FINAL
SURFACE WATER AND SEDIMENT REPORT

AREA IV RADIOLOGICAL STUDY
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

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Prepared for:

U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, CA 94105

December 21, 2012

HydroGeoLogic, Inc

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LIST OF ACRONYMS AND ABBREVIATIONS

Ag	silver
Am	americium
AOC	Administrative Order on Consent
Ba	barium
bgs	below ground surface
BTV	background threshold value
Cf	californium
Cm	curium
Cs	cesium
DOE	Department of Energy
DQO	data quality objective
DTSC	Department of Toxic Substance Control
EDD	electronic data deliverable
ETEC	Energy Technology Engineering Center
FAL	Field Action Level
FSP	Field Sampling Plan
GEL	GEL Laboratories, LLC
GPS	global positioning system
GRAY	gamma radiation anomaly
HGL	HydroGeoLogic, Inc.
HSA	Historical Site Assessment
MARLAP	Multi-Agency Radiological Laboratories Analytical Protocols
MCL	maximum contaminant level
MDC	minimum detectable concentration
MQO	measurement quality objective
NAA	North American Aviation
NASA	National Aeronautical and Space Administration
NBZ	Northern Buffer Zone
NORM	naturally occurring radioactive material
NPDES	National Pollutant Discharge Elimination System
pCi/g	picocuries per gram
pCi/L	picocuries per liter

PGRAY	potential gamma radiation anomaly
Pu	plutonium
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RMHF	Radioactive Materials Handling Facility
Rn	radon
RRC	radionuclide reference concentration
RTL	radiological trigger level
RWQCB	Regional Water Quality Control Board
SB990	Senate Bill 990
SMP	Site Management Plan
SOP	standard operating procedure
Sr	strontium
SRE	Sodium Reactor Experiment
SSFL	Santa Susana Field Laboratory
TAL	TestAmerica Laboratories, Inc.
Te	tellurium
Th	thorium
TM	technical memorandum
TPC	The Palladino Company, Inc.
U	uranium
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

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SURFACE WATER AND SEDIMENT REPORT
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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) conducted an extensive radiological characterization study of the Santa Susana Field Laboratory (SSFL) at Area IV and the Northern Buffer Zone (NBZ) located in Ventura County, California (Figure 1.1). SSFL Area IV consists of 290 acres, and the NBZ consists of a 182-acre tract of naturally vegetated land. The Boeing Company owns both Area IV and the NBZ. Collectively, these areas are referred to as the Area IV Study Area. USEPA conducted this study pursuant to federal legislative mandate HR2764, the Consolidated Appropriations Act of 2008, and the authority granted under the Comprehensive Environmental Response, Compensation, and Liability Act and subsequently the Administrative Order on Consent (AOC) for Remedial Action (DTSC, 2010). This work was executed by HydroGeoLogic, Inc. (HGL) under a USEPA Region 7 Architect and Engineering Services Contract EP-S7-05-05, Task Order 0038, Amendment 004, being administered and managed by USEPA Region 9. HGL is USEPA's contractor on this project.

1.1 PURPOSE AND OBJECTIVES

The Area IV Radiological Study was conducted to characterize radionuclide concentrations within the Area IV Study Area. The Area IV radiological study consisted of completing an Historical Site Assessment (HSA); conducting a gamma radiation survey of accessible ground surfaces; conducting a geophysical survey of targeted locations; and collecting and analyzing soil, groundwater, surface water, and sediment samples. The results of the HSA, gamma radiation scanning, geophysical survey, historical aerial photographic analysis, and groundwater sampling are detailed in the following documents for the Area IV Radiological Study:

- Final Historical Site Assessment (HGL, 2012a),
- Final Geophysical Investigation Report (HGL, 2011a),
- Aerial Photographic Analysis of Santa Susana Field Laboratory (USEPA, 2010),
- Final Gamma Radiation Scanning Report (HGL and TPC, 2012b), and
- Final Groundwater Report (HGL, 2012c).

This report describes the sampling regime and analytical results of surface water and sediment samples collected from potential areas of radiological contamination. The primary objective of the surface water and sediment sampling effort was to characterize the media for potential radiological contamination within the Area IV Study Area. To meet this objective, samples were collected during two rounds of sampling. Surface water and sediment samples were collected during Phase I, and sediment and soil samples were collected at step-out locations during Phase II sampling activities.

The initial Phase I sampling consisted of collecting surface water and sediment samples at specific, targeted locations identified from the findings of the HSA, aerial photographic analysis, direct field observations, and stakeholder requests. The Phase II sampling consisted of collecting step-out samples to delineate radionuclide concentrations in sediment and soils adjacent to Phase I sediment sample locations that exhibited concentrations above the project decision levels, called radiological trigger levels (RTL).

RTLs were used during the sampling events to identify locations of potential concern in the absence of defined cleanup values. The targeted and step-out sediment and soil sampling locations, justification, and supporting lines of evidence were outlined in the Surface Water and Sediment Addendum to the Phase I Field Sampling Plan (FSP) for Groundwater, Surface Water, and Sediment (HGL, 2010a) and the Final Phase II Sediment Sampling Addendum to the Final Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2012d). The addendums detail the planned sampling effort for each Phase and include stakeholder input. Sampling efforts were conducted in accordance with the Final Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2010b), the FSP addenda, and the Quality Assurance Project Plan (QAPP) for Groundwater, Surface Water, and Sediment (HGL, 2010c).

1.2 LIMITATIONS

This report is intended to characterize radiological areas of interest in the sampled media from past site activities within the Area IV Study Area. This report is not intended to identify remedial locations nor indicate areas of contamination. These determinations will be made at a future date by the State of California Department of Toxic Substances Control (DTSC).

The activities described in this report were conducted in general accordance with current regulatory guidelines and the standard-of-care exercised by environmental consultants performing similar work in the project area. The findings discussed in this report were derived from data collection efforts conducted with commercially available sampling and analysis equipment, techniques, and procedures available at the time the investigation was conducted. The samples collected and used for analysis, and the observations made, are believed to be representative of the Area IV Study Area; however, conditions can vary significantly between sampling locations, thus, conditions not observed or described in this report may be encountered during subsequent activities.

1.3 REPORT ORGANIZATION

This report consists of Sections 1.0 through 6.0 and Appendices A through E. Referenced tables and figures are provided in separate, tabbed sections. The Appendices include the surface water sampling results technical memorandum (TM), Phase I sediment sampling results TM, Phase II sampling results TM, the Radionuclide Reference Concentrations (RRC) paper, and the Background Threshold Value (BTV) and Radionuclide Selection Rationale paper. The contents of each section are summarized below:

- Section 1.0, Introduction. Describes the purpose and objectives, limitations, and organization of this report.

- Section 2.0, Site Background. Describes the site location, site and regulatory history, selection of radionuclides of concern and environmental setting including surface hydrology, soil types, topography, and geology.
- Section 3.0, Study Area Investigation Methodology. Discusses natural and cultural resources, lines of evidence used to identify surface water and sediment sample locations, sample collection process during the Phase I and Phase II sampling events, and the quality assurance (QA)/quality control (QC) procedures employed during sample collection and laboratory analysis.
- Section 4.0, Phase I and Phase II Analytical Results. Describes the evaluation approach, and discusses the analytical results, radiological contamination areas, and radiological areas of interest.
- Section 5.0, Summary. Summarizes the radiological contamination areas for the entire Area IV Study Area and general considerations.
- Section 6.0, References. Lists the documents cited in this report.

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2.0 SITE BACKGROUND

2.1 SITE LOCATION AND DESCRIPTION

The SSFL is located in southeastern Ventura County, California, approximately 30 miles northwest of Los Angeles between the Simi and San Fernando valleys in the Simi Hills (Figure 1.1). Residential developments are located near the southern, northern, and eastern boundaries of the site (Figure 2.1). The SSFL occupies 2,850 acres of rocky (sandstone) terrain with approximately 700 feet of topographic relief. Specifically, the study was focused on Area IV and the adjacent NBZ referred as the Area IV Study Area. The Area IV Study Area is composed of approximately 471 acres (290 acres in Area IV and 181 acres in the NBZ) that vary from relatively flat to steep relief and rugged terrain. The elevation of the Area IV Study Area is between 1,880 feet and 2,150 feet above mean sea level.

The Area IV Study Area was initially divided into eight subareas based on existing Resource Conservation and Recovery Act Facility Investigations. For the radiological characterization study, USEPA elected to further subdivide these eight subareas into 12 subareas based on features such as roads, drainage pathways, and building use as follows:

- Subarea 3
- Subarea 5A
- Subarea 5B
- Subarea 5C
- Subarea 5D-North
- Subarea 5D-South
- Subarea 6
- Subarea 7
- Subarea 8-North
- Subarea 8-South
- NBZ East
- NBZ West

Sediment sampling was not based on subareas but the subarea designations are provided in this report to orient the reader. The subareas are depicted on Figure 2.2.

2.2 SITE HISTORY

As a component of this radiological study, USEPA conducted an extensive HSA to document the site history and past facility operations, as well as to provide technical information for selection of soil samples. This section was derived from the USEPA's HSA and provides a very brief summary of the site history (HGL, 2012a).

Before development of the SSFL site, the area was used for ranching. In approximately 1948, North American Aviation, Inc. (NAA) began development of the site for the design, development, and testing of liquid propellant rocket engines. The facilities at the SSFL site supported many major space programs, from the earliest satellite launches to the Space Shuttle. The Rocketdyne Division of NAA operated these portions of the SSFL site until approximately 1996 when Rocketdyne merged into The Boeing Company. Since approximately 1996, operations at the site have been conducted by The Boeing Company (ETEC, 2010 and HGL, 2012a).

The SSFL is separated into four administrative areas. The Boeing Company owns all of Area I, except for 42 acres which are owned by the United States and under the administrative

control of the National Aeronautics and Space Administration (NASA). Area II is also owned by the United States and under the administrative control of NASA but is operated by The Boeing Company. The Boeing Company owns and operates Areas III and IV. Areas I, II, and III were also used by The Boeing Company, NASA, and the Department of Defense for rocket engine and laser testing.

Under contract to the Department of Energy (DOE), NAA also operated the Energy Technology Engineering Center (ETEC), located exclusively in Area IV, for researching, developing, and constructing nuclear reactors and associated equipment for harnessing nuclear energy through its Atomics International Division (NAA, 1960). Until its closure in 1996, DOE was responsible for operating ETEC. ETEC represented the group of facilities owned by DOE that were used for nuclear research and other experimental activities within Area IV. From the mid-1950s until the mid-1990s, DOE and its predecessor agencies were engaged in or sponsored nuclear operations including the development, fabrication, disassembly, and examination of nuclear reactors, reactor fuel, and other radioactive materials. Associated experiments included large-scale sodium metal testing for fast breeder reactor components. Nuclear operations at ETEC included 10 nuclear research reactors, including the Sodium Reactor Experiment (SRE), seven critical facilities, the Hot Laboratory, the Nuclear Materials Development Facility, the Radioactive Materials Handling Facility (RMHF), and various test and radioactive material storage areas. Each of these facilities has been described in the Final HSA volumes II through VIII (HGL, 2012a).

All nuclear research in Area IV was terminated in 1988 when DOE shifted its focus from research to decontamination and decommissioning activities. Decontamination and decommissioning of the sodium test facilities started in 1996 when DOE determined that the entire ETEC facility was surplus to its mission. DOE began formal cleanup and closure of its facilities in Area IV in preparation for returning the property to The Boeing Company.

The HSA report includes a summary of past operations and activities involving radioactive materials for all subareas. The results of past radiological surveys performed in Area IV are also summarized. Radiological surveys have been performed for several purposes including health and safety, characterization, remedial action support, and release.

2.3 REGULATORY HISTORY

The Atomic Energy Commission was abolished by the Energy Reorganization Act of 1974 and was succeeded by the Energy Research and Development Administration (now part of DOE) and Nuclear Regulatory Commission. Radiological contamination in Area IV has been sampled and analyzed, including radiological surveys conducted in 1988 and again in 1995 as well as radiological release surveys within the footprints of former radiological facilities.

In August 2007, DTSC, as the lead regulatory agency, and The Boeing Company, DOE, and NASA, as potential responsible parties, entered into a Consent Order for Corrective Action governing the remediation of chemical contamination at the SSFL (DTSC, 2007).

In October 2007, California enacted Senate Bill 990 (SB990) entitled "Cleanup of Santa Susana Field Laboratory" which became effective on January 1, 2008. SB990 asserted state jurisdiction over the SSFL remediation and required calculating the cumulative risk from radiological and chemical contaminants to the lower of either suburban residential or rural residential (agricultural) land use scenarios, whichever produces the lower permissible residual concentration for each contaminant.

In December 2010, DTSC signed an AOC with DOE to address the federal radiological and chemical remediation of soil in the Area IV Study Area to background values for both radiological and chemical contaminants by the year 2017 (DTSC, 2010). The Boeing Company and the USEPA are not a party to the AOC.

2.4 ENVIRONMENTAL SETTING

2.4.1 Soil Types and Topography

The SSFL is located on a ridge within the Transverse Ranges physiographic province. The facility is approximately 850 feet above the valleys to the north and south. While the laboratories and other facilities within Area IV are generally located on relatively flat ground, local relief can be up to approximately 270 feet. In the Area IV Study Area, the highest elevation (2,150 feet above mean sea level) is along the southern boundary (Figure 2.3). Along the northwest boundary, the land slopes steeply away to undeveloped land. The relatively flat area in the southern part of the Area IV Study Area is called "Burro Flats."

The parent material of the soil in the Area IV Study Area consists of weathered bedrock, colluviums and alluvium derived from the Chatsworth Formation. According to the Natural Resources Conservation Service, approximately 40 percent of the Area IV Study Area is classified as sedimentary rock outcrop. The two predominant soil types in the Area IV Study Area are a sandy loam of the Saugus series and a loam of the Zamora series. The Saugus series soils consists of deep, well drained soils that usually forms on dissected terraces and foothills and are moderately permeable. The sandy loam of the Saugus series usually has slopes of five to 30 percent. The Zamora series soils are typically well drained loam that forms on nearly level grade or on strongly sloping fans and terraces. The Zamora series in the Area IV Study Area has slopes that range from two to 15 percent (USDA, 2003).

2.4.2 Surface Hydrology

Surface water drainage in the northern portion of the Area IV Study Area flows north into Meier Canyon, which is a tributary to the Arroyo Simi, flowing westward and terminating in the Pacific Ocean. Drainage of the majority of the Area IV Study Area flows to the southeast into the Bell Creek drainage system as suggested by the location of the northeast-southwest trending drainage divide (Figure 2.4). Bell Creek is the headwater and tributary of the Los Angeles River, which flows south and eastward terminating in the Pacific Ocean.

Given the topographic divide and topographical rises to the east and west of Area IV, there is no drainage directly to the west or east from the Area IV (USGS, 1952). A site reconnaissance during the Area IV Radiological Study surface water sampling program

determined there was no surface water drainage from Area IV to the west into Runkle Canyon. However, a small area, approximately two acres in the southwest corner of the NBZ, was identified where surface water does flow to the west.

The California Regional Water Quality Control Board (RWQCB) has issued waste discharge permits to the SSFL since 1958. Starting in 1984, the RWQCB began issuing surface water discharge permits to the SSFL under the National Pollutant Discharge Elimination System (NPDES). Surface water discharges from the site are monitored at 18 NPDES locations, and according to the RWQCB, from 1998 through 2006 (RWQCB, 2006), discharges from the SSFL have continually exceeded effluent limits for dioxin, heavy metals, and other pollutants. In July 2007, the Los Angeles RWQCB issued an order requiring The Boeing Company to cease and desist all discharges of contaminants that exceed specified effluent limits (Weston Solutions, Inc., 2007).

Of these 18 historical surface water discharge outfall locations, there are 10 that receive surface water from Area IV or the NBZ. Outfall locations 3, 4, 5, 6, and 7 receive surface water from the northern portion of Area IV. Outfall locations 9 and 10 receive surface water from the NBZ. Outfall locations 17, 18 and 2 receive surface water from the southern portion of Area IV (Figure 2.3). Outfall locations 3, 4, 6, 10, 18 and 2 receive surface water from former operational areas and are specifically designed multimedia filtration systems engineered to filter the surface water before it travels downgradient. Currently, surface water from these outfalls is diverted to the Silvernale settling pond located in Area III as a result of the Los Angeles RWQCB cease and desist order issued in 2007 (Figure 2.3). Outfall locations 5 and 7 are lined settling ponds and are designed to retain surface water so it can be transferred to the Silvernale pond. Outfall location 9 is strictly an NPDES sampling location and is not designed to filter or retain surface water. The NPDES outfall permitting and monitoring program is regulated by the Los Angeles RWQCB.

The majority of surface drainage within Area IV is through man-made and natural ditches and swales that lead to natural streambeds. The drainage from some former operational areas is directed through various settling ponds and outfall locations. The following subsections provide a brief summary of these operational areas and their associated settling ponds and outfalls.

Former Sodium Disposal Facility

Surface water runoff in the vicinity of the Former Sodium Disposal Facility area flows to the east-northeast. Outfall locations 5 and 6 receive water from the former sodium disposal facility before the water flows into the NBZ. Outfall 5 is a settling pond. Outfall 6 is a multimedia filtration system engineered to filter the surface water before it travels downgradient.

Former Building 4373 (Hot Lab) and Building 4055

Runoff from the vicinity of former Building 4373 (Hot Lab) and Building 4055 flows to the east through the ditch on the south side of G street and the ditches on either side of H and I streets. The runoff water flows through these ditches, through the former Space Technology Laboratory IV complex in Area III, and into the R2 settling ponds located in Area II.

Building 4009, Building 4100, and the 56 Landfill

Runoff in the vicinity of Building 4009, Building 4100 and the 56 Landfill drains to the north along the west side of the landfill, into the NBZ. Outfall 7 is located approximately 70 feet north of building 4100 and only receives surface water from the vicinity of Building 4100.

Radioactive Materials Handling Facility

Runoff within the RMHF fenced area generally flows from east to west across the site to a storm drain culvert along the western perimeter of the site. Surface water flow to the northern perimeter drains into an asphalt-lined swale that leads to the storm drain culvert. Prior to 2006, the culvert drained to an asphalt-lined channel that conveyed surface water to the RMHF holding pond (RMHF 4614 Holdup Pond). The Holdup Pond had a capacity of approximately 30,000 gallons and was used to contain storm water runoff and any accidental releases. It was sealed with coated asphalt to prevent leakage and equipped with a radiation monitor connected to an alarm system to warn if any radioactive contamination entered the pond. The RMHF 4614 Holdup Pond and drainage channel were removed in 2006. The culvert now drains into an aboveground pipeline that conveys water to a 1,500-gallon polyurethane aboveground storage tank. After the accumulated storm water is tested for radionuclides, it was pumped from the aboveground storage tank to B Street where it enters a pipeline that discharges to a lined drainage along 17th Street. Drainage follows 17th Street to G Street and then continues through lined and unlined channels to the 17th Street Drainage.

Sodium Reactor Experiment Complex

The majority of the runoff from the SRE Complex is captured in the SRE pond which is located approximately 400 feet east of the complex. Runoff from the northern portion of the SRE complex flows to the east via a small asphalt-lined ditch, through Outfall 4, and into the SRE Pond. Runoff from the southern portion generally flows to the east via drains and underground culverts. The culverts lead to a concrete-lined ditch that diverts runoff around Outfall 4 and into the SRE Pond. Overflow from the pond is to the east-north east via a natural drainage that leads to Meiers Canyon.

Old and New Conservation Yards

Runoff from the Old and New Conservation Yards flows to the south-southeast via a natural unlined drainage that leads into Area III and, subsequently, into Silvernale Pond. Surface water in the northern portion of the Old Conservation Yard flows to the north and into the Northern Buffer Zone.

2.4.3 Geology

The SSFL is situated within the Transverse Ranges physiographic province, approximately 30 miles north of downtown Los Angeles (Bailey and Jahns, 1954). Two geologic formations

underlie the Study Area, the Cretaceous Chatsworth Formation and the Tertiary Santa Susana Formation. The Chatsworth Formation underlies approximately 80 percent of the Study Area. The following descriptions are derived from the Preliminary Geologic Map of the Los Angeles 30 feet by 60 feet Quadrangle, Southern California (Yerkes and Campbell, 2005). A geologic map of the area is presented as Figure 2.5.

The SSFL is located on the south flank of an approximately east-west striking, westward plunging syncline. There are three categories of geologic structures present in the SSFL faults/fault zones, deformation bands, and structures (MWH, 2007). The fault zones and deformation features displace primary geologic features, the former showing displacement of at least five feet and the later with minimal located displacement (less than 6 inches). Mapped faults in the SSFL are presented on Figure 2.5. The Burro Flats Fault places the Chatsworth Formation in structural contact with the Santa Susana Formation in the southwest portion of the Area IV Study Area.

2.4.3.1 Chatsworth Formation

The Chatsworth Formation consists of three unnamed members. The members were deposited by turbidity currents in a deep ocean at depths ranging from 4,000 to 5,000 feet. Turbidity currents cause massive submarine landslides from the continental shelf into submarine canyons which are generally more than a half-mile wide and greater than ten miles in length. During periods without turbidity currents, silt and clay particles from runoff filtered to the ocean floor and formed the siltstone strata found in the formation.

Deposited in the late Cretaceous, the Chatsworth Formation is in excess of 6,000 feet thick. The uppermost member is a thick strata of light gray to brown sandstone, which is hard, coherent, arkosic, micaceous, primarily medium grained separated by thin partings of siltstone. The middle member is a gray conglomerate of cobbles of rounded, polished clasts of quartzite, porphyry and granitic rocks in hard rock matrix. The lower member is gray clay shale, crumbly with ellipsoidal fracture where weathered, and may include sandstone strata.

2.4.3.2 Santa Susana Formation

The Santa Susana Formation underlies the southwestern most portion of the Area IV Study Area and consists of four members. The unnamed uppermost layer of the Santa Susana Formation consists of gray micaceous claystone and siltstone with a limited number of thin rock beds. Below the uppermost layer lies a second unnamed layer that is made up of tan coherent fine grained rock, which locally contains thin shell-beds and calcareous concretions. Underlying this layer is the Las Virgenes Sandstone Member, which is composed of tan semi-friable bedded sandstone and is locally pebbly. The oldest member is the Simi Conglomerate Member. This member contains gray to brown cobble conglomerate with smooth cobbles of quartzite, metavolcanic and granitic rocks in sandstone matrix that locally includes thin lenses of red clay. The Santa Susana Formation also was formed by turbidity currents.

3.0 STUDY AREA INVESTIGATION METHODOLOGY

3.1 NATURAL AND CULTURAL RESOURCES MONITORING

Several activities associated with the radiological study of the Area IV Study Area had the potential to impact natural and cultural resources. The following subsections describe the procedures used to protect natural and cultural resources during soil sampling activities.

3.1.1 Natural Resources Monitoring

The Area IV Study Area is home to many federally listed species and their critical habitat, as well as biological resources protected under other Federal and State laws. The activities conducted by USEPA had the potential to impact protected natural resources, including vegetation cutting, gamma scanning survey, geophysical surveys, surface and subsurface soil sampling, groundwater monitoring well sampling, surface water sampling, and sediment sampling. To minimize the impact to natural resources and riparian habitat within the Area IV Study Area, protection measures were developed and implemented during surveys and sampling activities on the project site, including associated vegetation clearance.

USEPA conducted this project pursuant to federal legislative mandate HR2764, the Consolidated Appropriations Act of 2008, and the authority granted under the Comprehensive Environmental Response, Compensation, and Liability Act. Formal consultation under Section 7 of the Endangered Species Act was conducted with the U.S. Fish and Wildlife Service (USFWS), and a Biological Opinion was issued on May 25, 2010 (USFWS, 2010). The USFWS Biological Opinion identified Avoidance and Minimization Measures keyed to each of the proposed activities and federally listed species with potential to occur within the Action Area. USEPA agreed to implement the various components of the Radiological Study in compliance with the Biological Opinion and its requirements. Although not under discretionary approval, USEPA also made efforts to comply with the substantive technical requirements of State of California natural resource protection laws, such as the California Endangered Species Act and California Fish and Game Code Section 1602 for impacts to riparian resources. Additional applicable biological resource laws or regulations to which the project adhered included the Federal Migratory Bird Treaty Act and California Fish and Game Code 3503 and 3503.5 (for protection of nesting birds).

Qualified Biological Monitors from Envicom Corporation were retained to assist with species identification and protection as outlined in the Site Management Plan (SMP) (HGL, 2010d). The Biological Monitors inspected the proposed work area for protected plant or animal species or critical habitats requiring protection. These areas were clearly marked with bright red-and-white-striped or pink flags tied to stakes to cordon off the area and to alert personnel to the presence of the protected biological resource (HGL, 2010d).

An information sheet was provided to site personnel containing a list of the federal and state species of concern in the Biological Assessment (HGL and Envicom Corporation, 2009) and the Biological Opinion issued by the USFWS (USFWS, 2010). Species at risk but not considered endangered or threatened from site activities were also monitored for protection

through the joint effort of field personnel and the Biological Monitors. The following is a list of plant and animal species that were identified in the field, flagged and avoided:

- Braunton's milk-vetch (*Astragalus brauntonii*)
- Lyon's pentachaeta (*Pentachaeta lyonii*)
- Spreading navarretia (*Navarretia fossalis*)
- California Orcutt Grass (*Orcuttia californica*)
- Conejo dudleya (*Dudleya abramsii* ssp. *parva* [=> *Dudleya parva*])
- Santa Monica Mountains dudleya (*Dudleya cymosa* ssp. *ovatifolia* [inclusive of *Dudleya cymosa* ssp. *agourensis*])
- Marcescent dudleya (*Dudleya cymosa ssp. marcescens*)
- Coastal California gnatcatcher (*Polioptila californica* ssp. *californica*)
- Least Bell's vireo (*Vireo bellii ssp. pusillus*)
- California red-legged frog (*Rana aurora* ssp. *draytonii* [=> *Rana draytonii*])
- Quino checkerspot butterfly (*Euphydryas editha* ssp. *quino*)
- Riverside fairy shrimp (*Streptocephalus woottonii*)
- Vernal pool fairy shrimp (*Branchinecta lynchi*)
- San Fernando Valley spineflower (*Chorizanthe paryii* var. *fernandina*)
- Santa Susana tarplant (*Deinandra minthornii*)

During the migratory season various birds were nesting within the Area IV Study Area. The nesting bird areas were identified, flagged, and continually examined by the Biological Monitor. These areas were avoided until Biological Monitors confirmed that the chicks had fledged and left the nest. Once these areas were cleared by the Biological Monitors, the flags were removed and access for field activities was approved.

Quarterly Biological Monitoring reports were submitted to the USFWS throughout all field activities identifying protected biological resources encountered and detailing the measures implemented to protect these resources.

3.1.2 Cultural Resources Monitoring

The SSFL was historically occupied by Native Americans and nineteen new archaeological sites and more than 50 isolated artifacts were identified during the course of the USEPA Radiological Study. John Minch and Associates, Inc., under subcontract to HGL, provided Archaeological and Native American monitoring for the duration of all ground disturbing activity. Consultation in accordance with Section 106 of the National Historic Preservation Act was conducted throughout the sampling efforts. Cultural Monitors and Native American Advisors/Consultants from local tribes monitored all ground disturbing activity and provided archaeological monitoring support as necessary during the execution of fieldwork. Cultural Monitors were qualified archaeologists who specialized in southern California Native American artifacts and culture. The Native American Advisors/Consultants were local Southern California tribal representatives from the most likely descendents of the former Native American inhabitants of the SSFL as discussed in the SMP (HGL, 2010d). The consultants were required to have knowledge of local customs, traditions, and religious

practices of the Tatavian and/or Fernandeno Indian Tribes and in particular the Eastern Coastal or Ventureno Chumash Indian tribes.

Before initiating any site activities Cultural Monitors and Native American Advisors/Consultants inspected each site for cultural resources that could have been adversely affected by site activities including:

- Archaeological deposits - soils that contained material evidence of human activity including the remains of houses, hearths, cemeteries, and other features,
- Artifacts - objects made by people such as whole or broken grinding stones, bowls and tools of various kinds,
- Rock paintings and carvings that are tied to the landscape, which provide information about the culture of the people who made and used them, and
- Certain plants and sacred sites - natural features of the landscape that are recognized in local traditions and places with religious significance.

Areas of cultural significance were marked with green flags tied to wooden stakes to cordon off these areas as protected resources. Identification, avoidance, and protective measures were employed during the execution of field activities at the SSFL site to protect Cultural Resources in accordance with all applicable laws, regulations, and policies as follows:

- HGL and subcontractor field personnel received training for identifying cultural features, archaeological sites, and artifacts. This training was jointly conducted by the Cultural Monitors and Native American Advisors/Consultants before work began.
- Cultural resources protection measures were applied during all ground disturbing field activities. All known cultural resources, as identified through previous surveys, as well as all archeological sites and artifacts discovered through the course of this undertaking were avoided. If potential artifacts were identified, the field crew left them in place and notified a Cultural Monitor and/or Native American Advisors/Consultant immediately.
- All sediment and soil samples were inspected by Cultural Monitors and/or Native American Advisors/Consultants to identify and remove any cultural resources from the sample as part of the sample preparation.

Upon the completion of fieldwork the Final Report of Cultural Resources Compliance and Monitoring was prepared, discussing the measures taken to protect and any impacts to archeological findings from the cultural surveys within the Area IV Study Area (John Minch and Associates, Inc., 2012).

3.2 LINES OF EVIDENCE USED TO SELECT SAMPLE LOCATIONS

The selection of targeted surface water and sediment sample locations for Phase I sampling was based on knowledge of the subarea being investigated and on professional judgment. For this study, the selection of targeted sampling locations was based on a combination of existing

data from historical sources and new data collection efforts. Information utilized in determining targeted sample locations included the results of the HSA, aerial photographic analysis, and reconnaissance activities that were conducted before sampling commenced.

For the Phase I sampling activities an FSP addendum (HGL, 2010a) was prepared with supporting maps showing the following:

- Findings identified in the HSA (HGL, 2012a); Aerial photographic analysis (USEPA, 2010);
- Past radiological surveys and results of past radiological soil sampling and analysis (HGL, 2012a);
- Observations identified by field reconnaissance.

The Phase I FSP Addendum identified targeted sampling locations based on the following:

- The likelihood that potential radiological sediment contamination was present,
- The technical information and lines of evidence that led to identifying each targeted sample location; and
- Stakeholder input.

Only one phase of surface water sampling was scoped for this project; therefore, the Phase II FSP Addendum was based on the analytical results of the Phase I sediment samples. The Phase II FSP addendum for sediment sampling was prepared to further delineate areas where radionuclides were identified in sediment during Phase I at concentrations greater than the RTLs (HGL, 2012d). The Phase II addendum included the findings from the Phase I sediment sampling activities, and locations and justifications for sediment and additional soil samples to be collected from below overlying sediment.

3.2.1 Historical Site Assessment

As part of USEPA's radiological study, a comprehensive HSA was completed for the Area IV Study Area and was documented in subarea-specific HSA TMs (HGL, 2012a). The objective of the HSA was to conduct comprehensive historical research to identify, collect, organize, and evaluate historical information relevant to nuclear research operations as it may pertain to potential radiological contamination in the Area IV Study Area. Once each subarea-specific HSA was complete, potential areas possibly associated with radiological contamination were identified for Round 1 targeted soil sampling and analysis. The information in the HSA was obtained from the review of more than 100,000 historical documents that describe past facility operational practices as well as facility processes and systems.

Each HSA TM also includes findings of interviews with former employees who worked in Area IV. During these interviews, former employees were questioned regarding their knowledge of spills or processes that may have resulted in releases of radionuclides, disposal practices for liquid and solid waste, and identification of areas where radiological

investigations should be performed. The interviews were used to assist in the identification of potential release areas (HGL, 2012a).

Preliminary findings presented in the HSA TM included:

- Descriptions and locations of potential, likely, or known activities that involved radioactive material, radioactive waste, or mixed waste;
- Initial Multi-Agency Radiation Survey and Site Investigation Manual (USEPA, 2000) classifications (e.g., Class 1, 2, 3) of potentially impacted areas;
- A site-by-site assessment of the likelihood or "weight of evidence" of radiologically contaminated media;
- An assessment of the likelihood of potential migration pathways; and,
- Identification and confirmation of potential radiological contaminants of concern (Section 3.3.1).

The information provided in each HSA TM together with comments and recommendations provided by SSFL stakeholders and the general public was used to develop the strategy for surface water and sediment sampling and analysis for residual radiological contamination in surface water and sediment within each subarea. These recommendations were based only on historical information and not on-the-ground evaluations (HGL, 2012a).

3.2.2 Aerial Photographic Analysis

An analysis of historical aerial photographs of the Area IV Study Area was performed by USEPA and used to support the identification of targeted sample locations. The process of photographic analysis involved the visual examination and comparison of many components of the photographic image. These components included shadow, tone, color, texture, shape, size, pattern, and landscape context of individual elements of a photograph. The photo analyst identified objects, features, and "signatures" associated with specific environmental conditions or events. The term "signature" refers to a combination of components or characteristics that indicate a specific object, condition, or pattern of environmental significance. Academic and professional training, photo interpretation experience gained through repetitive observations of similar features or activities, and deductive logic of the analyst as well as background information from collateral sources (e.g., site maps, geological reports, and soil surveys) were critical factors employed in the photographic analysis (USEPA, 2010).

Based on the review of aerial photos, a list of waste disposal areas, processing areas, open storage areas, fill areas, and impoundments was prepared for the Area IV Study Area. Each location was identified as certain, probable, or possible. Other features included in the analysis of aerial photographs included stains, storage tanks, pipelines, disturbed ground, mounded material, smokestacks, ground scars, building foundations, cleared areas, and buildings.

3.2.3 Gamma Scanning

A gamma radiation scanning survey was performed for 100 percent of the accessible ground surfaces in the Area IV Study Area to identify gamma radiation anomalies (GRAY), in accordance with the Gamma Radiation Scanning Sampling and Analysis Plan (HGL and TPC, 2010e). Approximately 265.73 acres out of 471.64 acres were scanned within the Area IV Study Area.

Gamma radiation emanates from certain man-made and/or naturally occurring radionuclides. Data collected during gamma scanning was evaluated and if a location was found to contain elevated gamma radiation measurements, it was classified as a potential gamma radiation anomaly (PGRAY). The PGRAY was then targeted for further investigation with gamma stationary (static) measurements. The static measurements increased detection sensitivity and the data were analyzed to determine if a PGRAY consisted only of naturally occurring radioactive material (NORM) or man-made radionuclides. PGRAYs consisting of only NORM were identified as "Not a GRAY" and no further action was recommended. A list of locations of GRAYs was prepared for each of the 12 subareas in the Area IV Study Area. The results of the gamma radiation survey are presented in the Final Gamma Radiation Scanning Report (HGL and TPC, 2012e) and are maintained in Geographical Information Systems format.

3.2.4 Geophysical Survey

A geophysical survey was performed at targeted locations identified in the Geophysical Investigation Plan (HGL, 2010f) for the Area IV Study Area. Targeted survey areas within each subarea were selected based on information summarized in the corresponding HSA TM (HGL, 2012a) and the aerial photographic analysis (USEPA, 2010). Areas suspected to have subsurface radioactivity with little or no surface indication were selected for geophysical measurements as well. For example, suspected subsurface process piping, leach fields, subsurface disposal areas, or trenches associated with past radiological activities were selected as target areas for geophysical survey. The results of the geophysical survey are presented in the Final Geophysical Investigation Report (HGL, 2011a).

3.3 SURFACE WATER AND SEDIMENT SAMPLING

The primary objective of the surface water and sediment sampling effort was to characterize the media for potential radiological contamination in surface water and sediment within the Area IV Study Area. This objective was accomplished by conducting two phases of sampling. Surface water and sediment samples were collected during Phase I sampling activities and sediment and soil samples were collected at step-out locations during Phase II sampling activities.

3.3.1 Identification of Radionuclides of Concern

USEPA developed a list of radionuclides for laboratory analyses during the SSFL radiological background study. Development of the initial list of background study radionuclides of concern was guided by the list from the Hanford Site in Hanford, Washington (Washington State Department of Health, 1996), with the understanding that the list of radionuclides of

concern for the SSFL background study would be derived from radionuclides actually used or produced at SSFL. The background study list of radionuclides was originally selected using the following screening criteria:

- The radionuclide was or could have been used or produced at SSFL.
- The physical state of the radionuclide is not a gas (if the radionuclide is a gas and its parent was not removed from the list, then it was retained).
- The radionuclide has a half-life greater than one year (if the radionuclide has a half-life of less than one year and its parent was not removed from the list, then it was retained).
- The SSFL Technical Stakeholder Workgroup elected to keep a specific radionuclide on the list.

Recognizing that the background study list of radionuclides contained specific radionuclides highly unlikely to have been used or produced at SSFL or extraordinary radionuclides that were expected to provide limited information at significant cost to the project, in consultation with the Technical Stakeholders, USEPA reduced the total number of radionuclides considered for the radiological study, and proposed two suites of radionuclides for soil analyses. The first was the default suite which included:

- Radionuclides detectable by gamma spectrometry;
- Strontium (Sr)-90 (which includes yttrium-90); and
- Commonly analyzed isotopes of uranium (U), thorium (Th), americium (Am), curium (Cm), and plutonium (Pu).

The second was the site-specific suites, which included more than one possible combination of analyses. Both suites are summarized in Table 2.3 of the Final FSP for Soil Sampling (HGL 2012e) and include criteria for selection of the site-specific analytical suites.

During Phase I sampling, all samples were analyzed for the default suite. Phase II sample analyses were conducted to further define exceedances identified during Phase I. The Phase II analyses were performed using the method(s) necessary to evaluate the Phase II exceedances and to further investigate radionuclides that were detected during previous investigations.

A final adjustment to the list of radionuclides contained in the default suite was made between the draft final (October 4, 2010) and final (February 17, 2012) versions of the Final FSP for Soil Sampling (HGL 2012e). The adjustment was to remove eight radionuclides from the gamma spectrometry method of the default suite: silver (Ag)-108, Ag-108m, barium (Ba)-133, Ba-137m, californium (Cf)-249, radon (Rn)-220, Rn-222, and tellurium (Te)-125m. The radionuclides Ag-108, Te-125m, Ba-137m, Rn-220, and Rn-222, were removed from consideration because they are redundant and are not measured directly, but are assumed to be in a state of secular equilibrium with their various parent or progeny radionuclides. The activity concentrations are calculated directly from the reported parent or progeny activity. For example Ba-137m is calculated directly from the reported cesium (Cs)-137 results and an

exceedance or data quality excursion in one would be repeated in the other. In addition, Ag-108m, Ba-133, and Cf-249, were removed from consideration because they are subject to significant spectral interference, making the measurement results unreliable. Due to the timing of this change, analytical results for these radionuclides are reported with some of the early Phase I data but not Phase II data.

3.3.2 Phase I Surface Water and Sediment Sampling

Phase I surface water and sediment samples were collected in accordance with the procedures outlined in the Final Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2010b) and the Surface Water and Sediment Addendum to the Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2010a).

Phase I surface water and sediment sampling locations were based on information acquired from the HSA, aerial photograph interpretation study, and direct field observations. Gamma radiation and geophysical surveys had not been completed at the time Phase I surface water and sediment samples were collected, therefore these surveys were not used to determine sampling locations. The potential Phase I sampling locations were verified during field reconnaissance conducted from October 6, 2010 to November 5, 2010. As a result of the steep terrain in the northern buffer zone most of the natural drainages have been scoured by erosion down to bedrock and sediment has accumulated in small areas where topographic conditions allow surface water to pool and deposit sediment. These small areas where sediment had accumulated were verified in the field. A total of 40 surface water and 40 sediment sampling locations were identified during the reconnaissance. Detailed notes and photographs were taken at each location, as well as X-Y survey coordinates, which were recorded using a SPS 852 handheld Trimble global positioning system (GPS) unit.

The potential surface water and sediment sampling locations were presented to the SSFL Technical Stakeholder Workgroup during the technical review meeting held on November 18, 2010. After the sampling locations were finalized with the technical stakeholders they were documented in the Surface Water and Sediment FSP addendum (HGL, 2010a). Before sampling activities commenced, utility clearances were performed at each location by Underground Service Alert (Dig Alert) and a private utility locator.

Thirty-four surface water and 40 sediment samples were collected during Phase I sampling activities. Additionally, four field duplicate surface water and two field duplicate sediment samples were collected as part of the Phase I surface water and sediment sampling activities. Table 3.1 summarizes the total number of surface water, sediment and soil samples collected for each phase of sampling.

3.3.2.1 <u>Surface Water Sampling</u>

Surface water samples were only collected during the Phase I sampling effort. Generally, surface water is very limited and intermittent due to the arid conditions and because the SSFL site is located near a topographic high. Surface water is present only during and immediately following periods of heavy rain. Therefore, surface water samples were collected immediately

following a significant precipitation event in which approximately 4-inches of rain fell within a 24 hour period on March 20, 2011.

Surface water samples were collected using the direct dip method in accordance with the procedures outlined in Standard Operating Procedure (SOP) 2.16, in Appendix A of the Final Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2010b). This method consists of collecting a single grab sample by immersing the sample bottle directly under the surface of the water as close to the center of the channel as possible. Samples obtained at each location were laboratory-filtered, as described in Section 4.1.4 of the Final Phase I Ground Water, Surface Water, and Sediment FSP (HGL, 2010b). The surface water samples collected from the 4056 excavation (Million Dollar Hole) were collected using a Kemmerer discrete depth sampler. Details of the Surface Water sampling effort are presented in the TM, Surface Water Sample Results in Appendix A.

3.3.2.2 Sediment Sampling

Phase I sediment samples were collected using a stainless steel trowel or shovel in accordance with SOP 2.15, in Appendix A of the Final Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2010b). The sample was collected from the top 6 inches of fine-grained sediment that had been deposited within the low velocity zones of the drainage feature, such as inside meanders, placed in a stainless steel bowl, then homogenized before placing the sample into the appropriate sample container.

3.3.3 Phase II Step-out Sediment and Soil Sampling

A total of 27 step-out environmental samples were collected during Phase II sampling activities. Phase II sediment and soil samples were collected in accordance with the Final Phase I FSP for Groundwater, Surface Water, and Sediment, (HGL, 2010b), the Surface Water and Sediment Addendum to the Phase I FSP for Groundwater, Surface Water, and Sediment (HGL, 2010a), and the Final FSP for Soil Sampling (HGL, 2012e). Phase II sampling locations were based on RTL exceedances detected in Phase I sediment samples. Phase I sediment analytical results were screened against project established RTLs to identify locations containing concentrations of radionuclides related to SSFL site operations that warranted further characterization. At the locations where radionuclide concentrations exceeded RTLs, additional sampling locations (step-out locations) were placed to further characterize potential contamination. Sediment step-out samples were collected in the drainageways and soil samples were collected from underneath the sediment and on the banks of the drainageways. The soil samples were collected to characterize potential radiological impact to the native soil in the vicinity of the Phase I exceedances. Each location was field verified and drainage patterns, topography, and locations of structural drainage from buildings were considered to characterize potential transport of elevated radionuclide results. Step-out locations were placed within the drainageway upgradient and downgradient from their respective Phase I sample location. The RTL exceedances, rationale used to place Phase II step-out sampling locations, and analytical results are presented in the TM, Phase I Sediment Sample Results (Appendix B). The process used to derive the RTLs and how they were used to determine Phase II step-out sampling locations is summarized below.

3.3.3.1 Radiological Trigger Levels

Analytical results from the Phase I sediment sampling were compared to the RTLs established specifically for the Area IV Study Area. RTLs were decision levels for the radionuclides of concern used as comparison concentrations for Phase II analytical data in the absence of established clean up levels. The process used to derive the RTLs is presented in the TM, RTL (HGL, 2011b), and is briefly summarized below.

During the SSFL Radiological Background Study (HGL, 2011c), 149 soil samples were collected from off-site locations representing the two geological formations present at the SSFL Site. Based on the results of the Radiological Background Study, BTV were developed for 64 radionuclides, which represent the upper limits of background concentrations. The rationale for the selection of the 64 BTVs between datasets that represent results across surface and subsurface soil, different geologic formations, separate reference locations, and datasets with very low detection frequency (that is, single detections in a dataset) are summarized in the BTV and Radionuclide Selection Rationale paper (Appendix E).

In some cases, the laboratory data used in the Area IV Study Area did not support the use of the BTVs in the decision-making process, due to practical or technological limitations in data quality. In those cases, where the laboratory minimum detectable concentration (MDC) for a given radionuclide was greater than the associated BTV, that MDC was used as the lowest practical alternative to the BTV. In addition, one radiochemistry laboratory was selected and contracted for the background study, Pace Laboratories, and two radiochemistry laboratories were contracted for the Radiological Study: TestAmerica Laboratories, Inc. (TAL) and GEL Laboratories, LLC (GEL). Using three laboratories typically resulted in three different MDCs for each analysis. For consistency in evaluation of analytical results, when the MDC values differed between the laboratories, the higher concentration value was used to form the RTL.

RTLs were only used to determine Round 2 step-out sampling locations, and included the method uncertainty from the analytical techniques. The RTL was based on the BTV (or the associated MDC, whichever was higher) plus a method uncertainty factor and was calculated based on a decision error rate of 5 percent, specified in the Final QAPP for Soil Sampling (HGL, 2012f). A laboratory result that exceeded the RTL indicated that, at the specified confidence interval, the sample was likely to have exceeded the BTV (or MDC). As described in Appendix D, a calculation error in the RTLs was discovered after the soil and sediment results were reported and verified (and after the analytical results were presented and discussed with the stakeholders). Therefore, to be consistent with all Round 1 TMs and discussions with technical stakeholders, the data presented in all the Round 1 TMs was compared to original RTLs. The analytical results themselves are unaffected by the RTL error and no additional locations are found based on corrected screening levels. Radiological trigger level exceedances identified during Phase I sediment sampling activities are discussed in the TM, Phase I Sediment Sample Results (Appendix B).

After sample results had been validated, an evaluation of all laboratory results was conducted to provide the most defensible and technically sound advice to project Stakeholders, in particular the DTSC regarding the procurement of future laboratory services. Thus, RRCs

were developed from the entire dataset of soil and sediment sample analytical results. These RRCs were developed in a similar methodology as the RTLs but with enhancements. The development, appropriate uses, and limitations of the RRCs and the associated calculation parameters are detailed in Appendix D.

3.3.3.2 Sediment Step-out Locations

Analytical results of 40 sediment samples collected during Phase I showed two samples containing radionuclide concentrations that exceeded RTLs: one located downgradient of Outfall 3, east of the SRE; and one located downgradient of Outfall 4, northwest of the RMHF. Phase I sample results are presented in Figure 2 of the TM, Phase I Sediment Sample Results (Appendix B). A total of 15 sediment step-out samples were collected from within the drainageway, at locations upgradient and downgradient of the Phase I RTL exceedances. Analytical results for the Phase II sediment samples are documented in the TM, Phase II Sediment Sample Results (Appendix C). Sampling locations where radionuclide concentrations exceeded the FALs are presented in Figures 4.3, 4.4, and 4.5 of this document.

3.3.3.3 Surface and Subsurface Soil Step-out Sampling Locations

In addition to the Phase II sediment samples, surface and subsurface soil samples were collected to characterize the soil beneath the sediment and in the overbanks of the drainageways. The sampling locations are presented in Figures 2 and 3 of the TM, Phase II Sediment Sample Results (Appendix C). Eight subsurface soil samples were collected from beneath the sediment at the following locations:

- EPASED41,
- EPASED43,
- EPASED46,
- EPASED48,
- EPASED49,
- EPASED51,
- EPASED52, and
- EPASED53.

Two surface and two subsurface soil samples were collected from locations EPASED44 and EPASED45. These samples were collected from the banks north and south of Phase I Location EPASED13. Analytical results for the Phase II surface and subsurface soil samples are documented in the TM, Phase II Sediment Sample Results (Appendix C).

Surface soil samples were collected in the same manner as sediment samples. Subsurface samples were collected using a stainless steel hand auger because of the inaccessibility of the sampling locations. The boreholes were advanced to a depth of 10 feet below ground surface (bgs) or refusal. Depth intervals to be sampled were determined based on borehole gamma logging results. Soil associated with gamma radiation anomalies was sampled for laboratory analysis. If no gamma radiation anomalies were identified, a soil sample was collected at the upper portion of the boring (1 to 5 feet bgs). The soil within this interval was homogenized and a representative composite sample was collected for analysis. Due to the relatively low mobility of the radionuclides of interest, higher radionuclide concentrations were expected in the upper portion of the soil profile; collecting soil within the upper 5 feet increased the likelihood of detecting radiological contamination at a particular location.

3.4 QUALITY ASSURANCE/QUALITY CONTROL

The QA and QC program implemented during surface water and sediment sampling and analysis efforts ensured that equipment and instruments functioned properly and the data collection process was performed consistently with project requirements. The QA program ensured that all data collection procedures and measurements were scientifically sound; were of known, acceptable, and documented quality; and were conducted in accordance with the requirements of the project as discussed in the Final FSP for Ground Water Surface Water and Sediment (HGL, 2010b), QAPP for Ground Water, Surface Water, and Sediment (HGL, 2010c), Final FSP for Soil Sampling (HGL, 2012e) and the Final QAPP for Soil Sampling (HGL 2012f). Systematic monitoring of QA processes reduced occurrences of errors during soil collection and analysis.

The QC program focused on testing procedures to verify field methods and laboratory detection systems were functioning correctly and fully operational before data collection commenced, and to ensure collected data were consistent, comparable, accurate, and within specified limits of precision.

Before submission of field samples to the two laboratories, a single-blind performance evaluation was conducted. This evaluation assessed the ability of TAL and GEL to generate results within acceptable limits of analytical accuracy and precision. The single-blind samples were of known concentrations to the manufacturer and HGL but unknown to the laboratories. Performance evaluation sample results were evaluated against the certified values provided by the manufacturer.

3.4.1 Laboratory Quality Control Elements

Laboratory QC samples included calibration verification checks, method blanks, laboratory control samples, carrier and tracer performance, matrix spike analyses, and laboratory duplicates as required by each analytical method. These QC elements were specific to each analytical method and are described in general terms in the selected project laboratory QA manual in Appendix A of the QAPP for Ground Water, Surface Water, and Sediment (HGL, 2010c) and the Final QAPP for Soil Sampling (HGL, 2012f) and in more detail in method-specific standard operating procedures.

The laboratory QC elements were based on descriptions presented in the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) (USEPA, 2004). The acceptance criteria, corrective action, and evaluation protocols associated with these QC elements are presented in Table 3.3 of the QAPP for Ground Water, Surface Water, and Sediment (HGL, 2010c), and Final QAPP for Soil Sampling (HGL, 2012f). Laboratory-specific information on technical approaches to comply with the QC element requirements of this section are presented in the laboratory-specific QAPP addenda (HGL, 2010c). Results of the QC tests were included in the analytical data packages and used during the data validation process to determine data usability.

3.4.2 Quality Control Samples

Field QC samples were collected to gauge the accuracy and precision of field collection and laboratory analytical activities and to assess data usability. QC samples collected in the field and submitted to the laboratory for analysis included field duplicates, equipment rinsates, and decontamination source water blanks. Each phase-specific FSP addendum provided specific information on the number and types of analyses to be performed. Requirements for QC samples were specified in the QAPP for Ground Water, Surface Water, and Sediment (HGL, 2010c), Final FSP for Soil Sampling (HGL, 2012e), and the Final QAPP for Soil Sampling (HGL, 2012f) and are also summarized in the following subsections.

3.4.2.1 Field Duplicates

Field duplicate samples were collected at a rate of 1 per 20 (5 percent) environmental samples collected. Sediment and soil field duplicates were obtained using co-located samples rather than the conventional homogenized and split samples. This method resulted in the collection of representative samples that better suited the project requirements. Field duplicate samples were collected within 2 feet of the location of the parent sample.

Field duplicate samples were submitted to the laboratory as blind QC samples (with unique sample identifiers) to ensure that they were analyzed in the same manner as all other environmental samples. Field duplicate results were used to estimate the overall precision of sample collection, field sample preparation, site homogeneity, and laboratory analysis (total measurement of sample variability).

3.4.2.2 Equipment Rinsate and Source Water Blanks

Equipment rinsate blank samples were collected to ensure proper decontamination of non-dedicated sampling equipment. One equipment rinsate blank was collected for each type of sampling equipment per field team per day. Following decontamination, the blank was collected by pouring ASTM Type II water (also called organic free water) through or over the equipment and collecting the rinse water in the appropriate container. Each equipment blank sample was analyzed for uranium isotopes and tritium (on a sample-dependent basis).

A sample of the ASTM Type II decontamination source water used for the equipment decontamination and rinsate blank was collected and analyzed for uranium isotopes and tritium. The decontamination source water blank samples were collected each time a new lot of source water was received. The source water samples were used to document existing radionuclide concentrations in the water. The results of the source water blanks were compared to the equipment rinsate blanks to aid in determining the effectiveness of decontamination procedures. These comparisons are discussed in the surface water and sediment sample results TMs (Appendices A, B, and C).

3.4.3 Data Validation

Data validation ensured that laboratory analytical results met the objectives of the project as documented in the Final QAPP for Groundwater, Surface Water, and Sediment (HGL, 2010c)

and the Final QAPP for Soil Sampling (HGL, 2012f). Data validation compared the final dataset against a set of criteria as detailed in the QAPPs to ensure the data were usable.

Analytical data packages were received from the laboratories in electronic data deliverable (EDD) formats for uploading into the project database. Data verification and validation services were subcontracted to third parties, The Palladino Company, Inc. (TPC) and Validata Chemical Services, Inc., in order to maintain maximum transparency of data quality. A quality check of the laboratory results was performed by reviewing sample numbers against chain-of-custody forms and field sheets for consistency and completeness. Qualifiers were reviewed and added by the validator to determine usability of results.

Data validation was performed in accordance with the DOE guidance documents: Evaluation of Radiochemical Data Usability (DOE, 1997) and MARLAP (USEPA, 2004). Each data validator was a radiochemist with at least two years of experience in radiochemical separations and measurement and did not have any perceived or actual conflict of interest with the laboratory generating data, such as recent prior employment by the same laboratory.

Table 3.3 of the Final QAPP for Groundwater, Surface Water, and Sediment and the Final QAPP for Soil Sampling shows data qualification conventions for QC elements associated with the project analyses. These conventions are general, and were supplemented by method-specific QC elements where appropriate. When analytical results were reported in association with QC results that did not meet the performance criteria, the validator applied the appropriate qualifier. Alternative qualification approaches that contradicted the requirements of Table 3.3 were allowed if, in the validator's judgment, the alternative was appropriate for a specific QC issue. Each instance of application of an alternative protocol was documented in the corresponding data validation report to allow for USEPA review and final approval.

3.4.3.1 Data Validation Methods

Laboratory analytical data packages were validated using a two-tiered approach. Tier 1 required Level IV data validation for 100 percent of data packages. Tier 2 required Level IV data validation for 25 percent of data packages and Level II data validation for 75 percent of data packages.

For surface water samples and for Phase I sediment samples, a Tier I approach was taken. The choice of validation tier was based on the ability of the laboratory to provide data of acceptable quality. A data package was unacceptable if any portion of its contents were considered non-defensible, could not be validated due to insufficient supporting documentation, or data was returned by HGL to the laboratory for repair.

These criteria were applied to 10 consecutive data packages for analytical method for each laboratory. Tier 1 data validation was performed for the first 10 consecutive data packages for a specific analytical method. If nine or more data packages met the quality criteria then Tier 2 data validation was performed. If more than one data package did not meet the quality criteria then Tier 1 data validation was continued until nine of 10 consecutive data packages for the specific analytical method passed the criteria.

Tier 2 data validation was conducted as long as nine of 10 consecutive data packages met the quality criterion; else Tier 1 data validation was resumed.

Due to data package discrepancies and deficiencies all TAL data packages were validated using Tier 1, Level IV validation. GEL data packages were initially validated using Tier 1 then for Round 2 soil samples went to Tier 2 to expedite the data throughput.

Level IV validation requirements are discussed in detail in the QAPP for Groundwater, Surface Water, and Sediment. Level II validation requirements are discussed in detail in the Final QAPP for Soil Sampling and were applied to a single sediment data package. Level IV validation required a more in-depth and thorough review of the analytical data package than Level II. Both validation levels consisted of verification and validation checks for the compliance of sample receipt, sample characteristics, and analytical results. Additionally, results were checked for transcription errors from raw data to summary forms and calculation verifications were performed for selected samples.

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4.0 PHASE I AND PHASE II ANALYTICAL RESULTS

This section presents the radiological analytical results for the Phase I and Phase II surface water and sediment sampling performed in the Area IV Study Area.

Surface water samples were compared to Federal and State of California Drinking Water Maximum Contaminant Levels (MCL).

Phase I sediment and soil samples were compared to project established RTLs. As described in Section 3.3.3.1 the RTLs were developed and used as field decision levels in the absence of established cleanup levels to determine where Phase II step-out samples should be located. As noted above, the RTLs (applied to select Phase II sample locations) included both method uncertainty and the maximum of two project radiochemistry MDC values; hence, they are not the most conservative values with which to present study results. These RTLs are not used in the final evaluation of the radiological data.

Currently, Lookup Table levels for radionuclides have not been established. These levels will be established by DTSC in accordance with the AOC which states that the Lookup Table will "*include both background concentrations as well as minimum detection limits for specific contaminants whose minimum detection limits exceed local background concentrations*" (DTSC, 2010). To satisfy this AOC requirement, the final radiological data have been compared to Field Action Levels (FAL) consisting of either the BTVs or the 2σ upper confidence limit (UCL) MDCs, as applicable. The FAL is lower than the RTL or RRC values because they do not consider the method uncertainty as described above. How the FALs were derived is further described in Section 4.3.1. Because DTSC has not yet established Lookup Table values, all analytical results from USEPA's radiological study exceeding the FAL are presented.

The final Look-up Table values depend on the level of data quality performance to be contracted by DTSC. The FALs (being action levels) are a conservative way to present the radiological study data, that is, FALs are the lowest values with which to compare soil and sediment results. USEPA provided recommendations for the development of Look-up Table values in a TM (HGL, 2012g),

Sample results exceeding the FAL do <u>not</u> necessarily represent locations of contamination. In accordance with the AOC, DTSC will determine Lookup Table values for comparison to all sample results to determine locations of contamination that warrant remediation. Results that exceed the USEPA's FAL are potential locations that may require further investigation and/or remediation dependent upon the Look-up Table values. However, these results do not represent areas of contamination or areas of remediation.

The following subsections describe the development of FALs in more detail, the results of the data quality evaluation, and summarize the Phase I and Phase II analytical results.

4.1 DATA QUALITY EVALUATION

The quality of the analytical data and the applicability of that data for its intended use has been evaluated against the data quality objectives (DQO) and measurement quality objectives described in the QAPP for Groundwater, Surface Water, and Sediment Sampling (HGL, 2010c) and the Final QAPP for Soil Sampling (HGL, 2012f) including applicable revisions and addenda. These DQOs and measurement quality objectives (MQO) include routine criteria such as spike recovery, method blank activity and duplicate precision, as well as non-routine, project-specific criteria such as the required method uncertainty and the use of explicitly defined detection limit calculations.

Field sample data have been thoroughly reviewed, verified, and validated to ensure that any data used to evaluate the nature of areas of interest in the Area IV Study Area either meet the stated DQOs and MQOs described in the QAPP for Groundwater, Surface Water, and Sediment Sampling and the Final QAPP for Soil Sampling or was explicitly qualified to describe any limitations impacting the use of the data. Field sample data that was determined to be unsuitable for its intended purpose has been rejected and removed from consideration. Wherever feasible, rejected data was returned to the laboratory, the affected samples were reanalyzed, and the data was either repaired or replaced.

Technical review of field sample results, as well as the field QC sample results discussed below, suggests that in some cases the laboratories' reported uncertainty values, which accompany the sample activity results, may be slightly underestimated. Such an underestimate of the reported uncertainty is considered conservative, as no data is believed to be accepted when it should have been rejected. This small underestimate of the reported uncertainty values appears to be generally associated with very low-level gamma spectrometry and alpha spectrometry results. As those results tend to be well below the levels of concern for this project, the overall data quality is not believed to be significantly affected and the data is acceptable for its intended use.

The quality and integrity of the field sample data was further evaluated by the laboratory analysis of 15 field sampling equipment blanks and associated source water samples, collected during sediment and soil sampling activities. Surface water samples were collected using the direct dip method as described in the Final Groundwater, Surface Water, and Sediment FSP, (HGL, 2010b); therefore, no equipment blanks were collected during the surface water sampling effort. The evaluation of equipment blank results indicated that the decontamination of the field sampling equipment was effective and that there was no evidence of sample cross-contamination from the sampling equipment that could have adversely affected the quality or usability of the reported field sample data.

Heterogeneity in the field, i.e. variability in the concentration of the various analytes of interest over relatively small areas, was evaluated by the analysis field duplicate samples. The evaluation of results (individual radionuclides from all analyses) from four surface water and four sediment and soil field sample/duplicate pairs (1) suggests a degree of heterogeneity in field sampling locations slightly higher than the 10 percent initially assumed in the development of field duplicate acceptance criteria, and (2) generally supports the assessment of

a small underestimate in the laboratories' reported uncertainty values for certain analyses. Neither the degree of heterogeneity observed in the field duplicate sampling locations, nor the potential underestimate of the reported uncertainty was believed to significantly impact the usability of the data.

Overall, the data were usable for their intended purpose, which was to evaluate the nature and extent of areas of interest within the Area IV Study Area that may have resulted from past nuclear research activities within SSFL Area IV.

4.2 SURFACE WATER SAMPLE RESULTS

Analyses of surface water samples were conducted in accordance with the QAPP for Groundwater, Surface Water, and Sediment (HGL, 2010c). Figure 4.1 presents the locations of all the surface water samples collected during the surface water sampling event. Surface water samples were analyzed for the Priority 1 analyte suite, as detailed in the Final Phase I FSP (HGL, 2010b), which includes the following:

- Gross Alpha,
- Gross Beta,
- Strontium-90,
- Isotopic Uranium,
- Gamma Spectroscopy, and
- Tritium.

Surface water sample results show radionuclide concentrations at or above the respective MCLs at two sampling locations as shown in Figure 4.2. The surface water sample collected from Location EPASW24 contained a concentration of total gross beta (51.2 picocuries per liter [pCi/L]) that exceeded the MCL of 50 pCi/L. The surface water sample collected from Location EPASW26 contained a concentration of suspended gross beta (190 pCi/L) that exceeded the MCL of 50 pCi/L. The surface water samples were filtered in the laboratory as described in Section 4.1.4 of the Final FSP for Groundwater, Surface Water and Sediment, (HGL, 2010b). The laboratory analyzed and reported concentrations of the filtered (aqueous), suspended (solid), and total (summation of filtered and suspended) fractions of the sample. The exceedances of the MCL in both samples were due to elevated concentrations of gross beta in the suspended fraction. This is commonly caused by turbidity that occurs when using the direct dip sample collection method. The concentrations of gross beta detected in the filter (aqueous) fraction of both samples was well below the MCL.

Table 4.1 presents the sample location, concentration and reporting basis of the radionuclide that exceeded the MCL. Figure 4.1 presents the locations of all the surface water samples collected during the surface water sampling event. Figure 4.2 presents the location, radionuclide, and concentration detected above the MCLs in surface water samples collected from the areas discussed above.

4.3 SEDIMENT AND SOIL SAMPLE RESULTS

Analyses of sediment and soil samples were conducted in accordance with QAPP for Groundwater, Surface Water, and Sediment (HGL, 2010c) and the Final QAPP for Soil Sampling (HGL, 2012f). Sediment and soil sample analytical results were compared to FALs (Table 4.2). Sample locations with results equal to or greater than the FAL were considered locations of interest, and are illustrated on Figures 4.3, 4.4, and 4.5.

4.3.1 Field Action Levels

The FALs were derived from the Radiological Background Study BTVs and from the Area IV Radiological Study 2 sigma (2σ) (97.7 percent confidence level of the standard normal cumulative probability) UCL MDCs as described in this section. The 2σ UCL MDCs were calculated from 3,772 sample results, which represent all solid matrix samples collected and analyzed during the Area IV Radiological Study. These MDCs are empirical reported MDCs obtained by each laboratory.

The sample analytical results were compiled for each radionuclide for each laboratory. The datasets for each radionuclide ranged from 5 to 2,464 samples. For each radionuclide and each laboratory, the mean MDC and the standard deviation of the mean MDC were calculated. The mean MDC was summed with twice the standard deviation or sigma to determine the UCL for the respective MDC dataset as follows:

$$2\sigma \text{ UCL MDC} = \text{mean MDC} + (2^{*}\text{standard deviation of mean MDC})$$

The greater of the BTV or 2σ UCL MDC was selected as the FAL for each laboratory for each radionuclide. Table 4.2 summarizes the FALs. Sample results were compared to the FALs and results equal to or greater than the FAL were identified as potential Radiological Areas of Interest. To provide enhanced visual analysis of sample data on the figures, results were categorized into five data ranges as follows:

- Less than the FAL,
- Equal to or greater than the FAL and less than twice the FAL,
- Equal to or greater than twice the FAL and less than thrice the FAL,
- Equal to or greater than thrice the FAL and less than four times the FAL,
- Equal to or greater than four times the FAL.

4.3.2 Radionuclides Exceeding Field Action Levels

Of the 55 radionuclides analyzed, three were detected above the FALs in sediment, surface and subsurface soils collected during the sediment sampling portion of the Area IV Radiological Study (Table 4.2). The three radionuclides exceeding the FALs are Cs-137, Pu-239/240, and Sr-90. These radionuclides can be attributed to SSFL radiological operations, and are referred to as site-related radionuclides. The analytical results for these three radionuclides are presented in Table 4.3 and on Figures 4.3, 4.4, and 4.5.

The following subsections discuss the radionuclides detected above FALs in the order of frequency of occurrence. The locations are described relative to various features (building, drainage, etc.) within the Area IV Study Area.

4.3.2.1 Cesium-137

The FAL for Cs-137 is the BTV of 0.193 picocuries per gram (pCi/g). Cesium-137 was detected in three samples at concentrations of 0.205 pCi/g, 0.208 pCi/g, and 0.233 pCi/g. Cesium-137 was part of the default analyte suite; therefore, all Phase I sediment samples were analyzed for Cs-137. Phase II step-out samples were analyzed for the Gamma Spec default suite (which includes Cs-137) based on data collected during previous investigations and result from Phase I sampling. These concentrations are presented in Table 4.3 and are illustrated on Figure 4.3. Details pertaining to the distribution of Cs-137 are provided in the following subsections.

Downgradient of Outfall 4 and the SRE Pond

In this area, 8 sediment and 4 subsurface soil samples were collected for Cs-137 analysis. One sediment and one subsurface soil sample contained Cs-137 at concentrations exceeding the FAL of 0.193 PCi/g. The sediment sample collected at Location EPASED17 contained Cs-137 at a concentration of 0.208 pCi/g, and the subsurface soil sample collected at Location EPASED51 contained a concentration of Cs-137 of 0.233 pCi/g. These samples were collected approximately 270 feet northeast, downgradient of Outfall 4.

Downgradient of Building 4009 Leach Field

Three sediment samples were collected from the drainage ways associated with Building 4009, for Cs-137 analysis. One sediment sample, collected from Location EPASED06, contained Cs-137 at a concentration of 0.205 that exceeded the FAL of 0.193 pCi/g. This sample was collected approximately 300 feet northwest of Building 4009 and downgradient of the Building 4009 Leach Field.

4.3.2.2 Strontium-90

The FALs for Sr-90 are the MDC 2σ UCL of 0.387 pCi/g for GEL data and the BTV of 0.0750 pCi/g for TAL data. Strontium-90 was part of the default analyte suite; therefore, all Phase I sediment samples were analyzed for Sr-90. Phase II step-out samples were analyzed for Sr-90 based on data collected during previous investigations and result from Phase I sampling.

Strontium-90 was detected in six samples at concentrations above the FALs, ranging from 0.075 to 0.886 pCi/g. These concentrations are presented in Table 4.3 and are illustrated on Figure 4.4. Details pertaining to the distribution of Sr-90 are provided in the following subsections.

Downgradient of Outfall 4 and the SRE Pond

In this area, eight sediment and four subsurface soil samples were collected for Sr-90 analysis. Two sediment and one subsurface soil sample contained Sr-90 at concentrations exceeding the FAL. The sediment sample collected at Location EPASED19 contained a concentration of Sr-

90 of 0.185 pCi/g. The sample was collected from the lowest elevation within the SRE pond while the pond was dry. Sediment sample Location EPASED20 contained a concentration of Sr-90 at 0.075 pCi/g. This sample was collected approximately 300 feet northeast and downgradient of Outfall 4. The subsurface soil sample collected from Location EPASED52 contained Sr-90 at 0.698 pCi/g. Location 52 is approximately 325 feet northeast and downgradient of Outfall 4.

Downgradient of Outfall 3 and the RMHF

In this area, 18 sediment samples were collected for Sr-90 analysis. Two sediment samples contained Sr-90 exceeding the FAL. The sediment samples collected from Locations EPASED13 and EPASED47 contained Sr-90 at concentrations of 0.106 pCi/g and 0.886 pCi/g, respectively. These samples were collected approximately 300 feet west and downgradient of Outfall 3.

Northern Buffer Zone West

In the western portion of the NBZ the sediment sample collected from the south side ditch of the dirt road running east west contained a concentration of Sr-90 at 0.10 pCi/g.

4.3.2.3 Plutonium-239/240

The FALs for Pu-239/240 are the MDC 2σ UCL of 0.0369 pCi/g for GEL data and the BTV of 0.0142 pCi/g for TAL data. Plutonium-239/240 was part of the default analyte suite, therefore, all Phase I sediment samples were analyzed for Pu-239/240; however, there were no Phase I RTL exceedances and no detections during previous investigations so no Phase II step-out samples were analyzed for Pu-239/240.

Plutonium-239/240 was detected in one sediment sample at a concentration of 0.0302 pCi/g. This concentration is presented in Table 4.3 and is illustrated on Figure 4.5. Details pertaining to the distribution of Pu-239/240 are provided in the following subsection.

Downgradient of Outfall 4 and the SRE Pond

In this area, one sediment sample was collected for Pu-239/240 analysis. The sediment sample collected at Location EPASED17 contained Pu-239/240 at a concentration of 0.0302 pCi/g, which exceeded the FAL of 0.0142 pCi/g. This sample was collected approximately 250 feet northeast and downgradient of Outfall 4.

4.3.2.4 Naturally Occurring Radioactive Material

Naturally occurring radioactive materials are present in soils, sediment, and rock in the earth's crust. There are two types of naturally occurring radionuclides in sediment and soil: those occurring singly and those occurring as part of a decay series. The most common singly occurring NORM radionuclide is potassium-40. Three primordial decay series ubiquitous in rocks and soil originate from Th-232, U-235, and U-238. Each decay series is composed of a radionuclide parent (listed) and its progeny or radioactive decay product radionuclides. Progeny radionuclides are normally present in uncontaminated sediment and soil in secular equilibrium (the concentrations of parent and progeny radionuclides are equal). Secular

equilibrium enables the inter-comparison of radionuclides within a series to assess individual radionuclide exceedances.

An examination of the radionuclide concentration ratios within a series aids in assessing whether NORM radionuclide exceedances may be present due to site-related activities. The differences observed between naturally occurring radionuclide concentrations of a particular series are expected to be small if the sample does not represent contamination. For example, a U-238 exceedance of 2.5 pCi/g would be recognized as a higher than normal SSFL sample result. When the U-238 decay product radionuclides (bismuth-214 and lead-214) are approximately 2.5 pCi/g this affirms the U-238 result does not indicate site-related contamination, even though it exceeds the FAL (the modifier approximately is appropriate because concentrations reported from different radiochemistry methods are expected to differ, within the error limits of each method). This scenario suggests the sample has a high natural uranium concentration, within the range of natural variability. Conversely, a U-238 exceedance with a concentration that significantly differed from its decay product radionuclides may indicate site–related contamination.

The background study demonstrated that radionuclides are present in unaffected areas with a degree of variability in concentrations. It is possible that radionuclides could exceed FALs and not be due to SSFL radiological operations. The exceedances could be a result of natural variability due to the natural distribution in rock and soil formations or statistical variability inherent to analytical measurements.

One of the most important naturally occurring radionuclides is uranium. It is important because it is present and detectable at naturally occurring concentrations and is the primary radioactive element in most nuclear fuel. The U-235 contained in nuclear fuel is enriched or concentrated to approximately 3 percent versus 0.72 percent U-235 in natural uranium. After uranium nuclear fuel is made, the natural isotopic abundance ratios and secular equilibrium conditions of each nuclide within the respective decay series no longer apply. Thus, comparison between uranium isotopes 234, 235, and 238 is useful to understand whether uranium isotopic ratios indicate enrichment.

To assess NORM concentrations that exceed FALs, several factors were considered including:

- Are U-238 and Th-232 decay series radionuclide activities consistent within each series?
- How does the isotopic ratio of concentrations of U-235 compare with U-238 and U-234?
- Does the gamma scanning line of evidence indicate extensive high surface NORM content in the area?
- Are there rock outcrops immediately adjacent to the location?
- Is the location of the sample being evaluated just above bedrock?
- What information is contained in the borehole gamma scanning?

- Did information provided in the HSA indicate any site operations conducted at the location?
- Were there any lines of evidence, such as geophysical or aerial photo, that indicated a potential source for site-related NORM?

The answers to these questions, involving site data have been evaluated to determine whether NORM exceedances can be attributed to site-related contamination.

In addition, analytical method uncertainty is addressed by the RTLs and not by the FALs. As a result, the RTL concentrations are greater than their respective FAL concentrations. The evaluation of Phase I NORM RTL exceedances produced three results considered potentially site-related. The evaluation of Phase I and II NORM radionuclide results produced nine FAL exceedances.

5.0 SUMMARY

USEPA's radiological characterization study of the SSFL at Area IV and the NBZ covered a total of 472 acres. Area IV was historically used for research, development, and construction of nuclear reactors and associated equipment. Research of the historical record conducted during the HSA did not find documentation of any former operations or land use associated with Area IV within the NBZ (HGL, 2012a). The characterization consisted of an HSA; a gamma radiation survey; an aerial photograph analysis; a geophysical survey and collecting and analyzing soil, groundwater, surface water, and sediment samples from targeted locations. This report discusses the sampling approach and analytical results for surface water and sediment samples collected from specific targeted locations identified using information gleaned from the HSA, aerial photo evaluations, direct field observations, and Stakeholder input.

The sediment and surface water sampling was conducted in two phases: (1) Phase I targeted surface water and sediment samples collected from specific locations and (2) Phase II step-out sediment and soil samples collected adjacent to Phase I sediment samples that contained radionuclide concentrations greater than the RTLs. Phase I sediment sampling was conducted in December, 2010 and surface water sampling was conducted in March, 2011. RTLs were developed as temporary field decision levels for the radionuclides of concern, in the absence of established cleanup levels, and were used with other information to identify Phase II step-out locations. Phase II sediment and soil samples were collected in May, 2012.

Surface water samples were compared to Federal and State MCLs. Of 34 surface water samples collected, only two contained concentrations of radionuclides exceeding MCLs The surface water samples were filtered in the laboratory and the filtered (aqueous), suspended (solid), and total (summation of filtered and suspended) fractions were reported. In both samples that exceeded the MCL for gross beta, the elevated concentrations were detected in the suspended (solid) fraction of the sample. The concentrations of gross beta detected in the filter fraction of both samples were below the MCL.

Lookup Table values (aka, cleanup levels) for radionuclides have not been established. Lookup Table levels will be established by DTSC in accordance with the AOC which states that the Lookup Table will "include both background concentrations as well as minimum detection limits for specific contaminants whose minimum detection limits exceed local background concentrations" (DTSC, 2010). To satisfy the AOC requirement the final radiological sediment and soil data presented in this report were evaluated against either the BTVs or the 2σ UCL MDCs, as applicable. These values are called the FALs. Sample results were compared to FALs to identify Radiological Areas of Interest.

Of 55 sediment and soil samples collected during the sediment sampling program a total of nine samples contained concentrations of radionuclides that exceeded FALs. Analytical results of these nine samples show there were 10 instances where radionuclides exceeded the FALs. Cesium-137, Sr-90, and Pu-239/240 were the only radionuclides detected that exceeded FALs. Three samples contained concentrations of Cs-137 at concentrations of 0.205, 0.208 and 0.233 pCi/g. Six samples contained concentrations of Sr-90 from 0.1 to 0.886 pCi/g. One sample

contained a concentration of Pu-239/240 at 0.0302 pCi/g. The locations where FAL exceedances were detected have been grouped into the four following Radiological Areas of Interest.

- Downgradient of Outfall 3 and the RMHF
- Downgradient of Outfall 4 and the SRE Pond
- Downgradient of Building 4009 Leach Field
- Northern Buffer Zone West

Figure 5.1 illustrates all sample locations where one or more radionuclides were identified at concentrations greater than their respective FAL.

Approximately 90 percent of samples with radionuclide concentrations greater than their respective FAL are located either downgradient of Outfall 3 or Outfall 4. One exceedance of Cs-137 was detected approximately 300 feet northwest of Building 4009 and downgradient of the Building 4009 Leach Field. One exceedance of Sr-90 was detected in the western portion of the NBZ, along the dirt road that that runs northeast-southwest. The Radiological Areas of Interest, the operational history, and associated analytical results are summarized in Table 5.1.

In accordance with the AOC, DTSC will determine Lookup Table values for comparison to all sample results for determination of locations of contamination that warrant remediation. Results that exceed the FALs and Radiological Areas of Interest identified in this report are potential locations that may require further investigation and/or remediation depending on the Lookup Table values. Areas of contamination requiring remediation will be determined after DTSC establishes the Lookup Table values, and this process is not within the scope of USEPA's action, nor under USEPA purview.

The USEPA has provided recommendations to the DTSC regarding the future development of Look-up Table values (HGL, 2012g). Look-up Table values are a metric against which analytical sample results will be compared to determine if a sample contains or does not contain contamination requiring remediation. In addition, guidance is provided for the implementation and application of these Look-up Table values, and for addressing potential challenges in the procurement and use of analytical laboratory data.

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TABLES

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Table 3.1
Number of Samples Collected

Phase	Surface Water[1]	Surface Water Duplicate	Sediment	Surface[2]	Subsurface[2, 3]	Sediment/ Soil Duplicate	Total
Phase I	34	4	40	0	0	2	80
Phase II	0	0	15	2	10	2	29
Totals	**34**	**4**	**55**	**2**	**10**	**4**	**109**

Note:

[1]Surface water samples were only collected during Phase I sampling efforts, (i.e., there was only one surface water sampling

[2]Two surface and two subsurface soil samples were collected from the banks of the drainageway at Phase I Location EPASED13.

[3]Subsurface soil samples were collected from beneath the sediment at Phase II Locations EPASED41, EPASED43, EPASED46, EPASED48, EPASED49, EPASED51, EPASED52, and EPASED53.

Table 4.1
Surface Water Analytical Results Exceeding Maximum Contaminant Levels

Sample Location	Sample Identification	Radionuclide Detected	Reporting Basis	Activity	MCL
EPASW24	EPASW24-SW032511	gross beta	Filtered	10.3	50
EPASW24	EPASW24-SW032511	gross beta	Suspended	40.9	50
EPASW24	EPASW24-SW032511	gross beta	Total	51.2	50
EPASW26	EPASW26-SW032111	gross beta	Filtered	1.25	50
EPASW26	EPASW26-SW032111	gross beta	Suspended	190	50
EPASW26	EPASW26-SW032111	gross beta	Total	192	50

Notes:

Reporting units in picocuries per liter.

MCL - maximum contaminant level

Table 4.2
Radionuclides of Concern
Field Action Levels

Radionuclides	GEL FAL	TAL FAL	Radionuclides	GEL FAL	TAL FAL
Site-related radiouclides above the FAL			***Radionuclides below the FAL (cont.)***		
Cs-137	1.93E-01	1.93E-01	I-129	1.60E+00	NA
Pu-239/Pu-240	3.69E-02	1.42E-02	K-40	3.05E+01	3.05E+01
Sr-90/Y-90	3.87E-01	7.50E-02	Na-22	3.06E-02	2.95E-02
NORM radionuclides above the FAL			Nb-94	2.13E-02	1.72E-02
Ac-227	2.67E-01	1.69E-01	Ni-59	7.24E+00	6.48E-01
Th-234	3.04E+00	3.04E+00	Ni-63	1.78E+00	8.43E-01
U-233/U-234	1.87E+00	1.87E+00	Np-236	4.95E-02	3.68E-02
U-235/U-236	1.30E-01	1.30E-01	Np-237	5.42E-02	NA
U-238	1.68E+00	1.68E+00	Np-239	1.77E-01	1.02E-01
Radionuclides below the FAL			Pa-231	1.11E+00	7.91E-01
Ac-228	2.30E+00	2.30E+00	Pb-212	2.67E+00	2.67E+00
Ag-108m	NA	NA	Pb-214	1.68E+00	1.68E+00
Am-241	4.10E-02	1.62E-02	Pm-147	8.62E+00	NA
Am-243	3.72E-02	1.34E-02	Pu-236	5.10E-02	1.84E-02
Bi-212	2.04E+00	2.04E+00	Pu-238	4.80E-02	9.21E-03
Bi-214	1.57E+00	1.57E+00	Pu-241	3.73E+00	NA
C-14	2.54E+00	2.54E+00	Pu-244	2.59E-02	5.26E-03
Cd-113m	2.95E+03	2.95E+03	Ra-226	1.88E+00	NA
Cf-249	NA	NA	Ra-228	NA	NA
Cm-243/Cm-244	4.66E-02	1.62E-02	Sb-125	3.21E-01	3.21E-01
Cm-245/Cm-246	NA	1.62E-02	Sn-126	2.33E-02	1.95E-02
Cm-248	NA	2.34E-02	Tc-99	1.75E+00	3.87E-01
Co-60	2.52E-02	2.28E-02	Th-228	3.67E+00	3.67E+00
Cs-134	3.00E-02	6.88E-02	Th-229	1.35E-01	4.62E-02
Eu-152	6.70E-02	4.59E-02	Th-232	2.95E+00	2.95E+00
Eu-154	1.36E-01	1.25E-01	Th-230	2.04E+00	2.04E+00
Eu-155	1.98E-01	1.98E-01	Tl-208	9.23E-01	9.23E-01
H-3	9.99E+00	7.38E+00	Tm-171	6.59E+01	6.59E+01
Ho-166m	3.65E-02	3.65E-02			

Notes:

Refer to Table 2.1 of the Final Field Sampling Plan for Soil Sampling (HGL, 2012e) for a definition of radionuclide symbols.

Reporting units in picocuries per gram.

FAL - field action level

GEL - GEL Laboratories LLC

NA - not available

TAL - TestAmerica Laboratories, Inc.

Table 4.3
Sediment Analytical Results Exceeding Field Actions Levels

Key Locations/Facilities	Location	Sample Identification	Analyzing Laboratory	Activity	FAL	MDC	TPU	Critical Level	Sample Depth (feet bgs)
Cesium-137									
Building 4009 Leach Field	EPASED06	EPASED06	TAL	0.205	0.193	0.014	0.01	0.007	0.0 - 0.5
Outfall 4 (Downgradient of SRE)	EPASED17	EPASED17	TAL	0.208	0.193	0.02	0.013	0.01	0.0 - 0.5
Outfall 4 (Downgradient of SRE)	EPASED51	EPASED51B	GEL	0.233	0.193	0.0142	0.0146	0.0069	1.5 - 1.83
Plutonium-239/240									
Outfall 4 (Downgradient of SRE)	EPASED17	EPASED17	TAL	0.0302	0.0142	0.0014	0.0041	0.0013	0.0 - 0.5
Strontium-90									
Northern Buffer Zone West	EPASED02	EPASED02	TAL	0.1	0.075	0.078	0.026	0.044	0.0 - 0.5
Outfall 3 (Downgradient of RMHF)	EPASED13	EPASED13	TAL	0.106	0.075	0.06	0.021	0.034	0.0 - 0.5
Outfall 4 (Downgradient of SRE)	EPASED19	EPASED19	TAL	0.185	0.075	0.06	0.024	0.034	0.0 - 0.5
Outfall 4 (Downgradient of SRE)	EPASED20	EPASED20	TAL	0.075	0.075	0.068	0.022	0.038	0.0 -0.5
Outfall 3 (Downgradient of RMHF)	EPASED47	EPASED47S	GEL	0.886	0.387	0.293	0.149	0.177	0.0 - 0.5
Outfall 4 (Downgradient of SRE)	EPASED52	EPASED52B	GEL	0.698	0.387	0.344	0.142	0.212	3.0 - 5.25

Notes:

Reporting units in picocuries per gram.

bgs - below ground surface

FAL - field action level

GEL - GEL Laboratories LLC

MDC - minimum detectable concentration

RMHF - Radioactive Materials Handling Facility

SRE - Sodium Reactor Experiment

TAL - TestAmerica Laboratories, Inc.

TPU - total propagated uncertainty

Table 5.1
Radiological Areas of Interest

Key Location/Facility	Subarea	Operational History	Radionuclides Detected at Concentrations Equal to or Greater than the FAL						
					Sediment	Surface Soil		Subsurface Soil	
			Radionuclides Detected	Number of Sediment Samples	Sediment Sample Concentrations (pCi/g)	Number of Surface Soil Samples	Surface Soil Sample Concentrations (pCi/g)	Number of Subsurface Soil Samples	Subsurface Soil Sample Concentrations (pCi/g)
Radioactive Materials Handling Facility Complex									
Outfall 3 Radioactive Materials Handling Facility	7	The RMHF was a support facility to the SNAP program, the SRE, and the Hallam Nuclear Power Facility. It was designed to handle the storage, volume reduction, packaging, and shipping of the SNAP and SRE radioactive waste. In general, radioactive wastes handled at the RMHF were residues from chemical and metallurgical laboratory operations, spent reactor fuel decladding operations, maintenance work on contaminated equipment, and decontamination and decommissioning of facilities in which nuclear operations were previously conducted. The RMHF received radioactive water from the Hot Lab, the SRE, and any other DOE facilities that generated radioactive water as a part of operations.	Sr-90	1	0.106	1	0.886	0	NA
Sodium Reactor Experiment Complex									
Outfall 4 Sodium Reactor Experiment Complex	6	The area comprises Building 4143, concrete pads Nos. 4413, 4894, 4895, 4896, 4897, and 4898, electrical substation Building 4683, and the land surrounding these facilities located at the end of E Street. Building 4143 was constructed between April 1955 and February 1957 and was operated as a nuclear reactor until February 1964. Building 4143 housed a high-temperature reactor with a slightly enriched uranium metal fuel (Core I) and sodium-cooled, hexagonal zirconium clad graphite moderator elements. After an accident in 1959, the enriched uranium fuel was replaced with a 93 percent uranium-thorium metal alloy fuel (Core II). The SRE was developed to demonstrate a sodium-cooled, graphite–moderated reactor for civilian use. The SRE pond area (Site 4773) was constructed in 1956 as a retention pond and dam for the SRE. The pond was originally designed for natural seepage and evaporation to control the seasonal water level and provide capacity for winter storm water collection. After 1964, storm water runoff was the only source of water to the SRE pond. The SRE Pond is still in existence and contains surface water runoff from the SRE Complex during the wet season.	Cs-137	1	0.208	0	NA	1	0.233
			Pu-239/240	1	0.0302	0	NA	0	NA
			Sr-90	2	0.075 - 0.185	0	NA	1	0.698
Building 4009 Leach Field	8	A leach field, used for the disposal of both sanitary and radioactive liquid wastes before the central sewage system was installed in 1961, was located approximately 50 feet north of Building 4009. It contained six leach lines ranging in length from 15 to 42 feet. The leach lines extended north from a 2,340-gallon septic tank that was located outside the northwestern portion of Building 4009. The leach field comprised 4-inch diameter terra cotta clay piping surrounded by large gravel and buried at depths ranging from 4 to 5 feet below ground surface. The leach field was reported to include approximately 300 linear feet of leach lines.	Cs-137	1	0.205	0	NA	0	NA

Table 5.1
Radiological Areas of Interest

Key Location/Facility	Subarea	Operational History	Radionuclides Detected at Concentrations Equal to or Greater than the FAL						
					Sediment	Surface Soil		Subsurface Soil	
			Radionuclides Detected	Number of Sediment Samples	Sediment Sample Concentrations (pCi/g)	Number of Surface Soil Samples	Surface Soil Sample Concentrations (pCi/g)	Number of Subsurface Soil Samples	Subsurface Soil Sample Concentrations (pCi/g)
Northern Buffer Zone	NBZ-West	The NBZ area comprises land and drainage channels located north of Area IV extending west to east. The NBZ is also commonly referred to as the Northern Undeveloped Land. In May 1997, Rockwell purchased the 175 acres, to form the NBZ, from the adjoining Brandeis-Bardin Institute, which had owned the land since 1947. Rockwell purchased this land because radioactive and chemical contamination originating from the SSFL had been found on the property by environmental contractors in the early 1990s.	Sr-90	1	0.1	0	NA	0	NA

Notes:

Cs - cesium

DOE - Department of Energy

FAL - Field Action Level

NA - not applicable

NBZ - Northern Buffer Zone

pCi/g - picocuries per gram

Pu - plutonium

RMHF - Radioactive Materials Handling Facility

SNAP - Systems for Nuclear Auxiliary Power

SRE - Sodium Reactor Experiment

Sr - strontium

SSFL - Santa Susana Field Laboratory