radionuclides	Residential Soil Concentration (pCi/g)
Am-241	5.4
Co-60	1.9
Cs-134	3.3
Cs-137	9.2
Eu-152	4.5
Eu-154	4.1
Fe-55	6.3×10^5
H-3	3.2×10^4
K-40	28
Mn-54	6.1
Na-22	2.3
Ni-59	1.5 x 105
Ni-63	5.5×10^4
Pu-238	37
Pu-239	34
Pu-240	34
Pu-241	230
Pu-242	36
Ra-226	5.0
Sr-90	36
Th-228	5.0
Th-232	5.0
U-234	30
U-235	30
U-238	35

NOTE: Although soil DCGLs have been developed for these constituents, the shaded radionuclides above have not been identified as SSFL soil ROCs. See Appendix C for a discussion of these radionuclides.

[5] N001SRR140131, "Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL." February 18, 1999. Approved by the DOE and the DHS.

The Area IV site list and all site summaries are in Volume 2.

Based on the information contained in each site summary, individual sites were evaluated to determine if they had been radiologically impacted. Sites were classified as impacted if there was history of managing any type of regulated radiological material at the site, including sealed sources.[6] Specific questions posed to determine radiological impact are included in Figure 3-1. Answers to these questions were determined using information in the site summaries collected from the records developed to control radiological material.[7]

Following classification, all impacted sites were analyzed using the decision process depicted in Figure 3-2 and Figure 3-3 to determine further action in accordance with MARSSIM. Sites and adjacent soil requiring further action were classified based on the following criteria outlined in Figure 3-2 and Figure 3-3:

- Class I sites potentially have or had radioactive contamination above the DCGLs.
- Class II sites potentially have or had radioactive contamination below DCGLs, but above 20% of the DCGLs.
- Class III sites potentially have or had radioactive contamination above background, but below 20% of DCGLs.

Site classification defines the survey requirements for further action at the sites.

3.3 Site Classification Criteria

Several criteria were developed to allow a consistent approach for evaluating and classifying impacted sites and adjacent soil with remaining release activities.

Specific classification criteria include:

- Any site historically requiring decontamination is assumed to be an impacted Class I site. This assumption is conservative because decontamination may have been required in some facilities with minor contamination (<DCGL) due to the DOE's As Low As Reasonably Achievable (ALARA) policy,[8] which requires contamination to be cleaned up even when contamination is well below DCGLs to "as low as reasonably achievable."

[6] Buildings where sealed sources were used typically are not classified as impacted but were classified as impacted in the Area IV HSA to ensure all buildings with any history of managing regulated radiological material were identified.
[7] Radiological material must be licensed; the requirements are very specific and extensive record keeping is required in order to meet the requirements of the license.
[8] The ALARA policy directs that every reasonable effort will be made to maintain exposures to radiation as far below the dose limits as practical and consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations (see 10 CFR 20.1003).

Figure 3-1. Process to Determine Impacted Sites

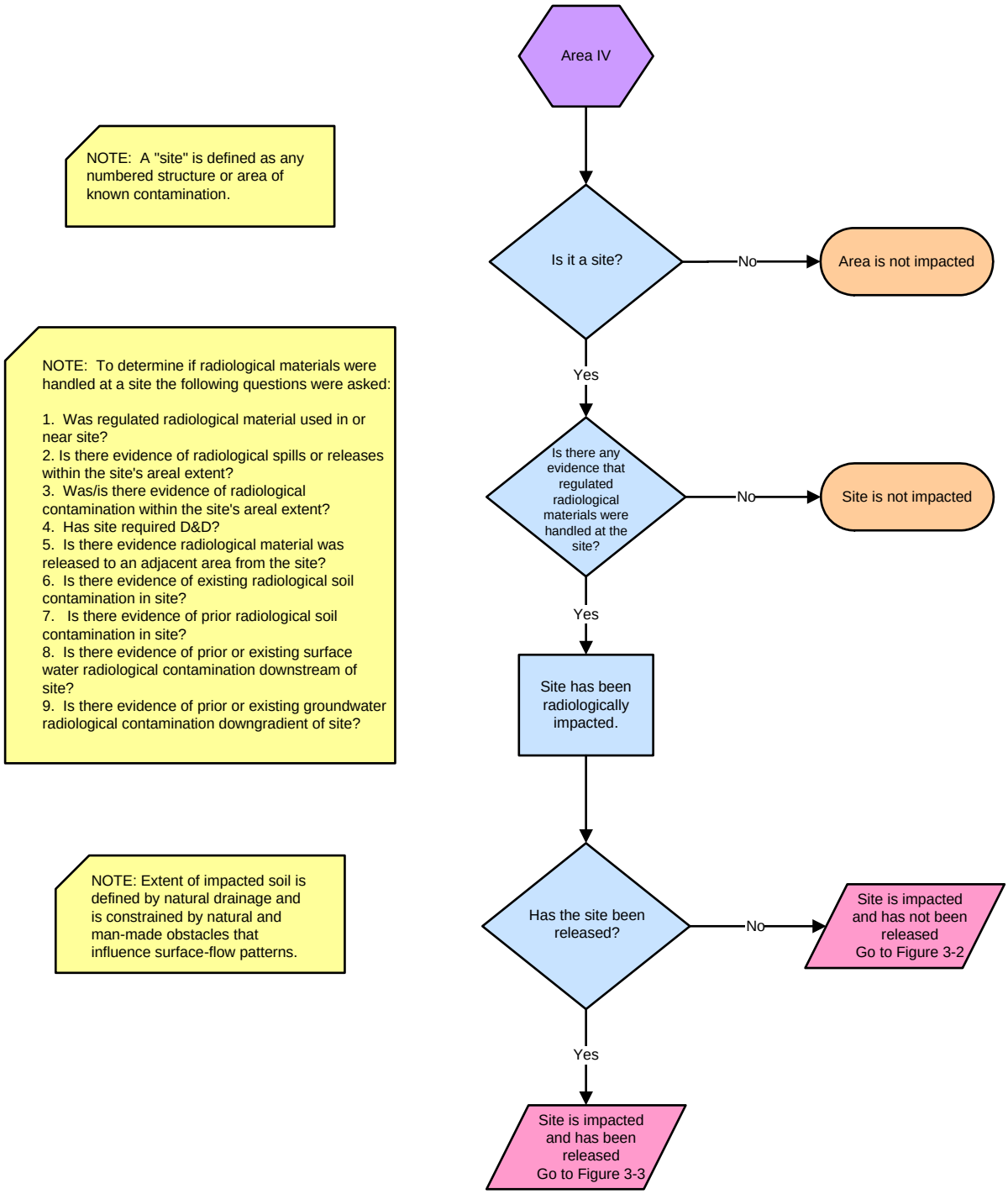


Figure 3-2. Process to Determine Remaining Activities – Sites

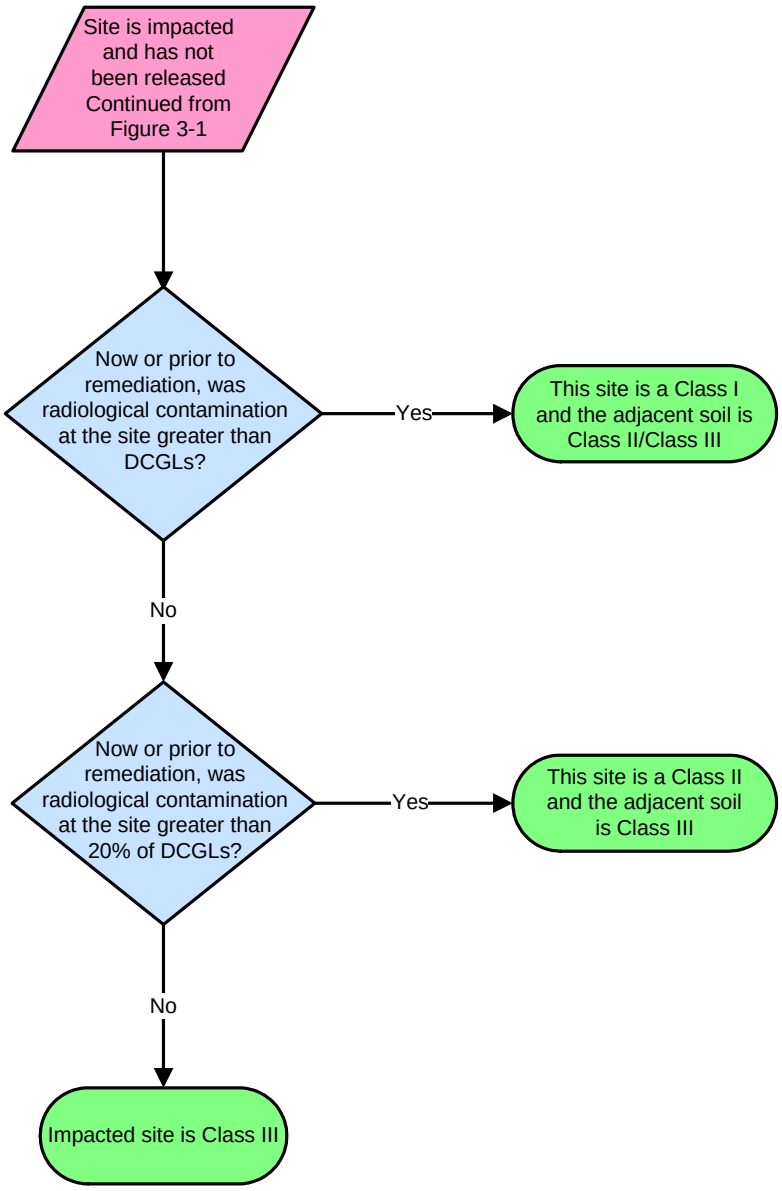
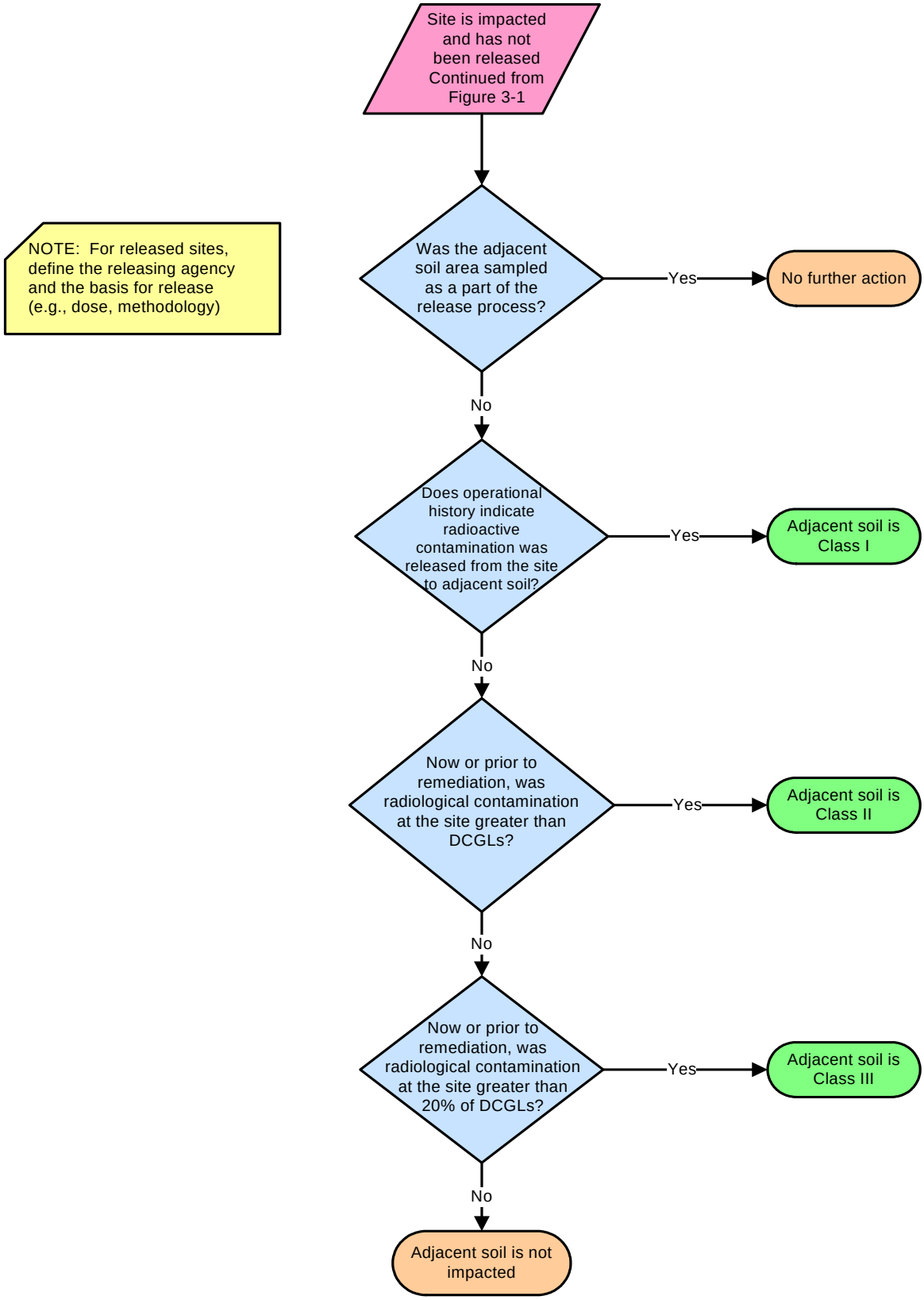


Figure 3-3. Process to Determine Remaining Activities – Adjacent Soil



- Adjacent soil (e.g., underlying or adjacent to sites) is classified consistent with the operational history of the site, any radiological materials used at the site and the potential for their release into underlying or adjacent media.

- Leachfields, sanitary drain lines and outfalls are classified consistent with the site they serviced.

Consistent with MARSSIM, surficial adjacent soil to Class I or Class II sites or soil areas of known contamination have been nominally classified as Class II or Class III to provide a "buffer" between impacted and non-impacted areas.

Other criteria required to consistently classify buffer areas include:

- Buffer areas follow drainage pathways and are constrained by natural (i.e., rocks) and manmade (e.g., curbs) obstacles that would have influenced any surface flow pattern.

- The boundaries of buffer areas are approximate until specific site survey plans are developed.

3.4 Site Summaries

Site summaries provide operational history, current status and other information (e.g., radiological surveys, decontamination and demolition status, aerial photographs, etc.) relevant to each site. Site summaries were developed using information consisting of archived information from the Radiation Safety Records Management System (RSRMS), personnel interviews, site environmental monitoring program and any relevant published material (e.g., DOE reports). This information was searched for operational history, incident reports, facility and environmental contamination data, survey status and regulatory release history for all sites. The RSRMS has been located and controlled by personnel working in Area IV since its inception in 1953.

An individual site summary was developed for each site within Area IV. See Figure 3-4 for an example site summary. All Area IV HSA site summaries are contained in Volume 2.

References and personnel interviews used to develop individual site summaries are listed within that site summary. All references and personnel interviews used in the Area IV HSA are compiled in the Volume 2 Reference List.

Figure 3-4. Example Site Summary

Site Summary – Site 4XXX

Site Identification:

- Any name used for the site (site purpose and association changed over time, resulting in several different names). Includes any additional support structures used to service the building not warranting an individual site summary (e.g., substations, guard shacks, time clock structures and construction shacks).

Operational Use/History:

- The date the site was constructed, programs the site supported, dates these programs were operating, deactivation/decontamination activities, and demolition date.

Site Description:

- A physical description of the site and any holding tanks or other below ground structures, leachfield, or air filter structure (stacks, HEPA filtration) associated with the site.

Relevant Site Information:

- Type of radiological material managed at the site, use authorizations, and any incidents that would have resulted in potential releases to the environment.

Radiological Surveys:

- Radiological surveys performed at the site, description of survey purpose (routine, characterization, final status, verification), date conducted, agency conducting the survey, survey scope (e.g., interior, exterior), measurements collected, acceptable limits for the survey, and survey results.

Status:

- Site release date and releasing agency (if applicable), and demolition date or current use.

References:

- Documents, maps, photographs, personnel interviews, review of RSRMS, or any other information used to develop the site summary.

Photograph:

- If a photograph of the site was available, it was included in the site summary.

3.4.1 Radiation Safety Records Management System (RSRMS)

The RSRMS consists of approximately 170 file cabinets containing paper records of Boeing's Radiation Safety Department. Control of radioactive materials and implementation of radiation protection programs has been the responsibility of various departments in Area IV since 1953, including Health and Safety, Nuclear Safety and Licensing, Nuclear Materials Management, Radiation and Nuclear Safety, Radiation Protection and Health Physics Services, and, currently, Radiation Safety. The RSRMS has compiled departmental and personnel files from all radiation protection programs.

Key types of information included in the RSRMS are radioactive material use authorizations, routine radiation survey data sheets, personnel radiation exposure records, environmental measurement data, instrument calibration records, incident reports, facility decommissioning reports, final status surveys, verification surveys, regulatory agency correspondence, facility health physics logbooks[9] and radiation safety plans, procedures and reports.

Other Area IV information repositories containing information regarding programmatic and contractual records were not used to develop site summaries because the information provided in these records was not useful in determining if there was potential radiological impact for a site. Radiological information from these types of records would have been included as a part of the RSRMS.

3.4.2 Personnel Interviews

Personnel from Boeing and its predecessors were interviewed to confirm documentation found in the RSRMS or to verify additional information not found in the RSRMS to confirm operational history.

3.5 Site Environmental Monitoring Program

The environmental monitoring program at Area IV was established as a component of routine operations in May 1954 prior to construction of the first radiological facility.[10]

The environmental monitoring program is in place to provide monitoring of Area IV operations, facility boundary and off-site locations surrounding the facility to determine if any contamination resulting from operations in Area IV migrated offsite. The environmental monitoring program consists of facility-specific monitoring and general environmental monitoring. Facility-specific environmental monitoring programs are depicted in Figure 3-5. General monitoring programs are summarized in section 3.5.2.

[9] Health physicists kept logbooks to record daily operations at each building.

[10] Monitoring results were published and updated semi-annually in the Environmental Monitoring Annual Report. This report evolved into the Annual Site Environmental Report (ASER) to fulfill the requirements of DOE Orders 5400.1 and 231.1. The purpose of the ASER is to inform stakeholders of impacts to the environment due to site activities.

3.5.1 Facility Monitoring Programs

The typical monitoring programs used for Area IV radiological facilities summarized in Figure 3-5 include:

Air Emissions

In all facilities with radiological work areas or where un-encapsulated or unpackaged radioactive material was handled, samples of air emissions released from exhaust stacks were monitored for gross alpha and beta radioactivity on a weekly basis to detect any release of airborne radioactivity. The stack sampling systems had real-time alarms to detect increased levels of effluent. Air emissions were also analyzed for isotope specific content.

Surface Water Discharges

Area IV surface water discharges consist of both process water and surface runoff from precipitation events.

Operational discharges of process water from Area IV facilities and most Area IV site-wide surface water drain to the Rocketdyne retention pond R-2A. Water from R-2A is discharged into Bell Creek. From 1966 to 1987, a sampling station for Bell Creek was established 3.4 miles downstream from the site boundary. Since 1976, the water from R-2A has also been sampled at the discharge point of R-2A to Bell Creek in accordance with the National Pollutant Discharge Elimination System (NPDES) permit.[11]

Most of Area IV surface water drains to the southeast, and is collected by a series of drainage channels, which drain to R-2A pond. A small amount of surface water drains toward the northwest and is not collected by the R-2A pond. In 1989, five catch basins were installed near the site boundary in the northwest to capture this runoff. The catch basins are sampled in accordance with the NPDES permit for radiological and non-radiological constituents following rainfall events when water accumulates.

Non-Radiological Drains

Prior to 1961, facilities sanitary waste (i.e., non-radioactive drains) was discharged into facility-specific leachfields. Sanitary waste discharges to the leachfields were not monitored for radiological contaminants. All leachfields have since been removed. Soil samples were collected during the removal of leachfields as part of routine excavation procedures in Area IV. Samples collected during removal of the leachfields confirmed no radiological impact.

[11] The NPDES permit for R-2A imposes numerical limits for radiological contaminants similar to those for drinking water standards. Grab samples at the outfall are collected and sent to a certified testing laboratory for analysis. Analyses include radiological and chemical constituents listed on the permit.

A sitewide sanitary sewer system was installed for all of the SSFL in 1961. In Area IV the facility-specific leachfields were abandoned and all non-radiological drains were collected and piped to the Area III sewage treatment plant for treatment. Radiation detectors were installed at the sewage treatment plant to confirm radiological contamination was not present in the sewage. The treated water was discharged to the R-2A retention pond until 2001. After 2001, the treated water was hauled offsite for proper disposal under the Publicly Owned Treatment Works (POTW) permit.

Radioactive Drains

Facilities where liquid radioactive material was managed had radioactive waste handling systems (e.g., underground tanks) to store the waste. Liquid radioactive material was taken to the RMHF for treatment (solidification) before it was shipped to DOE-approved sites for disposal. As radioactive waste handling systems are removed, sampling is conducted to confirm no leaks or spills resulted in radioactive contamination of the adjacent soil.

3.5.2 General Environmental Monitoring Programs

General monitoring programs were used to determine if contamination spread to the environment via unplanned releases (i.e. leaks or spills). This included general soil sampling, groundwater monitoring, ambient radiation monitoring, ambient air monitoring, and vegetation and wildlife sampling.

Soil

Until 1986, routine soil sampling was conducted monthly in Area IV and representative offsite locations for gross alpha and beta radioactivity. Plutonium levels were also measured from 1979 to 1986. In 1986, reductions in the nuclear operations performed at Area IV led to reduction of sampling frequency from monthly to quarterly. Routine soil sampling was halted when nuclear operations were terminated in 1989. Subsequent soil sampling has been conducted as part of facility-specific remediation programs, offsite sampling projects (e.g., Brandies-Bardin and Bell Canyon) and the Area IV Radiological Survey.

Groundwater

Groundwater supplied to Area IV restrooms was sampled monthly from 1957 to 1989 for gross alpha and beta. Groundwater well monitoring for radiological constituents began in Area IV in 1984 under the direction of the Los Angeles Regional Water Quality Control Board (RWQCB). Samples are taken periodically from both shallow surface wells and from deep wells.[12] By 2000, there were 47 monitoring wells located in and around Area IV. Analytes sampled for include gross alpha/beta, tritium, and gamma emitting radionuclides.

[12] Groundwater occurs at Area IV in the alluvium, weathered bedrock, and un-weathered bedrock. For monitoring purposes, shallow surface groundwater is defined as groundwater that is present in the alluvium and weathered bedrock; Chatsworth Formation occurs below the weathered bedrock and is where deep wells are located.

Ambient Radiation

From 1971 to present, ambient radiation at Area IV has been monitored at facility fence lines, selected locations throughout Area IV, and along the Area IV boundary. For comparison purposes, offsite locations were included in the monitoring program to determine ambient background radiation levels. The DHS also measures nine locations around the Area IV site boundary for independent monitoring of radiation levels at Area IV and the adjacent soil.

Ambient Air Activity

From 1959 to present, ambient air activity has been measured continuously (i.e., 24-hour sampling cycles) in five locations around Area IV. These screening measurements were used to identify any release of radioactivity to the ambient air. The air has been measured for gross alpha and beta radioactivity.[13] Currently, ambient air samples are also analyzed for isotope-specific content.

Vegetation

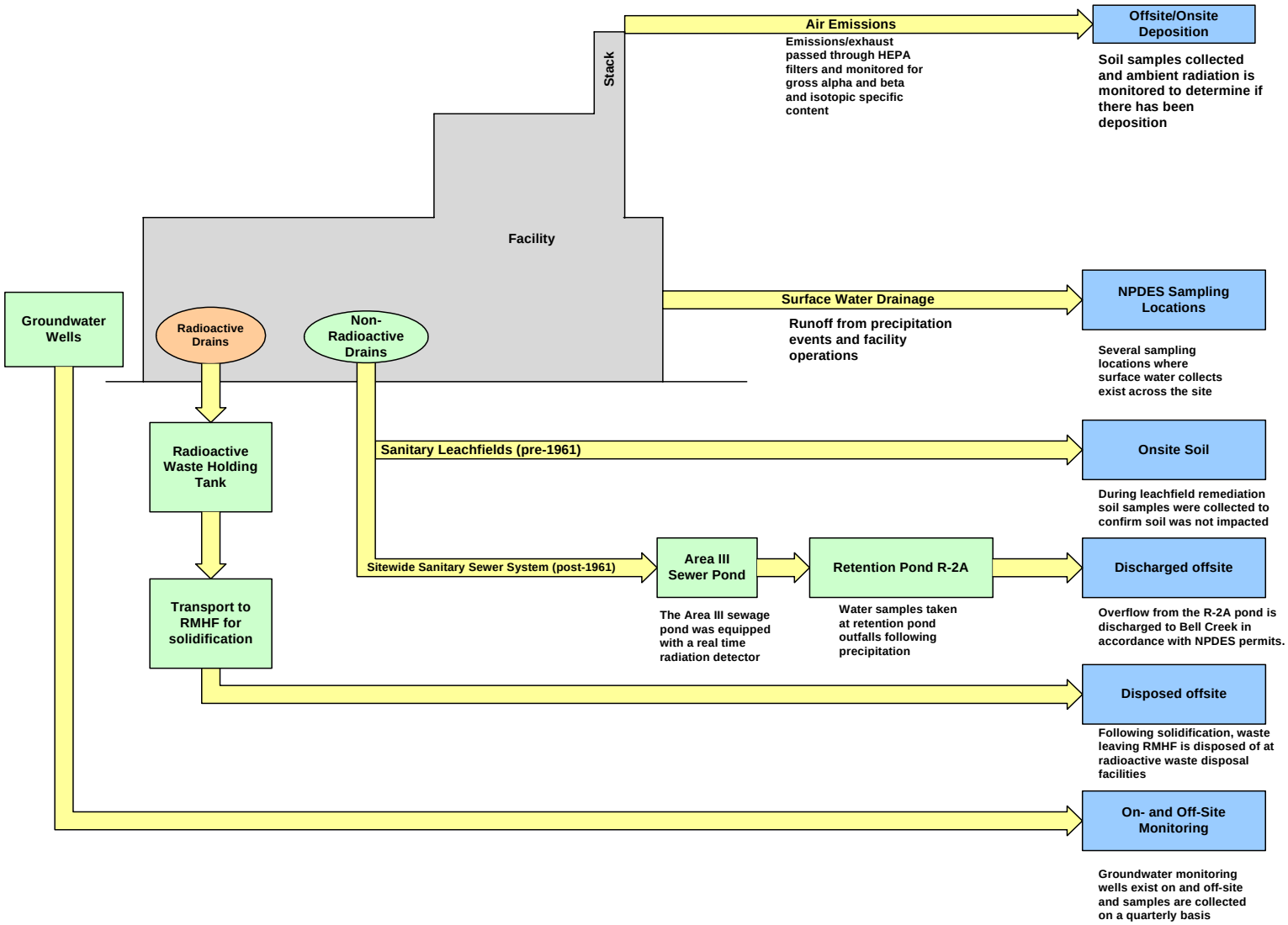
Between 1954 and 1986, vegetation was regularly sampled for radiological contamination within Area IV and offsite. After 1986, as nuclear operations were reduced, vegetation was monitored intermittently. In 2000 a comprehensive vegetation survey (gamma emitting radionuclides) was completed in response to stakeholder concerns to determine if radioactive vegetation was present in Area IV.

Wildlife

Area IV is home to an abundance of terrestrial wildlife; an aquatic environment is not present in Area IV. While there is no concerted effort to collect terrestrial wildlife samples, occasional samples of road kill are analyzed for the presence of radiological contamination.

[13] Measurements taken prior to 1963 did not measure alpha activity.

Figure 3-5. Summary of Area IV Facility Monitoring Program



Section 4.0 – Site Results and Conclusions

4.1 Classification of Area IV Sites

All sites that exist or had existed in Area IV were evaluated based on operational history to determine if they were potentially radiologically impacted. Sites were classified based on the process described in Section 3.0, Figure 3-1.

If there was no indication radiological material was managed at a site, the site was classified as non-impacted. If regulated radiological material was managed at a site or historical survey records indicated a site had been contaminated, then it was classified as impacted.

Table 4-1 provides the two resulting site classifications. Figure 4-1 identifies the location of impacted sites.

A total of 95 sites were classified as impacted or potentially impacted by radiological materials. Appendix D is a crosswalk of how the 95 impacted sites correlate with the 27 radiological facilities previously identified in Area IV.[1]

Sites classified as non-impacted totaled 177. At these non-impacted sites, regulated radiological material was not handled, nor is there any history of radiological contamination.

4.2 Remaining Survey Activities

Following initial classification, all impacted sites were analyzed using the decision process depicted in Figures 3-2 and 3-3. Impacted sites that have been released require no further action. Impacted sites that have not been released require further action per the MARSSIM classification.

Table 4-2 provides the status of impacted sites. In total, 27 sites require further surveys. Figure 4-2 identifies areas that require further survey activities.

4.3 Conclusions

Based on the information and analysis presented in the Area IV HSA, the 272 Area IV sites are classified as:

- 177 non-impacted sites that require no further action
- 95 impacted sites whose status is:
    - 68 sites and adjacent soil that have previously been released by cognizant regulatory agency and do not require further action

[1] Historically, only 27 radiological facilities have been identified in Area IV. However, some facilities consist of several sites, which accounts for the increase in the number of impacted sites. A crosswalk identifying the sites that compose the 27 radiological facilities is included in Appendix F.

  - 2 sites where building surveys are required prior to being released

- 10 sites whose buildings were released and require no further action but whose footprints require further soil sampling to be released.

- 15 sites that have not been released and require additional survey activities

The 27 sites that require further action will undergo surveys planned using MARSSIM protocol appropriate for the site classification. Final status surveys for these sites will be submitted to the appropriate regulatory agencies for release.

Site	Impacted	Group
4001	No	Not Built
4003	Yes	G
4005	Yes	O
4006	Yes	O
4007	No	Q
4008	No	Q
4009	Yes	CC
4010	Yes	L
4011	Yes	R
4012	Yes	L
4013	No	L
4014	No	E
4015	No	W
4019	Yes	L
4020	Yes	AA
4021	Yes	I
4022	Yes	I
4023	Yes	J
4024	Yes	J
4025	No	J
4026	No	P
4027	No	J
4028	Yes	K

Site	Impacted	Group
4029	Yes	E
4030	Yes	E
4032	Yes	J
4033 (Included in 4053)	No	E
4034	No	I
4035 (Included in 4030)	Yes	E
4036	No	J
4037	No	J
4038	No	V
4039	Yes	V
4040	Yes	D
4041	Yes	G
4042	Yes	J
4043 (Included in 4053)	No	E
4044	Yes	I
4046	No	E
4048	No	N
4049	Yes	N
4052	No	Not Built
4053	No	E
4055	Yes	X
4056 Landfill	No	V
4057	No	V

Site	Impacted	Group
4059	Yes	M
4062	No	U
4063	No	F
4064	Yes	E
4065	Yes	U
4066	No	U
4073	Yes	H
4074	No	H
4075	Yes	I
4083	Yes	H
4093	Yes	H
4100	Yes	BB
4100 Trench (Included in 4100)	No	BB
4103 (Included in 4083)	Yes	H
4113 (Included in 4511)	No	A
4114	No	A
4123	Yes	H
4133	No	G
4143	Yes	G
4153	No	G
4155 (Included in 4055)	Yes	X
4163	Yes	G

Site	Impacted	Group
4171	No	R
4172	No	R
4173	No	Y
4183	No	G
4184	No	G
4185	Yes	G
4226	No	P
4228	No	L
4273	Yes	F
4283	Yes	F
4293	No	P
4310	No	P, L
4313 (Included in the OCY)	No	A
4314 (Included in 4814)	No	DD
4316 (Included in 4273)	No	F
4317	No	DD
4318[2]	No	DD
4320	No	C
4323 (Included in 4020)	No	AA
4333 (Included in 4513)	No	E
4334	No	P

[2] This site was renumbered later as 4820.

Site	Impacted	Group
4335	No	P
4343 (Included in 4573)	No	W
4353	Yes	Z
4354	No	P
4355	No	P
4356	No	P
4357	No	P
4358	No	P
4359	No	P
4360	No	P
4361	No	P
4362	No	P
4363	Yes	Y
4373	Yes	W
4374	No	W
4375	Yes	Y
4383	No	S
4392	No	P
4393 (Included in 4383)	No	S
4402	No	O
4403 (Included in 4011)	No	R
4413 (Included in 4013)	No	L

Site	Impacted	Group
4413 (Included in 4143)	Yes	G
4425	No	DD
4426 (Included in 4026)	No	P
4453	Yes	H
4457	No	P
4459	No	M
4461	No	T
4462	No	T
4463	No	T
4468	Yes	AA
4473	No	Y
4478	No	P
4482	No	S
4483	No	S
4484	No	S
4485	No	S
4486	No	S
4487	No	S
4500	No	R
4501	No	Q
4502	No	P
4504	No	K
4505	No	G

Site	Impacted	Group
4506	No	O
4509	No	CC
4510	No	BB
4511	No	A
4513	No	E
4514 (Included in 4814)	No	DD
4520	No	AA
4521	No	R
4523	No	H
4524	No	J
4535	Yes	E
4536	No	J
4537	No	J
4538	No	S
4540	No	D
4553	No	Z
4563	Yes	I
4573	No	W
4575	Yes	Y
4583-New Salvage Yard	No	B
4583-Old ESG Storage Yard	Yes	C
4606	No	O
4607	No	O

Site	Impacted	Group
4611	No	R
4612	No	R
4614	Yes	I
4615	No	O
4616 (Included in 4006)	Yes	O
4621	Yes	I
4622	Yes	I
4623 (Included in 4511)	No	A
4624 (Included in 4040)	No	D
4625	No	J
4626	No	V
4633	No	H
4636 (Included in 4536)	No	J
4638	No	Not Built
4639	No	Not Built
4640	No	Not Built
4641	Yes	E
4643	Yes	H
4653	Yes	G
4654	Yes	G
4656 (Included in 4356)	No	P
4657 (Included in 4502)	No	P

Site	Impacted	Group
4658	No	I
4662	No	T
4663	Yes	I
4664	Yes	I
4665	Yes	I
4683 (Included in 4143)	No	G
4684	No	G
4686	Yes	G
4687	Yes	G
4688	Yes	I
4689	Yes	G
4693 (Included in 4003)	No	G
4695	Yes	G
4701	No	FF
4702	No	FF
4703	Yes	G
4704	No	O
4705 (Included in 4005)	No	O
4706 (Included in 4006)	No	O
4707 (Included in 4015)	No	W
4708 (Included in 4228)	No	L
4709 (Included in 4009)	No	CC

Site	Impacted	Group
4710 (Included in 4228)	No	L, CC
4711 (Included in 4011)	No	R
4713 (Included in 4012, 4013)	No	L
4714	No	G, O
4719 (Included in 4019)	No	L
4720 (Included in 4020)	No	AA
4723	Yes	G
4724	Yes	G
4725 (Included in Building 4024, 4025)	No	J
4726 (Included in 4026)	No	P
4727 (Included in Building 4027, 4032, 4036, 4037)	No	J
4730	No	DD
4731	No	C
4732	No	C
4733	Yes	G
4735	No	R
4742 (Included in Building 4042)	No	J
4743	Yes	G
4753	Yes	G
4755 (Included in 4055)	Yes	X
4756 (Included in 4355)	No	P

Site	Impacted	Group
4757 (Included in 4038, 4057)	No	V
4759 (Included in 4059)	No	M
4760 (Included in 4462)	No	T
4762 (Included in 4062, 4065, 4066)	No	U
4763 (Included in 4063)	No	F
4773	Yes	G
4780 (Included in 4463)	No	T
4783 (Included in 4014)	No	E
4793	No	H, N
4800 (Included in 4100)	No	BB
4805 (Included in 4026)	No	P
4806 (Included in 4502)	No	P, U
4807 (Included in 4010, 4228)	Yes	L
4808 (Included in 4010, 4228)	Yes	L
4809 (Included in 4010, 4228)	Yes	L
4810	No	Not Built
4811 (Included in 4028)	No	K
4814	No	DD
4816 (Included in 4606)	No	O
4820	Yes	DD
4823 (Included in 4013)	No	L,Q

Site	Impacted	Group
4826	No	P
4836 (Included in 4536)	No	J
4848 (Included in 4373)	Yes	W
4853 (Included in 4353)	Yes	Z
4854	No	Z
4863	No	Y
4864 (Included in 4064)	Yes	E
4865 (Included in 4173)	No	Y
4873	No	Y
4874	Yes	Y
4875	Yes	Y
4883 (Included in 4383)	No	S
4885	No	EE
4886	Yes	EE
4893 (Included in 4093)	Yes	H
4894 (Included in 4143)	Yes	G
4895 (Included in 4143)	Yes	G
4896 (Included in 4143)	Yes	G
4897 (Included in 4143)	Yes	G
4898 (Included in 4143)	Yes	G
4924 (Included in 4025)	No	J

Site	Impacted	Group
4925 (Included in 4025)	No	J
4926 (Included in 4025)	No	J
4927	No	J
4928 (Included in 4024)	Yes	J
4XXX (Included in 4030 and 4641)	No	E
4XXX (Included in 4228)	No	L
17th St. Drainage Area	Yes	Q
Old Conservation Yard (OCY)	Yes	A

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4003	Impacted	DOE released facility and adjacent soil in 1985	None
4005	Impacted	DHS released building and adjacent soil in 1995	None
4006 (Includes 4616)	Class III Regulated radiological material was handled here	Currently standing but inactive	MARSSIM compliant Class III survey of the building
4009	Impacted	DHS released building and adjacent soil in 1999	None
4010 (Includes 4807, 4808, 4809)	Impacted	DOE released facility and adjacent soil in 1982	None
4011	Impacted	DHS released building in 1998	None
4012	Impacted	DOE released the building in1997 DHS concurred with building release in 1997	None
4019	Impacted	Surveyed in 1998 DOE confirmed that DOE and DHS approved cleanup limits had been met; the building is suitable for release for unrestricted use	MARSSIM compliant Class II survey in the building footprint when the building is demolished
4020	Impacted	Surveyed in 1999 DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use	None
4021 (RMHF)	Class I Process history	Currently active	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4022 (RMHF)	Class I Process history	Currently active	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4023	Impacted	DOE released the building in 1997 DHS concurred with building release in 1998. *[Note: Soil sampling was not conducted]*	MARSSIM compliant Class II survey in the building footprint

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4024 (Includes 4928)	Class I Process history and decontamination	The first phase of decontamination has been completed, the building has not been demolished	MARSSIM compliant Class II survey in the building footprint when the building is demolished
4028	Impacted	DOE released the building in 1997 DHS concurred with building release in 1995. *[Note: Soil sampling was not conducted]*	MARSSIM compliant Class II survey in the building footprint
4029	Impacted	DOE released the building and adjacent soil in 1997 DHS concurred with building and adjacent soil release in 1995	None
4030 (Includes 4035)	Impacted	DOE released the building in 1997 DHS concurred with building release in 1999. *[Note: Soil sampling was not conducted]*	MARSSIM compliant Class II survey in the building footprint
4032	Class III Sealed sources were handled here	Surveyed in 1988 Demolished in May 2003	None
4039	Impacted	Surveyed in 2003 Demolished in 2003	None
4040	Impacted	Surveyed in 1997 Demolished in 1997	None
4041 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4042	Class III Possible VO2 powder handled at the facility	Surveyed in 1988 Demolished in May 2003	None
4044 (RMHF)	Class III Regulated radiological material was handled here	Currently active	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4049 (Uranium Carbide Fuel Pilot Plant)	Impacted	Surveyed in 1988 Demolished in 1999	None
4055 (Includes 4155, 4755)	Impacted	NRC released building and land in 1987	None

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4059	Impacted	DOE approved building 4059 for demolition in 2003 Land pending DOE confirmation that release criteria are met Class I final status survey has been performed	Complete and submit to DOE and DHS a MARSSIM compliant final status survey report
4064 (Includes 4864)	Impacted	DOE released building in 1996 DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use	None
4065	Class III Sealed sources were handled here	Demolished in 1999	None
4073	Impacted	ERDA released facility and adjacent soil in 1976	None
4075 (RMHF)	Class II Impacted by drainage from RMHF	Currently standing but inactive	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4083 (Includes 4103) (L-85)	Impacted	NRC released building and adjacent soil in 1987	None
4093 (Includes 4893)	Impacted	NRC released building and adjacent soil in 1987	MARSSIM compliant Class II survey in the building footprint when the foundation is removed
4100	Impacted	NRC released building in 1980	MARSSIM compliant Class II survey in the building footprint when the building is demolished
4123 (KEWB)	Impacted	ERDA released facility and adjacent soil in 1976	None
4143 (Includes 4413, 4894, 4895, 4896, 4897, 4898)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4163 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4185 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4273	Class III Regulated radiological material was handled here	Soil surveyed in 1988 Demolished in 1976	None
4283	Class III Regulated radiological material was handled here	Soil surveyed in 1988 Demolished in 1976	None
4353 (Includes 4853)	Impacted	Septic tank surveyed in 2001 Demolished in the late 1970s, concrete pad and septic tank removed in 2001	None
4363	Impacted	DHS released building in 1998 [*Note: Soil sampling was not conducted]*	MARSSIM compliant Class II survey in the building footprint
4373 (Includes 4848)	Impacted	DHS released building in 1995 [*Note: Soil sampling was not conducted]*	None
4375	Impacted	DHS released building in 1995 [*Note: Soil sampling was not conducted]*	None
4453 (L-85)	Impacted	NRC released building and adjacent soil in 1987	MARSSIM compliant Class III survey in the building footprint when the foundation is removed
4468 (Hot Laboratory)	Impacted	Surveyed in 1999 DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use	None
4535	Class III Regulated radiological material was handled here	Surveyed in 1988 Demolished in 2004	None
4563 (RMHF)	Class II Impacted by drainage from RMHF	Currently active	MARSSIM compliant Class I survey of the soil footprint following building demolition.

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4575	Impacted	Surveyed in 1988 Demolished in 1999	None
4583 (Old ESG Storage Yard)	Class III Handled regulated radiological material	Soil surveyed in 1988 This area was replaced with the Fuel Oil Tank Farm in the early 1980s	MARSSIM compliant Class III survey of the site
4614 (RMHF)	Class I Process history and decontamination	Currently active	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4621 (RMHF)	Class II Contamination above 20% of DCGL	Currently active	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4622 (RMHF)	Impacted	Demolished in 1976	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4641	Class III Regulated radiological material was handled here	Surveyed in 1988 Demolished in 2004	None
4643 (KEWB)	Impacted	ERDA released facility and adjacent soil in 1976	None
4653 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4654	Impacted	Surveyed in 1999 DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use	None
4663 (RMHF)	Impacted	Demolished in 1970s, concrete pad serves as non-radioactive storage	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4664 (RMHF)	Impacted	Demolished in the early 1980s	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4665 (RMHF)	Class III Regulated radiological material was handled here	Currently active, storage of non-radioactive materials and equipment	MARSSIM compliant Class I survey of the soil footprint following building demolition.

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4686 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4687 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4688 (RMHF)	Class III Regulated radiological material was handled here	Currently active, storage of non-radioactive materials and equipment	MARSSIM compliant Class I survey of the soil footprint following building demolition.
4689 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4695 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4703 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4723 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4724 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4733 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4743 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4753 (SRE)	Impacted	DOE released facility and surrounding soil as part of 1985 SRE release	None
4773 (SRE)	Impacted	DOE released facility and adjacent soil as part of 1985 SRE release	None
4820	Class III Regulated radiological materials were handled here	Soil surveyed during the Area IV Characterization Survey in 1995 Demolished in the middle 1970s	None

Site	Site Classification	Release Survey Status	Remaining Survey Activities Required for Release
4874	Class III Evidence suggests contaminated barrels were stored here	Soil surveyed in 1988 Demolished in the middle 1970s	None
4875	Class III Evidence suggests contaminated barrels were stored here	Soil surveyed in 1988 Demolished in the middle 1970s	None
4886	Impacted	DHS released soil in 1998	None
17th Street	Impacted	DHS released soil in 2004 DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use	None
OCY	Impacted	DHS released soil in 1995	None

Appendix A – Area IV Radiological Background Soil Data

A.1 Site Survey Background

During the 1990s, extensive media sampling programs were conducted on SSFL's northern neighbors (including the Brandies-Bardin Institute and the Santa Monica Mountains Conservancy), the Bell Canyon neighbors to the south, the Rocketdyne Recreation Center in West Hills, various private homes in the Chatsworth and West Hills locales, and places as far a-field as Wildwood Park and Tapia Park. During this period, all soil samples were analyzed for isotope-specific content.

In addition to Boeing-led efforts, independent off-site sampling has been performed by 15 separate organizations.

- ANL – Argonne National Laboratory
- DHS/EMB – California Department of Health Services - Environmental Management Branch
- DHS/RHB – California Department of Health Services - Radiologic Health Branch
- EPA/ORIA – US Environmental Protection Agency - Office of Radiation and Indoor Air
- Essentia- Essentia Management Services for Los Angeles City Department of Water and Power
- Joel Cehn (consultant to the Brandies-Bardin Institute)
- Kleinfelder-for Washington Mutual
- LLNL – Lawrence Livermore National Laboratory
- McLaren-Hart Environmental Engineering Corp.
- ORAU – Oak Ridge Associated Universities
- ORISE – Oak Ridge Institute of Science and Education
- Ogden Environmental and Energy Services
- RWQCB – Regional Water Quality Control Board

Table A-1 shows the media sampled by these organizations and the sampling periods. None of these off-site soil-sampling projects were conducted specifically to fulfill the requirements of a "MARSSIM reference area." Depending on the project, not all analytes were conducted for every sample. For instance, the initial Off-Site Multi-Media Study conducted by McLaren-Hart in 1992 did not analyze for isotopic uranium or thorium. Different laboratories were utilized by different agencies and organizations, sometimes with significantly different

detection levels. In general, soil samples were taken at the surface only (0 to 6 inches in depth).

Although all data from these different projects has been compiled into a single database, use of the entire database as a "MARSSIM reference dataset" is problematic for the reasons stated above. Soil samples taken during the 1998 Bell Canyon sampling project have been utilized as a suitable "MARSSIM reference dataset." Bell Canyon data is suitable for the following reasons:

- Sampling date of 1998 is relatively contemporary.
- A sufficient number of samples were taken to facilitate use in the Wilcoxon Rank Sum test if required
- All samples were taken with the oversight of the DHS, EPA and DTSC.
- All samples were analyzed by gamma spectroscopy for gamma emitting radionuclides (including Cs-137, Co-60, Eu-152, Eu-154), Sr-90, H-3, and alpha spectroscopy for U-234, U-235, U-238, Th-228, Th-230, Th-232, Pu-238 and Pu-239/240.
- Samples were analyzed at the same State certified laboratory using the same protocols.
- Splits of selected samples were analyzed by the EPA and confirmed Boeing sample results.
- No samples indicated evidence of contamination from the SSFL.
- DHS and the EPA stated that sample results do not indicate any contamination resulting from the SSFL.
- Sampling location geology and topography were similar to that of the SSFL on the Chatsworth Formation of the Simi Hills on the Los Angeles-Ventura County line.
- Sampling location is sufficiently close to the SSFL that weapons-test fallout should be similar yet sufficiently far that it has not been impacted by the SSFL.
- Soil data is cited in "Bell Canyon Area Soil Sampling Report, Ventura County, California," prepared by Ogden Environmental and Energy Services Co., Inc. for Boeing North American, October 1998.

The range of Bell Canyon data is shown in Table A-2. All samples were surface samples (0 to 6 inches depth) and were taken in locations of uncultivated land, home backyards and Bell Creek stream bank material. Specific sampling locations were random and not based on a uniform grid pattern. Locations were chosen by consensus of Boeing personnel, homeowners and agency personnel. Locations are shown on Figure A-1.

A.2 Relevance of Background to MARSSIM

For situations when the mean background is much smaller than the DCGL, knowledge of background is not very important. Background can be conservatively assumed to be zero and the gross soil concentration measurement can be directly compared to the net DCGL using the Sign Test. The Sign Test ignores background. This is possible for the majority of contaminants of concern including Cs-137, Sr-90, Co-69, all uranium isotopes, all plutonium isotopes, etc.

When the DCGL is approaching the mean or variability of background, then precise knowledge of background is very important. When the DCGL is less than the mean background or variability in background, then identification of contamination at the DCGL is problematic.

A.3 Depth Profile of Background

Primordial radionuclides, such as uranium isotopes, thorium isotopes and radium isotopes, which are derived from erosion of rocks, are likely to be independent of depth in native soil. In contrast, weapons test fallout such as Cs-137, Sr-90 or the plutonium isotopes are likely to be concentrated in the top six inches of soil in uncultivated soil. In completely uncultivated soil one would not expect to find any of these isotopes at increasing depth. These isotopes are only likely to be present at lower depths in cultivated, excavated and/or backfilled soil or when the chemical form of the isotope is highly soluble and transportable by water.

Therefore, reference background, Bell Canyon data for primordial radionuclides, taken predominantly from the surface should be characteristic of soil at any depth, and could be compared with primordial radionuclides taken from site-sampled areas at any depth. This is not necessarily the case for typical fallout radionuclides. However, since DCGLs for fallout radionuclides (Cs-137, Sr-90, Pu isotopes) are so much larger than typical background levels (see above), this should not be an issue.

Although it is important for the Wilcoxon Rank Sum Test to compare soil of similar characteristics (including depth), it is important to remember that the DCGL is added to the reference data set. The DCGL is derived by assuming uniform contamination from the surface to a 1 to 2-meter depth. Any depth profile dissimilarities in the soil data are therefore completely overshadowed by the uniform profile of the DCGL.

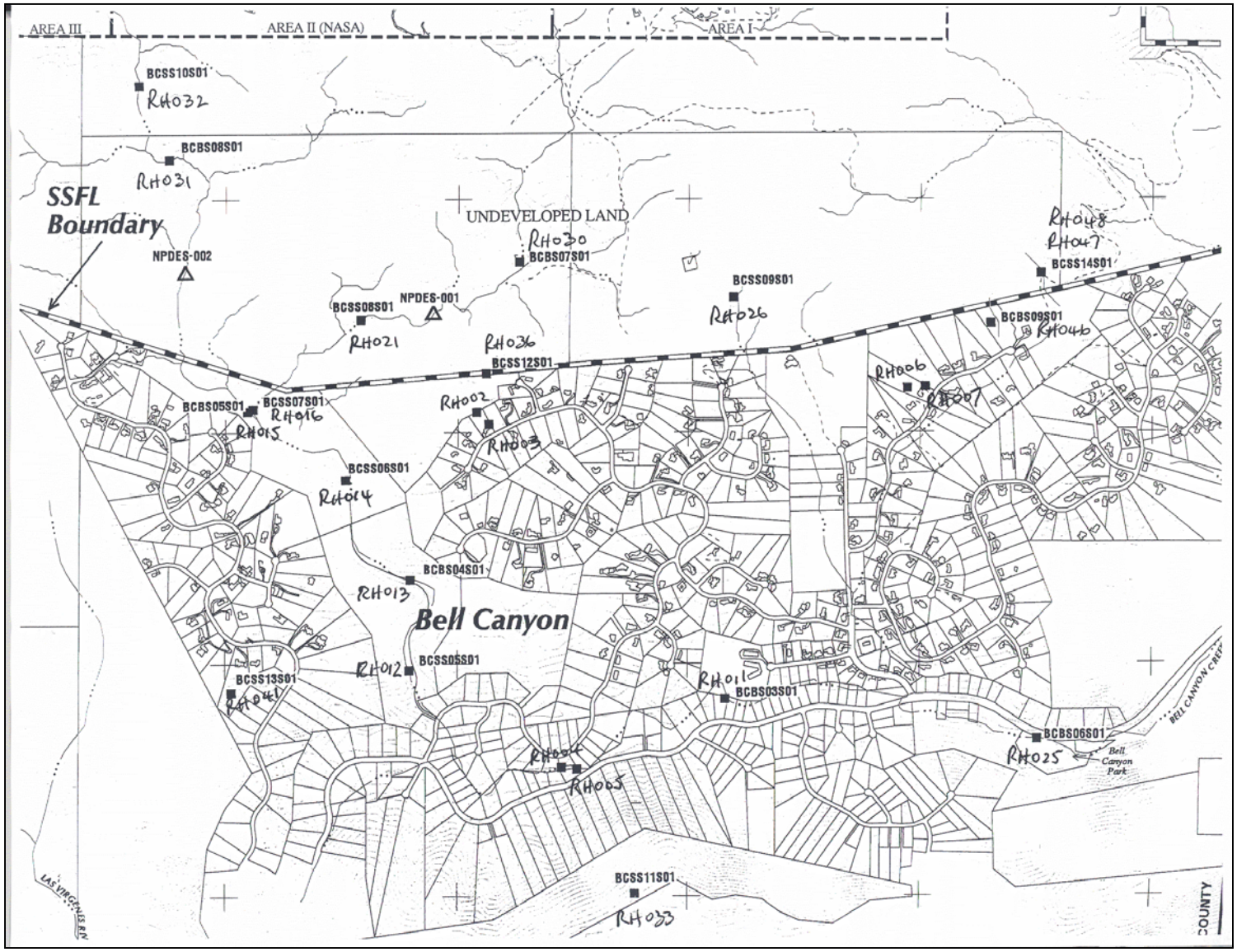
Table A-1. Environmental Sampling for Radiation/Radioactivity Surrounding Santa Susana

Environmental Sampling for Radiation/Radioactivity Surrounding Santa Susana					
Location	**Media Sampled (Date Range and Organization)**				
	Soil	**Groundwater**	**Surface water**	**Airborne Particulates**	**Radiation Exposure**
On-site	1956-Present (Rocketdyne) 1975, 81, 84 (ANL) 1986-87 (ORAU) 1992-Present (ORISE) 1993 (RWQCB) 1992-Present (DHS-RHB) 1994-95 (DHS-EMB)	1960-Present (Rocketdyne) 1998 (EPA-ORIA)	1970-Present (Rocketdyne) 1993-98 (RWQCB)	1956-Present (Rocketdyne)	1971-Present (Rocketdyne) 1975, 81, 84 (ANL) 1981-Present (DHS-RHB) 1986-87 (ORAU) 1992-Present (ORISE)
North Off-site	1956-89 (Rocketdyne) 1992-94 (McLaren-Hart) 1992-94 (EPA-ORIA) 1992-94 (DHS-EMB) 1991-97 (Cehn) 1995 (Rocketdyne) 1995 (ORISE)	1984-Present (Rocketdyne) 1991-96 (Cehn) 1998 (EPA-ORIA)	1992-94 (McLaren-Hart) 1992-94 (EPA-ORIA) 1992-94 (DHS-EMB) 1992-94 (Cehn)	1989 (DHS-RHB & LLNL)	1974-Present (Rocketdyne) 1992-94 (EPA-ORIA) 1995 (ORISE)
East Off-site	1956-89 (Rocketdyne) 1986 (ORAU) 1994 (Rocketdyne) 1995 (ORISE) 1997 (LLNL) 2004 (Essentia)	1984-Present (Rocketdyne) 2004 (Essentia)	1961-71 (Rocketdyne)	1959-Present (Rocketdyne)	1974-Present (Rocketdyne) 1986 (ORAU) 1995 (ORISE)
South Off-site	1956-89 (Rocketdyne) 1992-94 (McLaren-Hart) 1992-94 (EPA-ORIA) 1992-94 (DHS-EMB) 1992-94 (Cehn) 1995 (Rocketdyne) 1998 (Ogden)	1984-Present (Rocketdyne)	1966-89 (Rocketdyne)	1989 (DHS-RHB & LLNL)	1974-Present (Rocketdyne)
West Off-site	1956-64 (Rocketdyne) 1992-94 (McLaren-Hart) 1992-94 (EPA-ORIA) 1992-94 (DHS-EMB) 1992-94 (Cehn) 1995 (Rocketdyne) 1999 (Kleinfelder)	1984-Present (Rocketdyne) 2003 (DHS-RHB)	1999 (Kleinfelder)	None	1974-Present (Rocketdyne)

Table A-2. Bell Canyon Background Data

Isotope	Soil Concentration (pCi/g)					Comments
	Mean	Std. Dev.	Range		Mean MDA	
			Minimum	Maximum		
Cs-137	0.053	0.05	0.01	0.18	0.03	13 of 24 samples non-detect
Sr-90	-0.018	0.04	-0.09	0.04	0.14	all 24 samples non-detect
U-234	0.73	0.21	0.36	1.00	0.03	
U-235	0.044	0.02	0.01	0.07	0.02	
U-238	0.73	0.21	0.37	1.10	0.02	
Th-228	0.87	0.25	0.43	1.30	0.06	
Th-230	0.74	0.28	0.35	1.40	0.08	
Th-232	0.87	0.25	0.44	1.50	0.15	
Pu-238	0.0017	0.0082	-0.01	0.03	0.04	all 24 samples non-detect
Pu-239/240	0.0025	0.0061	-0.01	0.02	0.03	all 24 samples non-detect
Ra-226	0.94	0.31	0.5	1.5	0.05	
K-40	22.1	1.7	19	25	0.25	

Figure A-1. Bell Canyon Sampling Locations



Appendix B – Derived Concentration Guideline Levels for Soil

B.1 DCGL Background

Boeing established DCGLs for soil based on the RESRAD exposure pathway analysis in N001SRR140131 (Reference 1). The DOE and the DHS approved these DCGLs for use in the remediation of radiological facilities at the SSFL.

The most realistic anticipated exposure pathway was determined to be suburban residential for the SSFL site. During the original formulation of these DCGLs in 1996, a 15 mrem/yr exposure goal was chosen. This was consistent with both NRC and EPA exposure goals at that time. Subsequently, the NRC issued 10 CFR 20 Subpart E, License Termination Rule, based on a higher dose of 25 mrem/yr. The EPA currently maintains its position that 15 mrem/yr is fully protective of public health. The DOE has adopted the NRC's 25 mrem/yr standard for other DOE facilities.

B.2 Residual Radioactivity (RESRAD) Versions

The original DCGLs for soil were calculated using RESRAD Version 5.61 in 1996. Subsequently, many revisions have been released and the current version, as of July 2003, is Version 6.21. Site-specific scenarios have been run using some of these revisions, including the latest. See Table B-1. There is little change in most soil DCGLs as a result of RESRAD revisions. The H-3 DCGL has decreased from 31,900 to 4,511 pCi/g-soil. Even this value far exceeds the more limiting groundwater SSFL DCGL of 20,000 pCi/L-water, and therefore the change does not impact remediation requirements. Alpha emitting plutonium DCGLs have increased approximately a factor of 2.5 which would relax remediation requirements.

B.3 Site Specific Input Parameters

Several site-specific input parameters were chosen that deviated for the RESRAD standard defaults. These are discussed in N001SRR140131, and summarized here.

B.3.1 Site Hydrology

- Total soil porosity was increased from 0.4 to 0.43.
- Contaminated zone hydraulic conductivity was increased from 10 m/yr to 3,000 m/yr.
- Saturated zone hydraulic conductivity was increased from 100 m/yr to 3,000 m/yr.
- Uncontaminated and unsaturated strata hydraulic conductivity was increased from 10 m/yr to 3,000 m/yr.
- Precipitation rate was reduced from 1 m/yr to 0.47 m/yr.
- Well pumping model was reduced from 250 m^3/yr to 70 m^3/yr.

B.3.2 Source of Contamination

- Thickness of the contaminated zone was reduced from 2 meters to 1 meter.

B.3.3 Home Grown Food Consumption

- Fruit and vegetable and grain consumption was reduced from 160 kg/yr to 16 kg/yr.
- Leafy vegetable consumption was reduced from 14 kg/yr to 1.4 kg/yr.

B.3.4 House Construction and Occupancy

- External gamma shielding factor was reduced from 0.7 to 0.51.
- Building foundation thickness was reduced from 0.15 m to 0.1 m.
- Foundation depth below ground surface was reduced from 1 m to 0.1 m.

In addition, several site-specific food pathway input parameters were chosen for the suburban residential scenario that deviated for the RESRAD resident farmer (agricultural) scenario defaults. These are discussed in N001SRR140131, and are summarized here.

B.3.5 Food Pathway

- Since a suburban residential scenario was modeled, the meat, milk and aquatic food ingestion pathways were suppressed.
- Milk consumption was reduced from 92 L/yr to 0 L/yr.
- Meat and Poultry consumption was reduced from 63 kg/yr to 0 kg/yr.
- Fish consumption was reduced from 5.4 kg/yr to 0 kg/yr.
- Other seafood was reduced from 0.9 kg/yr to 0 kg/yr.
- Livestock water contamination was suppressed.
- Aquatic pond contamination was suppressed.
- Livestock fodder and water intake was suppressed.

Consequently, hydrological parameters have been changed from the default values to the site-specific input values. Total soil porosity was increased from 0.4 to 0.43, a relatively small change. Hydraulic conductivity was increased from 10/100 to 3,000 m/yr, a very conservation assumption for groundwater contaminant transport.

In order to assess the impact of different exposure scenarios and site-specific input data, various parametric analyses have been performed using the latest RESRAD 6.21 default data sets for recreationist, industrial worker, suburban resident and resident farmer. (See Table B-

2.) Although resident farmer DCGLs are lower than suburban resident DCGLs, analysis of post-remedial soil sample data using the Wilcoxon Rank Sum Test demonstrates that even the more restrictive resident farmer DCGLs are met. Cesium-137, the primary radionuclide of concern (ROC), is reduced from 9.2 to 6.1 pCi/g in the most restrictive resident farmer scenario. At the other end of the spectrum, the recreationist (parkland) scenario DCGLs are significantly larger and less restrictive that the suburban resident DCGLs.

B.4 Comparison to EPA/NRC Memorandum of Understanding Soil DCGLs

The approved DCGLs are compared in Table B-3 to the residential soil concentration goals from the EPA/ NRC Memorandum of Understanding (MOU) (Reference 2). The SSFL DCGLs for 60% of the radioisotopes are more restrictive that the EPA/NRC DCGLs. Cesium-137, the primary COC, is reduced from 9.2 to 6 pCi/g for the MOU DCGL, an identical level to the RESRAD resident farmer DCGL.

B.5 Comparison to EPA Preliminary Remediation Goals and Dose Compliance Concentrations

The EPA has published Preliminary Remediation Goals (PRGs) based on a theoretical 10^{-6} risk level (EPA 3). See Table B-4 for PRGs. Data for a 10^{-4} risk level can be calculated simply by multiplying the PRGs by 100. These ranges of soil concentration therefore represent the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) risk range of 10^{-6} to 10^{-4}. Note that the 10^{-4} risk level data corresponds with the EPA/NRC MOU data in Table B-3. The EPA 10^{-4} PRGs exceed SSFL DCGLs for 15 isotopes. The SSFL DCGLs exceed EPA 10^{-4} PRGs for 10 isotopes.

The EPA has also published Dose Compliance Concentrations (DCCs) corresponding to a 15 mrem/year residential scenario (Reference 4). These are also shown on table B-4. The EPA DCCs exceed SSFL DCGLs for 21 isotopes. The SSFL DCGLs exceed EPA DCCs for 4 isotopes.

As summarized in Table B-4, 15 SSFL DCGLs fall within the 10^{-6} to 10^{-4} risk range and six SSFL DCGLs are less than a 3×10^{-4} risk level.

Table B-1. Soil DCGLs for a 15 mrem/yr Residential Scenario

	RESRAD (1996)			RESRAD Version 6.21			Derived Risk Standards based on RESRAD 6.21					
Isotope	**N001SRR140131 15 mrem/y dose based standard**			**15 mrem/y dose based standard**			**1 x 10^{-4} risk based standard**			**1 x 10^{-6} risk based standard**		
	Soil	**Soil ***	**Risk ****	**Dose**	**Risk**	**Soil**	**Risk**	**Dose**	**Soil**	**Risk**	**Dose**	**Soil**
	pCi/g	**pCi/g**		**mrem/y**		**pCi/g**		**mrem/y**	**pCi/g**		**mrem/y**	**pCi/g**
Am-241	5.44	5.44	1.1E-05	15	1.1E-05	5.53	1.0E-04	135	50	1.0E-06	1.35	0.50
Co-60	1.94	1.94	8.5E-05	15	9.1E-05	2.07	1.0E-04	16	2.3	1.0E-06	0.16	0.02
Cs-134	3.33	3.33	3.3E-05	15	3.9E-05	3.92	1.0E-04	38	10.0	1.0E-06	0.38	0.10
Cs-137	9.20	9.20	2.4E-04	15	2.5E-04	9.31	1.0E-04	6	3.8	1.0E-06	0.06	0.04
Eu-152	4.51	4.51	1.7E-04	15	1.8E-04	4.63	1.0E-04	9	2.6	1.0E-06	0.09	0.03
Eu-154	4.11	4.11	1.3E-04	15	1.4E-04	4.27	1.0E-04	11	3.1	1.0E-06	0.11	0.03
Fe-55	629,000	629,000	1.6E-04	15	2.0E-04	764,500	1.0E-04	7	381,297	1.0E-06	0.07	3,813
H-3	31,900	31,900	2.1E-04	15	2.9E-05	4,511	1.0E-04	51	15,486	1.0E-06	0.51	155
K-40	27.6	27.6	2.4E-04	15	2.5E-04	28.1	1.0E-04	6	11.3	1.0E-06	0.06	0.11
Mn-54	6.11	6.11	1.4E-05	15	2.0E-05	8.92	1.0E-04	74	44	1.0E-06	0.74	0.44
Na-22	2.31	2.31	3.9E-05	15	4.5E-05	2.66	1.0E-04	33	5.9	1.0E-06	0.33	0.06
Ni-59	151,000	151,000	8.6E-04	15	8.7E-04	153,900	1.0E-04	2	17,635	1.0E-06	0.02	176
Ni-63	55,300	55,300	6.9E-04	15	7.0E-04	56,260	1.0E-04	2	8,022	1.0E-06	0.02	80
Pu-238	37.2	37.2	1.3E-05	15	3.2E-05	90.9	1.0E-04	47	283	1.0E-06	0.47	2.8
Pu-239	33.9	33.9	1.4E-05	15	3.3E-05	82.1	1.0E-04	45	249	1.0E-06	0.45	2.5
Pu-240	33.9	33.9	1.4E-05	15	3.3E-05	82.1	1.0E-04	46	250	1.0E-06	0.46	2.5
Pu-241	230	230	1.2E-05	15	1.2E-05	234	1.0E-04	120	1,881	1.0E-06	1.20	19
Pu-242	35.5	35.5	1.3E-05	15	3.3E-05	86.3	1.0E-04	46	263	1.0E-06	0.46	2.6
Ra-226	0.20	5 and 15	5.0E-03	15	2.6E-04	0.26	1.0E-04	6	0.1	1.0E-06	0.06	0.001
Sr-90	36	36	1.9E-04	15	1.9E-04	36.7	1.0E-04	8	19.3	1.0E-06	0.08	0.19
Th-228	2.81	5 and 15	5.2E-05	15	3.7E-05	3.61	1.0E-04	40	9.6	1.0E-06	0.40	0.10
Th-232	1.53	5 and 15	9.5E-04	15	3.4E-04	1.77	1.0E-04	4	1	1.0E-06	0.04	0.01
U-234	106	30	3.1E-05	15	1.2E-04	114	1.0E-04	13	98	1.0E-06	0.13	0.98
U-235	32.1	30	2.3E-04	15	2.9E-04	38.3	1.0E-04	5	13.1	1.0E-06	0.05	0.13
U-238	90.9	35	6.3E-05	15	2.7E-04	149	1.0E-04	6	55	1.0E-06	0.06	0.55
Average				**15**	**1.8E-04**							

* Includes non-RESRAD ARAR soil standards for Ra-226, Th-238, Th-232, U-234. U-235 and U-238

** Equivalent risk of approved cleanup standards based on the EPA 2001 HEAST morbidity dose/risk factors in RESRAD 6.21 and 30 year exposure period.

Table B-2. Comparison of Site-Specific SSFL DCGLs with Default Exposure Scenarios

	Using RESRAD 6.21 (2003) Default Parameters				RESRAD 6.21 (2003) (SSFL Site Specific Residential)	N001SRR140131	
Isotope	Resident Farmer	Suburban Resident	Industrial Worker	Recreationist		RESRAD (1996) (Residential)	SSFL Approved Soil Guidelines (Residential)
Am-241	0.8	56	307	78	5.5	5.4	5.4
Co-60	1.7	1.7	5.9	55	2.1	1.9	1.9
Cs-134	2.9	3.3	11	35	3.9	3.3	3.3
Cs-137	6.1	7.8	27	47	9.3	9.2	9.2
Eu-152	3.9	3.9	13	384	4.6	4.5	4.5
Eu-154	3.6	3.6	12	353	4.3	4.1	4.1
Fe-55	33,110	621,600	3,295,000	39,120	764,500	629,000	629,000
H-3	601	6,176	129,500	4,150	4,511	31,900	31,900
K-40	8.6	22	87	31	28	28	28
Mn-54	7.3	7.5	25	709	8.9	6.1	6.1
Na-22	2.1	2.2	7.5	57	2.7	2.3	2.3
Ni-59	6,165	79,530	8,199,000	58,130	153,900	151,000	151,000
Ni-63	2,252	29,050	3,012,000	21,230	56,260	55,300	55,300
Pu-238	37	89	412	1,184	91	37	37
Pu-239	34	81	372	1,067	82	34	34
Pu-240	34	81	372	1,067	82	34	34
Pu-241	25	1,718	12,210	2,371	234	230	230
Pu-242	35	85	391	1,124	86	36	36
Ra-226	1.0	2.0	7.9	25	0.26	0.20	5 and 15*
Sr-90	2.5	19	2,791	9.4	37	36	36
Th-228	3.0	3.1	10	292	3.6	2.8	5 and 15*
Th-232	1.0	1.5	5.4	38	1.8	1.5	5 and 15*
U-234	14	523	2,633	1,729	114	106	30*
U-235	3.2	33	112	121	38	32	30*
U-238	15	133	487	1,995	149	91	35*

* Based on ARARs

Table B-3. Comparison of DCGLs and EPA/NRC MOU Standards for Soil

Nuclide	Residential Soil Concentration (pCi/g)	
	DCGL[1]	MOU[2]
Am-241	**5.44**	187
Co-60	**1.94**	4
Cs-134	**3.33**	16
Cs-137	9.2	**6**
Eu-152	4.5	**4**
Eu-154	**4.1**	5
Fe-55	629,000	**269,000**
H-3	31,900	**228**
K-40	**27.6**	-
Mn-54	**6.1**	69
Na-22	**2.3**	9
Ni-59	151,000	**20,800**
Ni-63	55,300	**9,480**
Pu-238	**37.2**	297
Pu-239	**33.9**	259
Pu-240	**33.9**	-
Pu-241	**230**	40,600
Pu-242	**35.5**	-
Ra-226	5	5
Sr-90	36	**23**
Th-228	**5**	15
Th-232	5	5
U-234	**30**	401
U-235	30	**20**
U-238	**35**	74

1. N001SRR140131, "Approved Sitewide Release Criteria for Remediation of Radiological Facilities at SSFL." February 18, 1999. Approved by DOE and DHS.

2. Memorandum of Understanding Between the Environmental Protection Agency and the Nuclear Regulatory Commission. October 9, 2002. EPA MOU numbers are based on EPA PRGs at a 10^{-4} risk level for a "reasonably anticipated" residential land use scenario.

3. More restrictive standard bolded and shaded.

Table B-4. Comparison of SSFL DCGLs, PRGs and DCCs

Nuclide	RESRAD SSFL DCGLs[1]			EPA PRG[2]		EPA DCC[2]			
	15 mrem/y	15 mrem/y incl. ARARs	Risk Equivalent (incl. ARARs)	10^{-4} risk	10^{-6} risk	15 mrem/yr (ICRP-60)	Risk Equivalent	15 mrem/yr (ICRP-30)	Risk Equivalent
	pCi/g	pCi/g		pCi/g	pCi/g	pCi/g		pCi/g	
Am-241	5.4	5.4	2.9E-06	187	1.9	295	1.6E-04	72	3.8E-05
Co-60	1.9	1.9	5.4E-05	3.6	0.036	13	3.6E-04	12	3.4E-04
Cs-134	3.3	3.3	2.1E-05	16	0.16	56	3.6E-04	53	3.4E-04
Cs-137	9.2	9.2	1.5E-04	6.0	0.060	21	3.6E-04	20	3.3E-04
Eu-152	4.5	4.5	1.1E-04	4.2	0.042	15	3.6E-04	14	3.4E-04
Eu-154	4.1	4.1	8.2E-05	5.0	0.050	18	3.6E-04	17	3.4E-04
Fe-55	629,000	629,000	2.3E-04	269,000	2690	1,710,000	6.4E-04	3,440,000	1.3E-03
H-3	31,900	31,900	1.4E-02	228	2.3	3,130	1.4E-03	7,600	3.3E-03
K-40	28	28	2.6E-04	11	0.11	39	3.6E-04	39	3.6E-04
Mn-54	6	6	8.8E-06	69	0.69	249	3.6E-04	235	3.4E-04
Na-22	2	2	2.7E-05	8.7	0.087	31	3.6E-04	29	3.4E-04
Ni-59	151,000	151,000	7.3E-04	20,800	208	91,200	4.4E-04	101,000	4.9E-04
Ni-63	55,300	55,300	5.8E-04	9,480	95	42,600	4.5E-04	40,900	4.3E-04
Pu-238	37	37	1.2E-05	298	3.0	358	1.2E-04	95	3.2E-05
Pu-239	34	34	1.3E-05	260	2.6	293	1.1E-04	77	3.0E-05
Pu-240	34	34	1.3E-05	261	2.6	294	1.1E-04	77	2.9E-05
Pu-241	230	230	5.6E-07	40,800	408	28,700	7.0E-05	7,480	1.8E-05
Pu-242	36	36	1.3E-05	274	2.7	305	1.1E-04	81	2.9E-05
Ra-226	0.20	5[3]	4.0E-04	1.2	0.012	4.0	3.2E-04	3.7	3.0E-04
Sr-90	36	36	1.6E-04	23	0.23	49	2.1E-04	36	1.6E-04
Th-228	2.8	5[3]	3.2E-05	15	0.15	56	3.6E-04	53	3.4E-04
Th-232	1.5	5[3]	1.6E-06	312	3.1	318	1.0E-04	99	3.2E-05
U-234	106	30[4]	7.5E-06	402	4.0	1,090	2.7E-04	700	1.7E-04
U-235	32	30[4]	1.5E-04	20	0.20	71	3.7E-04	64	3.3E-04
U-238	91	35[4]	4.7E-05	74	0.74	254	3.4E-04	233	3.1E-04

NOTE: Although soil DCGLs have been developed for these constituents, the shaded radionuclides above have not been identified as SSFL soil ROCs.

1. DOE and DHS approved cleanup standards from N001SRR140131
2. Using EPA online calculators for PRGs and DCCs
3. EPA and DOE ARARs for Ra-226 and thorium isotopes
4. NRC ARARs for Uranium isotopes

Appendix C – Radionuclides of Concern

C.1 Development of Radionuclides of Concern

The Area IV HSA includes a description of operations for each facility and assigns each facility a classification based on the potential for radiological contamination. A list of radionuclides of concern (ROCs) based on historical activities (reactor and nuclear support operations) and the potential for release of those contaminants into the environment was prepared based on information used to develop the Area IV HSA. The ROCs reflect both the materials used on-site (e.g., uranium-238 from fuel rods), as well as radioactive byproducts of operations (e.g., fission products such as cesium-137 and strontium-90). This list of ROCs is summarized in the Area IV HSA Volume 1, Tables 2-1 and 2-2.

In addition to a list of ROCs based on historical activities, Boeing has developed a list of cleanup goals for the remediation of Area IV. The DHS and the DOE approved these cleanup goals, known as DCGLs, in 1996.[1] The DCGLs were calculated using the RESRAD computer model so that annual dose as a result of exposure to residual radionuclides would not exceed 15 mrem/yr. The DCGLs were calculated for an exposure to a single radionuclide; however, multiple radionuclides are occasionally found in a single location (co-located) in Area IV, which could result in a dose greater than 15 mrem/year if each radionuclide present in soil is only cleaned up to its DCGL. To ensure protectiveness of future uses, Boeing's cleanup of Area IV employs the ALARA principle, which results in final cleanup levels that are below DCGLs (i.e., cleaner than the approved cleanup level). For multiple contaminants, the sum-of-fractions and unity rule are used to ensure 15 mrem/yr is not exceeded.

It should be noted that DCGLs were developed for some radionuclides that are not considered ROCs in the Area IV HSA.[2] Most DCGLs were calculated for those radionuclides that could be generated from past reactor and nuclear support operations. The primary reasons that ROCs are a smaller subset of the DCGLs include:

- The contaminant is an ***activation product*** limited to steel rebar and concrete. These radionuclides tend to stay in the rebar or concrete, and are generally not found in soil and/or water. The few instances when they have been found in soil, the levels have been many orders of magnitude lower than the DCGLs.

- Though the isotope could have been generated as a result of the fission process, it has a ***short-half life*** and has decayed to undetectable levels since reactor and nuclear support operations ceased. The last reactor ceased operating in 1980 or 25 years ago.

[1] Boeing Document, N001SRR140131, "Approved Sitewide Release Criteria for Remediation of Radiological Facilities at SSFL," February 18, 1999.

[2] In its final Environmental Assessment for Cleanup and Closure of the ETEC (DOE/EA-1345) (EA), the DOE identifies only the following as potential ROCs: uranium-238, thorium-232, cesium-137, strontium-90, and cobalt-60. This list of ROCs is much less extensive than the list of DHS-approved DCGLs or the ROCs identified in the Area IV HSA because the DOE only considered a radionuclide to be "of concern" if historical information indicates that it has been released to the environment and was at levels exceeding 10% of the DCGL.

Any radioisotope with a half of less than 2.5 years would have decayed to a factor less than 2^{10} or 1024 of its original activity.

- The radioisotope is a ***naturally occurring*** isotope in soil and is not present as a result of nuclear operations. Levels observed in soil are consistent with natural background.

- Radionuclides have ***not been observed*** in Area IV soil.

Table C-1 clarifies isotopes that are not considered ROCs for Area IV.

Table C-1. Area IV Isotopes Not Considered ROCs

Radionuclide	Activation Product	Short Half-Life	Naturally Occurring	Not Been Observed
Cesium-134		X		X
Iron-55	X			
Potassium-40			X	
Manganese-54		X		X
Sodium-22	X	X		X
Nickel-59	X			X
Nickel-63	X			
Plutonium-242				X

Appendix D – Impacted Sites and Radiological Facilities Crosswalk

D.1 Introduction

Table D-1 provides a summary of all impacted sites and how they correlate with the 27 radiological facilities. Table D-2 lists 18 sites that were not previously identified as radiologically impacted or correlated with a radiological facility.

Table D-1. Known Impacted Sites with 27 Correlating Radiological Facilities

Radiological Facility	Site	Release Survey Status
17th Street Drainage Area	17th Street	DHS released the land in 2004 DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use
Engineering Test Building	4003	DOE released facility and surrounding soil in 1985
Uranium Carbide Fuel Pilot Plant	4005	DHS released building and surrounding land in 1995.
	4049	Surveyed in 1988 Demolished in 1999
Organic Moderated Reactor Sodium Graphite Reactor In-Service Inspection	4009	DHS released building and surrounding land in 1999
SNAP Experimental Reactor Facility	4010	DOE released facility and surrounding soil in 1982
	4807	DOE released facility and surrounding soil in 1982
SNAP-8 Experimental Reactor	4808	DOE released facility and surrounding soil in 1982
	4809	DOE released facility and surrounding soil in 1982
Radiation Instrument Calibration Laboratory	4011	DHS released building in 1998
SNAP Critical Test Facility (2nd)	4012	DOE released the building in 1997 DHS concurred with building release in 1997
SNAP Flight System Critical Facility	4019	Surveyed in 1998. DOE confirmed that DOE and DHS approved cleanup limits had been met; the building is suitable for release for unrestricted use
Hot Laboratory	4020	Surveyed in 1999. DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use
	4468	Surveyed in 1999. Land pending DOE and DHS release.
Radioactive Materials Disposal/Handling Facility	4021	Currently active
	4022	Currently active
	4044	Currently active
	4075	Currently standing but inactive
	4563	Currently active
	4614	Currently active
	4621	Currently active
	4622	Demolished in 1976
	4663	Demolished in 1970s, concrete pad serves as non-radioactive storage

Radiological Facility	Site	Release Survey Status
Radioactive Materials Disposal/Handling Facility, Continued	4664	Demolished in the early 1980s
	4665	Currently active, storage of non-radioactive materials and equipment
	4688	Currently active, storage of non-radioactive materials and equipment
Sodium Corrosion Test Loop	4023	DOE released the building in 1997. DHS concurred with building release in 1998.
SNAP Environmental Test Facility SNAP-2 Development Reactor SNAP-10 Flight Simulation Reactor SNAP Transient Test	4024	The first phase of decontamination has been completed, the building has not been demolished
	4928	The first phase of decontamination has been completed, the building has not been demolished
Shield Test Facility Shield Test Irradiation Facility	4028	DOE released the building in 1997. DHS concurred with building release in 1995
Radiation Measurement Facility	4029	DOE released the building and surrounding land in 1997. DHS concurred with building and surrounding land release in 1997
Van de Graaff Accelerator	4030	DOE released the building in 1997. DHS concurred with building release in 1999.
	4035	DOE released the building in 1997. DHS concurred with building release in 1999.
Nuclear Materials Development Facility	4055	NRC released building and land in 1987
	4155	NRC released building and land in 1987
	4755	NRC released building and land in 1987
SNAP Ground Prototype Test Facility SNAP-8 Development Reactor	4059	DOE approved building 4059 for demolition in 1999. Lend pending DOE release and DHS concurrence.
Fuel Storage Facility	4064	DOE released building in 1996. DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use
	4864	DOE released building in 1996. DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use
Kinetics Experiment Water Boiler	4073	ERDA released facility and surrounding soil in 1976
	4123	ERDA released facility and surrounding soil in 1976
	4643	ERDA released facility and surrounding soil in 1976
L-85 (AE-6) Research Reactor	4093	NRC released building and surrounding land in 1987
	4083	NRC released building and surrounding land in 1987
	4103	NRC released building and surrounding land in 1987
	4453	NRC released building and surrounding land in 1987
	4893	NRC released building and surrounding land in 1987
Fast Critical Experiment Laboratory	4100	NRC released building in 1980
Sodium Reactor Experiment	4143	DOE released facility and surrounding soil as part of 1985 SRE release
	4041	DOE released facility and surrounding soil as part of 1985 SRE release
	4163	DOE released facility and surrounding soil as part of 1985 SRE release
	4185	DOE released facility and surrounding soil as part of 1985 SRE release
	4413	DOE released facility and surrounding soil as part of 1985 SRE release
	4653	DOE released facility and surrounding soil as part of 1985 SRE release

Radiological Facility	Site	Release Survey Status
Sodium Reactor Experiment, Continued	4686	DOE released facility and surrounding soil as part of 1985 SRE release
	4687	DOE released facility and surrounding soil as part of 1985 SRE release
	4689	DOE released facility and surrounding soil as part of 1985 SRE release
	4695	DOE released facility and surrounding soil as part of 1985 SRE release
	4703	DOE released facility and surrounding soil as part of 1985 SRE release
	4723	DOE released facility and surrounding soil as part of 1985 SRE release
	4724	DOE released facility and surrounding soil as part of 1985 SRE release
	4733	DOE released facility and surrounding soil as part of 1985 SRE release
	4743	DOE released facility and surrounding soil as part of 1985 SRE release
	4753	DOE released facility and surrounding soil as part of 1985 SRE release
	4773	DOE released facility and surrounding soil as part of 1985 SRE release
	4894	DOE released facility and surrounding soil as part of 1985 SRE release
	4895	DOE released facility and surrounding soil as part of 1985 SRE release
	4896	DOE released facility and surrounding soil as part of 1985 SRE release
	4897	DOE released facility and surrounding soil as part of 1985 SRE release
	4898	DOE released facility and surrounding soil as part of 1985 SRE release
SNAP Component Testing	4363	DHS released building in 1998
SNAP Critical Test Facility (1st)	4373	DHS released building in 1995
	4375	DHS released building in 1995
	4848	DHS released building in 1995
Interim Storage Facility	4654	Surveyed in 1999. DOE confirmed that DOE and DHS approved soil cleanup limits had been met; the site is suitable for release for unrestricted use
Sodium Disposal Facility	4886	DHS released land in 1998
Old Conservation Yard	OCY	DHS released land in 1995

Table D-2. Sites Not Previously Classified as Radiological Facilities

Facility	Site	Release Status
Sodium Laboratory	4006	Currently standing but inactive
	4616	Currently standing but inactive
Liquid Metal Development Laboratory Space Environmental Test Facility	4032	Surveyed in 1988 Demolished in May 2003
SNAP Administration Building SNAP Office Building Number 4 LMEC Office Building	4039	Surveyed in 2003 Demolished in 2003
Protective Services Control Center Contaminated Medical Facility Facilities and Industrial Engineering Office Supply Storage ETEC Equipment Storage	4040	Surveyed in 1997 Demolished in 1997
LMFBR Development Testing SNAP Shield Casting Facility	4042	Surveyed in 1988 Demolished in May 2003
SNAP Thermoelectric Converter Test Building LMEC Chemical Laboratory Chemistry and Metallurgical Laboratory	4065	Demolished in 1999
Protective Clothing Storage Radioactive Laundry	4273	Land surveyed in 1988 Demolished in 1976
Protective Clothing Storage Radioactive Laundry	4283	Land surveyed in 1988 Demolished in 1976
Organics Reactor Development Building Research and Development Laboratory Building General Storage	4353	Septic tank surveyed in 2001 Demolished in the late 1970s, concrete pad and septic tank removed in 2001
	4853	Septic tank surveyed in 2001 Demolished in the late 1970s, concrete pad and septic tank removed in 2001
Parking Lot Between Building 4641 and 4030	4535	Surveyed in 1988 Demolished in 2004
Parking Lot Near Building 4375	4575	Surveyed in 1988 Demolished in 1999
Old ESG Storage Yard	4583	Land surveyed in 1988 This area was replaced with the Fuel Oil Tank Farm in the early 1980s
Shipping and Receiving	4641	Surveyed in 1988 Demolished in 2004
Isotope System Impact Test Device	4820	Surveyed during the Area IV Characterization Survey in 1995 Demolished in the middle 1970s
Control Rod Test Tower and Pad	4874	Land surveyed in 1988 Demolished in the middle 1970s
Pad and Creep Loop Tower	4875	Land surveyed in 1988 Demolished in the middle 1970s

References

1) The Boeing Company, N001SRR140131, "Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL," February 18, 1999.

2) EPA/NRC, Memorandum of Understanding, “Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites,” October 9, 2002.

3) EPA, Preliminary Remediation Goals for Radionuclides, “http://epa-prgs.ornl.gov/radionuclides/prg_search.shtml,” Date accessed September 2004.

4) EPA, Dose Compliance Concentrations for Radionuclides, “http://epa-dccs.ornl.gov/radionuclides/dose_search.shtml,” Date accessed September 2004.

5) Ogden Environmental and Energy Services, Co., “Bell Canyon Area Soil Sampling Report,” October 1998.

6) NRC, Regulatory Guide 1.86, “Termination of Operating Licenses for Nuclear Reactors,” June 1974

7) DOE, Order 5400.1,”General Environmental protection Program Requirements,” 1990

8) DHS, Letter from Gerard Wong (DHS) to Majelle Lee (Boeing), “Authorized Sitewide Radiological Guidelines for Release of Unrestricted Use,” August 9, 1996.

9) DOE-Environmental Management (EM), Letter from Sally Robison (DOE-EM) to Roger Liddle (DOE-OAK), “Sitewide Limits for Release of facilities Without Radiological Restriction,” September 17, 1996.

10) DOE-EA, 1345, “Environmental Assessment for Cleanup and Closure of Energy Technology Engineering Center (ETEC),” March 2003.

11) USEPA, OSWER, 9295.8-06a, October 9, 2002

12) EPA, 402-9-97-016, Rev. 1, “Multi-Agency Survey and Site Investigation Manual (MARSSIM),” August 2000.

13) DOE, Order 5400.5, “Radiation Protection of the Public and the Environment,” January 7, 1993.