National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020

January 30, 2013

Reply to Attn of: RE-12-014

New Mexico Environment Department
Attn: Mr. John E. Kieling, Chief
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: NASA WSTF 200 Area Investigation - Phase II Investigation Work Plan

The 200 Area Closure Investigation Work Plan (IWP) originally submitted to NMED on March 28, 2012 presented a phased investigation approach that was prepared in accordance with the WSTF Hazardous Waste Permit (NMED, 2009) Section V.B.6.b. On May 22, 2012, NMED issued a disapproval, requesting that NASA submit a separate IWP for each of the two proposed phases of the investigation. NASA submitted the 200 Area Phase I IWP that focused specifically on the Phase I investigation of the 200 Area on June 20, 2012. The Phase I IWP was approved by NMED on June 28, 2012.

The 200 Area Phase II IWP enclosed with this letter is provided in conjunction with the 200 Area Phase I Status Report as specified in the schedule for the NMED-approved Phase I IWP. The 200 Area Phase II IWP specifically addresses the installation of soil borings and multiport soil vapor wells within the vadose zone to investigate two HWMUs and five SWMUs identified in the Hazardous Waste Permit, as well as four supplemental areas of interest identified during the 200 Area Phase I investigation. The Executive Summary is included as Enclosure 1, a bound paper copy of the main body of the report (pages i-Appendix A) as Enclosure 2, and a CD-ROM containing the entire report and including all appendices as Enclosure 3.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for known violations. If you have any questions or comments concerning this submittal, please contact Tim Davis at 575–524–5024.

Michael Zigmond
for Radel Bunker-Farrah
Chief, Environmental Office

3 Enclosures

cc:
Mr. Dan Comeau
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Executive Summary

NASA is required by the Hazardous Waste Permit (Permit; NMED, 2009) issued by the New Mexico Environment Department (NMED) to develop investigation work plans (IWPs) for identified closed hazardous waste management units (HWMUs), solid waste management units (SWMUs), and areas of concern at the Johnson Space Center (JSC) White Sands Test Facility (WSTF). The 200 Area investigation follows a two-phase approach (Phase I and Phase II). This Phase II IWP describes vadose zone soil boring and sampling activities and multiport soil vapor monitoring (MSVM) well installation and sampling activities that will be conducted at the following locations:

- 200 Area former East and West Closure underground storage tanks (USTs).
- Five SWMUs identified in the Permit (consisting of historical 200 Area discharge pipes at the Clean Room [SWMU 4], Scape Room [SWMU 5], Building 203 [SWMU 6], and the South Highbay [SWMU 7]; and the 200 Area main burn pit [SWMU 9]).
- Adjacent areas of interest (AOIs) that NASA identified in the vicinity of the 200 Area during the Phase I investigation.

The phased approach was designed to provide a comprehensive evaluation of the 200 Area. The Phase I investigation addressed the USTs, SWMUs and other potential discharge sites identified in the Historical Information Summary (HIS), which was submitted in conjunction with the Phase I IWP (NASA, 2012[a]). Phase I of the investigation utilized geophysical and shallow soil vapor surveys to perform a comprehensive evaluation the 200 Area that supplemented several previous geophysical, soil boring, soil vapor, and groundwater investigations. In addition to the known USTs and SWMUs, Phase I specifically targeted six additional areas not previously addressed in the Permit but identified in the HIS.

Phase I geophysical surveys confirmed the existence of significant northeast-trending faulting and identified three primary faults (200 East Fault, Apollo Boulevard Fault, and 200 West Fault). The 200 East Fault and Apollo Boulevard Fault confine an elevated northeast-trending block of bedrock below the 200 Area main building complex. The depths to bedrock within the area vary from 20 feet (ft; 6.10 m) below ground surface (bgs) above the shallow part of the block to 120 ft (36.58 m) bgs on the downfaulted flanks of the block. The geophysical surveys showed pervasive fracturing beneath the WSTF 200 Area, predominantly on an orthogonal system, with one fracture set trending northeast-southwest and the other fracture set trending northwest-southeast. The two primary features identified that trend to the northwest are the 200-D Graben (a downfaulted feature dissecting the main 200 Area block) and the Road G offset.

The Phase I shallow soil vapor survey was conducted in two subphases across the entire 200 Area and portions of the adjacent 100, 600, and 800 Areas. The initial Phase I (a) survey incorporated 144 vadose zone survey points generally located on 250-ft (76.20 m) centers in a grid pattern. This survey was conducted to evaluate soil vapor adjacent to the two HWMUs (former USTs), SWMUs 4, 5, 6, 7, and 9, and six additional areas identified in the 200 Area HIS (NASA, 2012[a]).

An additional 38 Phase I (b) survey points were subsequently installed within the Phase I (a) grid in order to refine and add detail to the original survey results. A total of 45 VOCs were analyzed for each sample module using EPA Method 8260. Five VOCs showed relatively consistent detections in the vadose zone: trichloroethene (TCE); tetrachloroethene (PCE); trichlorofluoromethane (Freon 11); 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113); and total petroleum hydrocarbons (TPH). Four areas of interest (AOIs) were identified for further evaluation as part of the 200 Area Phase II investigation based on results of the geophysical and shallow soil vapor surveys.

The Phase II investigation will comprise the installation of soil borings with associated soil sampling, and the installation of multi-port soil vapor monitoring (MSVM) wells within the borings with associated soil vapor sampling. A total of 14 Phase II soil borings will be advanced from ground surface to the alluvium-bedrock interface anticipated at variable depths from approximately 20 ft to 120 ft (6.1 – 36.58 m) bgs. The planned borings include the following:

- Two soil borings installed through the 200 East Closure (200-SB-01 and 200-SB-02).
- Two soil borings installed as close as possible to the 200 West Closure 200-SB-03 and 200-SB-04).
- One soil boring located in the center of each of five 200 Area SWMUs identified in the Permit (200-SB-05 through 200-SB-09). Historical data exist for four of these SWMUs from soil borings drilled and sampled in 1996 (NASA, 1996).
- Five additional soil boring locations are proposed based on the four AOIs identified using results of the Phase I investigation (200-SB-10 through 200-SB-14). These borings include the areas identified through the evaluation of Phase I geophysical features and supporting VOC concentrations from the shallow soil vapor survey.

Between one to three chemical soil samples will be collected during the advancement of each boring, depending on depth to bedrock in the vadose zone. Samples will be analyzed for contaminants of concern (COCs), which include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), hydrazines, metals (including hexavalent chromium in selected borings), and N-nitrosodimethylamine. In addition, at least one geotechnical sample will be collected from each soil boring following the chemical sampling if a sufficient amount of soil sample is available.

Once the total depth of each boring is achieved, an MSVM well will be installed within the soil boring. Each MSVM well will include one to three soil vapor sampling ports depending on the depth to bedrock. Soil vapor sampling ports will be located at depths proximal to the soil sample locations. In the event that perched or local groundwater is encountered, a multi-port soil vapor and groundwater monitoring (MSVGM) well will be installed in the soil boring to facilitate sampling for soil vapor and groundwater. The 200 Area MSVM wells will be purged following installation and sampled once in conjunction with this investigation. The wells will be will be plugged and abandoned at a future date with NMED approval. The results of the soil sample analyses will be compared to results from historical 200 Area soil sample analyses and New Mexico soil screening levels (SSLs) in accordance with Attachment 15 of the Permit (NMED, 2009). MSVM well soil vapor concentrations will be compared to concentrations for the network of existing soil vapor wells in the 200 and 600 Areas. NASA developed and proposed site-specific regulatory criteria for soil vapor based on contaminant concentrations, attenuation factors, and potential receptors. The NMED review for these action levels is in progress.

A timeline for submittal of the 200 Area Phase II IWP, NMED review and approval, performance of fieldwork, data evaluation, and the submittal of the 200 Area Investigation Report (IR) is presented. This schedule is considered realistic; however, the assumption is made that several individual milestones can be met. Following NMED approval of this Phase II IWP, fieldwork is anticipated to start in September 2013. Anticipated NMED involvement in the field investigation process will include approval of soil boring lithologic logs and MSVM well or MSVGM well construction diagrams. Project status updates will be provided during field activities in accordance with a schedule specified by the NMED Project Manager.

National Aeronautics and
Space Administration

200 Area Phase II Investigation Work Plan

January 2013

NM8800019434
NASA Johnson Space Center White Sands Test Facility
12600 NASA Road Las Cruces, New Mexico 88012

NASA Johnson Space Center White Sands Test Facility

200 Area Phase II Investigation Work Plan

January 2013

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

For Radel Bunker-Farrah
Chief, Environmental Office

1/30/13
Date

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Table of Contents

List of Figures and Tables

List of Acronyms and Abbreviations

3-D	Three dimensional
AOI	Area of interest
ASTM	American Society for Testing and Materials
Bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylene
CAP	Corrective action process
CAS	Chemical abstract service
CFR	Code of Federal Regulations
CME	Corrective measures evaluation
CoC	Chain of custody
COC	Contaminant of concern
DQO	Data quality objective
EDD	Electronic data deliverable
EPA	Environmental Protection Agency
ETU	Evaporation treatment unit
eV	Electron volt
°F	Degrees Fahrenheit
GMP	Groundwater monitoring plan
GPS	Global positioning system
GSA	Gardner Spring Arroyo
HASP	Health and safety plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HIS	Historical information summary
HSM	Health and Safety Manager
HWMU	Hazardous waste management unit
ID	Identification
IDW	Investigation derived waste
IR	Investigation report
IWP	Investigation work plan
JDMB	Jornada del Muerto Basin
JSC	Johnson Space Center
MCL	Maximum contaminant level
MS	Matrix spike
MSVGM	Multiport soil vapor groundwater monitoring
MSVM	Multiport soil vapor monitoring
NASA	National Aeronautic and Space Administration
NELAP	National Environmental Laboratory Accreditation Program
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NOA	Notice of Approval
OSHA	Occupational Safety and Health Administration
PCC	Post-closure care
PCE	Tetrachloroethene
PDF	Adobe portable document files

PID	Photoionization detector
PL	Project Lead
PM	Project Manager
PPE	Personal protective equipment
QA	Quality assurance
QC	Quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SAM	San Andres Mountains
SB	Soil boring
SCEM	Site conceptual exposure model
SOP	Standard operating procedures
SOW	Statement of work
SSL	Soil screening level
SVOC	Semi-volatile organic compound
SWMU	Solid waste management unit
TCA	1,1,1-Trichloroethane
TCE	Trichloroethene
TIVC	Total ionizable volatile compounds
USCS	Unified Soil Classification System
UST	Underground storage tank
VOC	Volatile organic compound
WSTF	White Sands Test Facility

1.0 Introduction

The National Aeronautics and Space Administration (NASA) Johnson Space Center (JSC) White Sands Test Facility (WSTF) (Environmental Protection Agency [EPA] Identification No. NM8800019434) has supported testing of space flight equipment and hazardous materials for nearly 50 years. The facility has five closed hazardous waste management units (HWMUs) at the 200, 300, 400, and 600 Areas that are identified in the New Mexico Environment Department (NMED)-issued Hazardous Waste Permit (Permit; NMED, 2009). Two of these closures are located in the 200 Area. The underground storage tanks (USTs) associated with these closures were removed from service in 1986 and closed in 1989. The 200 Area East Closure contains the former location of the Chemistry Laboratory UST and adjacent Chemistry Laboratory acid UST or sump. The 200 Area West Closure includes the former location of the original Clean Room UST and a replacement UST that was installed in late 1978 or early 1979. The engineered environmental cover is an asphalt parking area at the 200 Area East Closure and a concrete floor inside an operational building at the 200 Area West Closure.

Current regulatory requirements pertinent to the closures are specified in WSTF's Permit (NMED, 2009). The Permit requires a 200 Area Investigation Work Plan (IWP) to assess historical releases of hazardous waste or hazardous constituents to the subsurface, and to determine whether the soils beneath the closed 200 Area HWMUs are continuing sources of groundwater contamination. Permit Attachment 16 requires that the 200 Area IWP be submitted to NMED by June 30, 2012. During a teleconference between NMED and NASA on August 17, 2011, NASA agreed to accelerate the 200 IWP submittal schedule and expand the planned scope of the work to include five 200 Area Solid Waste Management Units (SWMUs). These consist of the historical 200 Area discharge pipes (Clean Room, Scape Room, Building 203, and the South Highbay: SWMUs 4 – 7) and the 200 Area main burn pit (SWMU 9). Permit Attachment 16 lists the IWP submittal date for these SWMUs as June 30, 2014.

Following the August 17, 2011 teleconference, NASA proposed a revised corrective action schedule to NMED in a letter dated September 1, 2011 (NASA, 2011[c]). NASA requested postponement of the 400 Area Closure investigation and follow-on work at the 300 Area Closure until after submittal of the 200 Area IWP. The letter also indicated that the scope of the 200 Area IWP would include an investigation of SWMUs 4, 5, 6, 7 and 9 and the Gardner Spring Arroyo (GSA) area located adjacent and southeast of the 200 Area Closures. The GSA area represents the catchment area for all surface runoff from the southeast side of the 200 Area buildings. NMED issued a Notice of Approval (NOA) for the proposed schedule on October 6, 2011 (NMED, 2011). The accelerated schedule required that the 200 Area IWP be submitted to NMED by March 30, 2012. Table 1.1 shows the revised corrective action schedule for all affected submittals. All other submittal dates remain as listed in Permit Attachment 16. NASA submitted the 200 Area IWP describing Phase I and Phase II investigation activities to NMED on March 28, 2012 (NASA, 2012[a]). NMED issued a Disapproval with comments on May 22, 2012, which required NASA to revise the existing 200 Area Closure IWP to remove any anticipated Phase II activities (NMED, 2012[b]). NASA submitted the revised (Phase I) 200 Area Closure IWP on June 20, 2012 (NASA, 2012[b]), and approval from NMED was received on June 28, 2012 (NMED, 2012[c]).

This document presents the Phase II IWP for the 200 Area Closures with the scope expanded to include the five SWMUs listed in Table 1.2, and four areas of interest (AOIs) identified by the Phase I investigation. The Phase I investigation area was expanded to include the 200 Area and adjacent portions of the 100, 600, and 800 Area. The project area covered by the geophysical survey lines and the shallow soil vapor grid included the significant drainages and catchment areas on the northwest and southeast sides of the 200 Area. Details of the investigation area are provided in the 200 Area Phase I Status Report submitted in conjunction with this IWP (NASA, 2013).

1.1 Objectives and Scope

The objective of the 200 Area IWPs is to identify specific actions necessary to determine the nature and extent of contamination in the vadose zone and potential migration pathways of contaminant releases to the air, soil, and groundwater in the 200 Area. This study proposed a phased approach. Phase I consisted of an extensive initial investigation across the entire 200 Area and adjacent areas that included seismic refraction and resistivity surveys and a shallow soil vapor survey. The scope of this Phase II investigation is to evaluate specific targets (HWMUs and SWMUs) and AOIs identified in the Permit and by the Phase I investigation within the vadose zone. As part of the investigation, soil borings will be installed to bedrock at the two 200 Area Closures, five 200 Area SWMUs (4–7 and 9), and five additional locations defined during Phase I of the investigation.

1.2 Regulatory Requirements

The Permit requires that NASA investigate and address historical releases of hazardous waste and hazardous constituents that may have occurred at sites throughout WSTF as part of the Resource Conservation and Recovery Act (RCRA) corrective action process (CAP). The CAP consists of investigation, characterization, and, if necessary, cleanup. The principal components of the CAP are:

1. RCRA Facility Assessment.
2. RCRA Facility Investigation.
3. Interim Corrective Measures (if necessary).
4. Corrective Measures Study (if necessary).
5. Corrective Measures Implementation (if necessary).

NASA is currently implementing interim corrective measures to address contamination within a groundwater plume that extends from the source areas west toward the Mid-plume and Plume Front areas. RCRA Facility Investigations are being conducted for specific HWMUs, SWMUs, and areas of concern in the source areas.

Section V.B.6.a.i of the Permit (NMED, 2009) requires the investigation of historical contaminant releases to the subsurface to determine if there are sources of ongoing groundwater contamination at the closed 200 Area HWMU locations. The Permit also requires that the IWP include schedules for implementation and completion of specific actions necessary to determine the nature and extent of contamination and potential migration pathways of contaminant releases at each of the identified SWMU locations (Section VII.H.1.b). The expanded scope of this work plan combines the investigation of the closed 200 Area HWMUs with an investigation of 200 Area SWMUs 4, 5, 6, 7, and 9 (Table 1.2). NMED will require corrective measures if it is determined, based upon the investigation and other relevant information, that there has been a release of hazardous waste or hazardous constituents into the environment that requires corrective action to protect human health or the environment (Section VII.J). If required, proposed remedies for contaminant removal will be evaluated and submitted to NMED in a corrective measures evaluation (CME) (Section V.D.2) format (Section VII.J.2).

This document satisfies the requirements set forth in Permit Section V.B.6.a for the 200 Area Closures and Section VII.H.1 for SWMUs 4 – 7 and 9. The proposed methodology includes all investigations necessary to ensure compliance with Code of Federal Regulations (CFR) 40 CFR 264.101 and 264.111, as required by the Permit (NMED, 2009).

1.3 Other Considerations

The activities presented in this IWP will disturb and potentially compromise the integrity of the 200 Area East Closure cap due to the installation of soil borings directly through the cap. The cap was designed and constructed in accordance with an NMED-approved work plan that also included design details for the 200 Area West Closure cap. Both Closures were certified on May 11, 1989 (NASA, 1989[b]). The understanding at that time was that they would not be damaged or compromised under any situation. Per correspondence received from NMED and EPA, NASA has been directed to drill either through (East Closure) or as close as possible to (West Closure) the Closure caps to investigate soil directly beneath the Closures (EPA/NMED, 1997; NMED, 2009). The 200 Area East Closure will be breached during this investigation by the installation of two soil borings. The 200 Area West Closure is under an operational building and cannot be accessed. Two soil borings will be placed adjacent to this Closure, but the cap is not expected to be compromised at this time.

Small (approximately 1 ft^2 [0.09 m^2]) holes will be cut through the asphalt cap at the East Closure to provide access for the subsurface drilling equipment. These planned breaches will be repaired to restore the integrity of the structure after field work is complete. Any other intentional or unintentional damage to the Closure(s) will be identified during a post-investigation assessment of Closure conditions. If any repairs are required, a mitigation plan will be prepared and submitted to NMED for approval.

2.0 Background

During the course of testing and evaluation processes at WSTF, waste is generated. Specific 200 Area waste generating activities have included organic and inorganic wet-chemical analysis; metallurgical testing and analysis; fabrication of electrical, mechanical and printed aerospace components; and precision cleaning. Wastes from these and other activities historically were fluids discharged into the Chemistry Laboratory Underground Storage Tank (UST), Chemistry Laboratory Acid Sump (UST), Clean Room USTs, and potentially the SWMUs listed in Table 1.2. Figure 2.1 shows the locations of the 200 Area Closures and SWMUs.

Potential releases to grade occurred at the Clean Room, Scape Room, Building 203, and South Highbay discharge pipes (SWMUs 4 – 7). The Clean Room Discharge pipe discharged to a northeast-southwest trending ditch west of Building 200 across Apollo Blvd that eventually drained to a significant drainage to the northwest of the 200 Area. The remaining pipes discharged into ditches east of the 200 Area Buildings that are within the catchment area of GSA to the southeast of the 200 Area. Compromised USTs resulted in releases of contaminants to the subsurface at the Clean Room Tanks (Figure 2.1; the 200 Area West Closure, originally located near the southwest corner of Building 200, and now under the Laboratory Consolidation (LabCon) building). The Chemistry Laboratory UST and Chemistry Laboratory acid UST or sump were located at the current location of the 200 Area East Closure, approximately 80 ft (24.38 m) northeast of Building 203 (Figure 2.1). Both tanks were found to be in good condition when they were removed during closure activities, but historical activities may have resulted in possible overflow and discharge to grade. The 200 Area main burn pit (SWMU 9) was located approximately 140 ft (42.67 m) north of the present location of the 200 Area Evaporation Treatment Unit (ETU) and was used to burn liquid flammable wastes during firefighter training exercises. The operational history of each of these units is introduced in Section 2.1 of this document. Details of the operational history are provided in the 200 Area Historical Information Summary (HIS; NASA, 2012[a]).

2.1 Operational History

WSTF operational history and detailed photographs and descriptions of individual waste management areas are provided in the 200 Area HIS (NASA, 2012[a]). Individual descriptions are provided for each of the two 200 Area East Closure USTs, the two West Closure USTs, and five SWMUs (SWMUs 4, 5, 6, 7, and 9 as identified in the Permit). The HIS also includes the documented results of personnel interviews, site visits, and responses to a detailed survey that were used to identify additional potentially hazardous activities and AOIs. A total of six additional AOIs were identified within the HIS (the Chemistry Laboratory Acid Tank Drain Pipe, an additional industrial drain pipe from Building 203, the Chemical Storage Building 253 and adjacent contaminated soil pile, the 270 Area Military Transport Vehicle Fire Suppression Test Area, two additional 200 Area historical burn pits, and the 250 Area Possible Septic Tank Drainage Source; NASA, 2012[a]). These areas were evaluated during the 200 Area Phase I shallow soil vapor field investigation. Results of the Phase I investigation are included in the 200 Area Phase I Status Report (NASA, 2013).

The WSTF 200 Area was originally designed as a test article preparation and laboratory area. The 200 Area became operational in 1964, primarily to provide support to the site's propulsion testing facilities for the Apollo space program. In 1967, NASA began using the WSTF Clean Room for the precision cleaning of equipment for the Lunar Receiving Laboratory. At the same time, NASA began to evaluate flammability and toxicity characteristics of materials used in the Apollo spacecraft, with associated testing being performed in the 200 Area. By 1970, the Apollo program focused on materials testing capability for oxygen and propellant-exposure environments. This testing capability was implemented at WSTF and expanded rapidly in the following years to include all facets of materials characterization, compatibility, and component verification in support of post-Apollo space programs for government and industry. In 1973, the 200 Area precision cleaning and control capabilities were upgraded.

As materials testing expanded at WSTF, five test facilities were developed, four within or near the 200 Area: the Chemistry and Metallurgical Laboratories (200 Area), the High-Flow Components Facility (250 Area), Hazardous Hypervelocity and Detonation Facilities (270 and 272 Areas), and the Materials Test Facility (800 Area). The 800 Area Materials Test Facility was completed between 1975 and 1979, the 250 High-Flow Components Area was completed between 1989 and 1990, and the 270 and 272 Hypervelocity and Detonation Areas between 1987 and 1991.

The 200 Area capabilities by this time included: precision cleaning; analytical laboratory operations; materials testing of fight hardware; environmental testing for shock, acceleration, temperature, humidity, and altitude/vacuum conditions; electrical and mechanical fabrication; electronic component failure analysis; mechanical and electrical calibrations; and photography. The current test capabilities are oriented toward evaluating material and component behaviors in hazardous environments with five major areas of expertise: oxygen systems; propellant systems; hypervelocity impact testing; composite overwrapped pressure vessels; and standard materials testing.

VOCs known to have been managed in the 200 Area USTs and potentially discharged at SWMUs during historical operations include: trichloroethene (TCE); tetrachloroethene (PCE); trichlorofluoromethane (Freon®[1]11); 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113); 2-butanone (methyl ethyl ketone); 1,1,1-trichloroethane; chloroform; benzene; ethylbenzene; toluene; xylenes; acetone; and 2-propanol (isopropyl alcohol). These compounds are all included within a more comprehensive list of contaminants of concern (COCs) reported in Section 2.2 of this IWP. Process wastes and waste management practices at WSTF have been continually modified and improved through time at the 200 Area in order to effectively minimize, document, store, and dispose of wastes.

[1] The trade name Freon® is a registered trademark of E.I. du Pont de Nemours & Company Corporation (DuPont).

2.2 Contaminants of Concern

COCs are those substances likely to be present in environmental media affected by a release. The known operational history for the 200 Area documented in the HIS (NASA, 2012[a]), results of previous site investigations (refer to Appendix A), and results from the ongoing groundwater monitoring evaluation were used to develop a list of COCs (Table 2.1). The purpose of this list is to help select appropriate analytical methods and sampling techniques.

Preliminary COCs include chemicals and wastes known to have been released at this site. In addition, contaminants that were detected during previous soil and soil vapor investigations irrespective of frequency or concentration are also included. The only screening that was applied at this time was to exclude inorganic analytes considered to be essential nutrients (i.e. magnesium, potassium, iron, sodium, and fluoride). Calcium and chloride are retained as COCs based on the past use of calcium hypochlorite trihydrate to oxidize hydrazine fuels. However, these analytes are nontoxic and are being analyzed only for informational purposes. For example, the presence of high levels of chloride could impact the selection of construction materials for a potential future remediation system as chloride enhances the corrosion of stainless steel. The oxidation of hydrazine fuels was not performed in the 200 Area. In addition, hexavalent chromium was not historically used for operations in the 200 Area, however, it is retained as a COC as required by the Permit Section V.B.6.a.iii.

Contaminants that have been consistently and reliably detected in groundwater samples collected from 200 Area groundwater monitoring wells are identified as COCs for the vadose zone investigation. Although many of the contaminants listed in Table 2.1 are not groundwater COCs, they are of interest for this vadose zone investigation because they could potentially exist in the soil above the water table as a result of documented historical use or previous detections in soil or soil vapor.

2.3 Preliminary Site Conceptual Exposure Model

A preliminary site conceptual exposure model (SCEM) was developed (Figure 2.2) to provide an understanding of the potential for exposure to hazardous contaminants at the site based on the source of contamination, the release mechanism, the exposure pathway, and the potential receptor(s).

The two former UST locations (200 Area Chemistry Laboratory and 200 Area Clean Room tanks) and the five 200 Area SWMUs identified in the NMED Permit (SWMUs 4, 5, 6, 7 and 9) are identified as “200 Area Primary Sources.” The extended Phase I investigation of the 200 Area and adjacent areas (NASA, 2013) that incorporated the known primary sources and additional targets defined within the HIS led to the identification of four additional AOIs that are recognized as potential primary components of the conceptual model. Secondary sources are identified as: 1) groundwater that was directly impacted by releases of wastewater during historical operations; 2) subsurface soils beneath the “200 Area Primary Sources” that may have been contaminated with the waste from the leaking tanks, discharge pipes, burn pits, or storage areas; 3) surface soil or exposed subsurface soil that was commingled or in contact with the waste from the primary sources, including soil and sediment in swales, drainage ditches, and runoff areas (i.e., the arroyos to the northwest and southeast [GSA] of the 200 Area); and 4) airborne particulates/dust or gaseous materials originating from the primary sources before they were closed.

Six release mechanisms are identified in the SCEM as follows:

1. Hydraulic Pressure. This release mechanism is most applicable to sources that had inadequate containment systems or poor integrity. Hazardous substances and their constituents may have leaked from the unit to the soils beneath or down topographic gradient from the source. Under

this release mechanism, the mass of the hazardous substances is pulled by gravity toward the subsurface strata through the path of least resistance.

2. Leaching. This release mechanism refers to the movement of soluble chemicals via infiltration into subsurface soils. As a result of wastewater, precipitation, or storm runoff, leaching action removes the hazardous substances and their constituents from the source. This release mechanism could be viewed as the combined mechanisms of gravitational force, hydraulic pressure, and solubility. Leaching also serves as a migration pathway that transports the released hazardous substances and their constituents to other media or locations.
3. Runoff. This release mechanism refers to the physical force, posed by surface water moving downstream, that removes the hazardous substances and their constituents from the source. Runoff occurs when the rate of water interception is greater than the infiltration capacity of the medium. Runoff also serves as a migration pathway that transports released hazardous substances and their constituents to other media or locations. Runoff action is applicable to areas with measurable topographic relief, and is a predominant cause of release of hazardous substances in contaminated soils along channels or arroyos.
4. Digging. This mechanism refers to human activities that cause the hazardous substances or their constituents to be exposed. Construction activities that entail soil or sediment excavation are examples of this release mechanism.
5. Volatilization. This release mechanism is dependent on the chemical characteristics of the hazardous substance (i.e., molecular weight, vapor pressure, Henry's Law constant, boiling point, etc.), ambient temperature, and wind velocity or air movement. Under this release mechanism, the hazardous substances or their constituents are released from the matrix surfaces (solid or liquid) into air (pores in soil or the ambient air). This release mechanism is most applicable to volatile organic chemicals and, to a lesser extent, semi-volatile organic chemicals.
6. Wind Erosion. This release mechanism refers to the frictional force posed by air movement near the earth’s surface that removes the hazardous substances and their constituents from the source to air. Under this release mechanism, the hazardous substances or their constituents are released from the matrix surface into air. This release mechanism is most applicable to metals and semi-volatile organic chemicals in dry and dusty environments.

Four potential exposure pathways are identified: 1) ingestion of groundwater; 2) incidental ingestion of soil; 3) inhalation of volatile contaminants or particulate emissions (dust); and 4) dermal contact with soil.

Groundwater use is identified as a potential route of exposure. The groundwater underlying much of WSTF is known to be contaminated and its future use and potential risk to receptors are part of an ongoing site-wide evaluation and corrective actions. No water supply wells exist in the 200 Area. There are no current or future residential land use scenarios anticipated in the vicinity of the 200 Area. The area is within a controlled test site located on the U.S. Army White Sands Missile Range. The two UST locations are capped and managed under a RCRA permit. There are no encroaching residential areas. Therefore, there are no complete exposure pathways identified for residential land use scenarios. A risk assessment of the groundwater itself will not be conducted as part of this investigation.

There are no additional industrial/occupational land use scenarios anticipated for the 200 Area beyond the current use scenario. Industrial facilities and buildings are located immediately adjacent to the two primary UST locations. The two arroyos located down topographic gradient of the 200 area to the northwest and southeast are undeveloped, and there is no reasonable potential that these areas would be developed for future industrial use. Based on the current industrial land use scenario for the 200 Area, no complete exposure pathways are identified for an industrial/occupational receptor population.

A construction use scenario therefore provides the best fit for the Closures and HWMUs. Previous vadose zone investigations performed within the 200 Area have not identified contaminant concentration levels in soils (Section 2.4). However, the potential remains that construction workers could encounter contaminated material when working on roads or utility conduits in the area. Therefore, inadvertent ingestion of, inhalation of, or dermal contact with soil may be considered a complete exposure pathway for this evaluation.

2.4 Summary of Previous Investigations

Previous vadose zone investigations have specifically targeted historical contaminant releases in the 200 Area and adjacent areas, particularly in the vicinity of the GSA. These include a seismic reflection survey (1986; discussed in NASA, 1987[a] beginning on page 60), shallow soil vapor investigation (GCL, 1986), shallow soil boring investigations (Phase I - 1986 – 1987; NASA, 1987[b]; Phase II – 1994-1995; NASA, 1996), and the installation of soil vapor wells 200-SG-1, 200-SG-2, 200-SG-3, and 200-SG-4 in 1997 (NASA, 2004). Conventional groundwater monitoring wells 200-B-240, 200-D-109, and 200-D-240 and Westbay®[2] multi-port groundwater monitoring wells 200-F, 200-G, 200-H, and 200-I were also installed in the 200 Area during the 1987 to 1997 timeframe as part of WSTF's groundwater and post-closure care (PCC) monitoring programs. Multi-port soil vapor and groundwater monitoring (MSVGM) well 200-JG-110 was installed in 2011 to assist with investigation of the vadose zone and shallow aquifer in GSA between the WSTF 200 and 600 Areas. The location of soil vapor points, soil borings, and wells installed as part of previous investigations are provided in Figure 2.3.

The primary objectives of the previous 200 Area vadose zone shallow soil vapor, shallow soil boring, and MSVGM well investigations were to:

- Collect the data required to evaluate the integrity of the 200 Area East and West Closures and investigate the vadose zone surrounding the tanks.
- Investigate the vadose zone in the area surrounding SWMUs 4 through 7.
- Investigate the vadose zone and upper aquifer within GSA, particularly around the Well 200-D cluster, where the highest historical concentrations of TCE in groundwater have been reported.
- Support the investigation of the vadose zone and shallow aquifer between the WSTF 200 and 600 Areas.

A detailed description of the results of the historical shallow soil vapor and shallow soil boring investigations performed in the area is provided in the Draft RFI (NASA, 1996). A description of the Well 200-D vadose zone investigation and analytical results are provided in the Well 200-D Area Vadose Zone Investigation Report (NASA, 2004). Results from the MSVGM well 200-JG-110 are included in the latest 200/600 Area semi-annual soil vapor and groundwater data summary (NASA, 2012[c]). A summary of the location, construction, and analytical results from conventional and Westbay wells installed in the area between 1995 and 2009 are provided in annual Post-Closure Care reports (NASA, 1995 – 2009). A summary of each of the individual investigations along with data summary tables are provided in Appendix A.

3.0 Site Conditions

The local topography at WSTF is typical of the Basin and Range physiographic province of the southwestern United States; formed as a result of late Tertiary extensional tectonism. The adjacent San

[2] Westbay® is a registered trademark of Westbay Instruments Inc.

Andres Mountains (SAM) represent an uplifted northwest-trending mountain block immediately to the east of WSTF, separated from adjacent mountain ranges by broad intermontane basins. The Jornada del Muerto Basin (JDMB) is located on the west side of the SAM and the adjacent alluvial-covered bedrock pediment slope on which WSTF is located.

3.1 200 Area Closure and SWMU Descriptions

The two closures in the 200 Area are comprised of the former 200 Area UST locations. The USTs and surrounding soil were removed and replaced with compacted clay fill in 1987. Six inches of compacted granular soil was applied as a base course for an asphaltic concrete cap that was installed during closure activities in 1988 – 1989 (NASA, 1988).

The 200 Area East Closure cap was constructed over the former location of the Chemistry Laboratory UST and Chemistry Laboratory Acid Sump. This cap diverts water towards a concrete-lined drainage channel. A key joint integrated into the cap’s design limits water infiltration between the asphalt surface of the cap and the concrete surface of the drainage ditch. The 200 Area West Closure contains the former location of the original and replacement Clean Room USTs. The LabCon addition was added to the west side of Building 200 in 1989-1990, which now covers the closure and associated asphaltic concrete cap. A full summary of 200 Closure construction is provided in the 200 Area Closure Plan (NASA, 1988) and 200 Area Closure Report (NASA, 1989[a]).

The 200 Area SWMUs addressed in this work plan include four discharge pipes and the 200 Area main burn pit. The vicinity around the discharge pipes were investigated during a previous soil boring investigation (NASA, 1996). This and other previous vadose zone investigations conducted in the 200 Area are summarized in Section 2.4.

The Clean Room discharge pipe (SWMU 4) was a 3-in. steel pipe that discharged into a small northeast-southwest trending drainage ditch on the west side of Apollo Boulevard across from Building 200 and subsequently into the drainage to the northwest of the developed 200 Area. Use of the Clean Room pipe began in 1964, and it discharged cleaning solutions and solvents used in the Clean Room and at the Clean Room Pad. In 1989, use of the pipe was discontinued in conjunction with the LabCon project, and the pipe was removed in 1996.

The remaining SWMUs all discharged to the southeast into GSA. The 200 Area Scape Room discharge pipe (SWMU 5) discharged rinsate from suit decontamination activities into a ditch approximately 125 ft (38.1 m) southeast of the 200 Area North Highbay. It was used from 1964–1989, when the line was piped into the hazardous waste drain line system for the ETU. Long-term WSTF employees stated that use of the pipe continued for water condensate discharge until the mid-1990s.

The Building 203 discharge pipes (SWMU 6) consisted of two pipes, a 4-in. and a 6-in.-diameter pipe that merged together and discharged industrial wastewater into a northeast-southwest trending ditch approximately 70 ft (21.34 m) southeast of the south corner of Building 203. Two pipes were present at this location; one 4-in.-diameter pipe and one 6-in.-diameter pipe. The waste stream discharged to these pipes is not well documented, but the pipes are believed to have been used from 1964–1991 for industrial wastewater and from 1991 to the mid-1990s for cooling water discharge.

SWMU 7 is located at the former location of the 200 Area South Highbay discharge pipe. This steel pipe was 4 in. in diameter and discharged to a ditch approximately 125 ft (38.10 m) southeast of the South Highbay from 1964-1987. In 1987, a 1,000-gallon capacity steel stock tank was placed at the terminus of the pipe in order to contain the discharge. The pipe and stock tank were used from 1987–1991, when effluent was routed to the 200 Area wastewater lagoon. The pipe is no longer in use. It is believed that effluent from this pipe contained primarily cleaning solutions and solvents.

The 200 Area main burn pit (SWMU 9) was located approximately 140 ft (42.67 m) north of the present location of the ETU. The excavated soil pit was 25 ft long by 10 ft wide by 1 ft deep (7.62 m x 3.05 m x 0.3 m) and may have been in use from 1965–1969. However, historical WSTF photographs show use of a burn pit in this location only in 1964. It is estimated that 50 to 100 gallons of flammable liquid wastes were burned here annually during its operation. A soil vapor investigation performed in 1987 indicated trace levels of hydrocarbons and BTEX (benzene, toluene, ethylbenzene, and xylenes) in its vicinity. No soil sampling was performed.

3.2 Surface Conditions

The 200 Area industrial complex was constructed on a relatively level pediment of thin alluvium at an elevation of approximately 4,930 ft (1,502.66 m) above mean sea level (amsl). This area is located immediately west of and bound on the south by the GSA as it turns westward toward the JDMB. Pennsylvanian limestone, sandstone, and siltstone bedrock crops out approximately 1,000 ft (761.96 m) to the east of the 200 Area industrial complex on the east side of GSA.

Gardner Spring is the only natural surface water feature in the area and is located approximately 2,000 ft (609.57 m) northeast of the 200 Area industrial complex within GSA. Gardner Spring is an intermittent spring and ceases flow for long periods of up to several years between rare periods of heavy mountain-front rainfall. The nearest natural water body of significant scale is the ephemeral Isaacs Lake located approximately 10 mi (16.1 km) to the southwest of WSTF. It is located at the lowest point of the JDMB at an elevation of 4,285 ft (1,306 m) amsl.

Soils in the vicinity of the 200 Area are classified as Tencee-Nickel Association Gently Sloping and Steep units by the United States Department of Agriculture, Soil Conservation Service (USDA SCS, 1976). The Tencee Series is comprised of shallow, well-drained soils which formed in calcareous gravelly loamy alluvial sediments on old alluvial fans. The upper 5 ft (1.52 m) are characterized by brown to light-brown gravelly loam with interbeds of pink indurated caliche. Tencee Very Gravelly Loam is typically light to dark brown, weak, coarse, and has a subangular blocky structure. The soil is slightly hard, dry and very friable. Interstitial pores are common. The soil is approximately 30 – 45% caliche and gravel, is strongly calcareous, and has nearly continuous lime coatings on all clasts. The Nickel series soils comprise deep, well-drained soils on old alluvial fans. They are typically gravelly, medium textured alluvial sediments with gravel contents to 50%.

The Tencee-Nickel, Gently Sloping unit is approximately 65% Tencee Very Gravelly Loam and 20% Nickel Fine Sandy Loam. The soil is nearly level to gently sloping and occurs on old alluvial fans. Included within these soils are arroyo bottoms and areas of soils similar to Tencee and Nickel soils except that they contain less than 35% coarse fragments. The Tencee-Nickel, Steep unit is approximately 45% Tencee Very Gravelly Loam and 40% Nickel Fine Sandy Loam. The Tencee soil is a moderately sloping to steep soil in ridges and saddles, and the Nickel soil is a rolling to steep soil on broken areas of the landscape. These soils comprise gravelly soils containing less than 35% coarse fragments, badland, stony rock land, and arroyos.

The WSTF area is associated with a predominantly Chihuahuan Desert Shrub climate. This climate is characterized by abundant sunshine, low humidity, slight rainfall, and a large day-to-night temperature variance. The mountainous terrain in the area influences the climate by blocking the incursion of moisture laden maritime air masses.

Biotic resources at WSTF are typical of those found in the arid southwest, a desert area with low rainfall and sparse vegetation. The average rainfall of 10 in. per year makes it difficult to support agriculture. As is typical with all deserts and semi-arid areas, the overall species diversity is low.

Major vegetation within WSTF includes a combination of woody shrubs and grasses characteristic of the Chihuahuan Desert Shrub Biotic Community. These shrubs include Louisiana White Sage, Creosotebush, Honey Mesquite, Tarbush, Broom Snakeweed, and Lotebush. Common grasses include Alkali Sacaton, Side-Oats Grama, Fluff Grass, Tobosa Grass, and Purple Three Awn. In addition to GSA, numerous other well-developed arroyos are present but hidden from sight within the low profile topography and vegetation. Water flows in a westward direction toward the JDMB. Plant species biodiversity is low relative to that in better drained upland slopes. Shrubs provide a microhabitat for warm season grasses and forbs as well as herptiles and small mammals.

WSTF is considered to be a low affectability area. The facility receives little use by wildlife species because it has been physically altered by human disturbance or overgrazing. The area provides reduced topographic relief and vegetation diversity associated with food and cover.

3.3 Subsurface Conditions

Alluvium in the 200 Area vadose zone consists of coalescent alluvial fan deposits derived from the adjacent SAM to the east. The alluvium is an unconsolidated to moderately cemented, poorly sorted polygenetic pebble to boulder conglomerate. Lenticular sandy to clayey gravels, sandy silt and silty clays are interbedded with the conglomerate. Clast lithologies include varieties of subrounded to subangular granite, rhyolite, siltstone, and micritic limestone in sand to boulder-size clasts.

The GSA area hosts younger piedmont slope alluvium, characterized by unconsolidated silt, sand, gravel, and loam within the arroyo floor. Alluvial fan materials visible in cut sections of the GSA are indicative of irregular channeled morphologies with grain sizes ranging from clay and sand to well-graded sandy gravel. The primary lithology across the area is the piedmont slope facies of the Camp Rice Formation (Seager, 1981). The Camp Rice Formation within this area is a poorly indurated, gravelly alluvium. Previous 200 Area vadose zone investigations have identified moderately cemented caliche horizons at depths of 30 to 40 ft (9.14 – 12.19 m) and 55 to 65 ft (16.76 – 19.81 m). Significant barriers to soil vapor migration were not encountered within the 200 Area soil borings (NASA, 1987; NASA, 1996).

Alluvium in the 200 Industrial Area overlies limestone bedrock, which occurs at varying depths due to faulting in the area. Based on the interpretation of results of the 200 Area Phase I geophysical surveys, the 200 Area bedrock has been fractured pervasively, predominantly on an orthogonal system, with one fracture set trending northeast-southwest and the other fracture set trending northwest-southeast. Three primary subparallel northeast-striking bedrock structures in the 200 Area are the 200-East Fault (located approximately coincident with GSA), the Apollo Boulevard Fault (located below and immediately west of Apollo Boulevard), and the 200 West Fault (coincident with the arroyo located approximately 1,500 ft (457.18 m) northwest of Apollo Boulevard; Figure 3.1). Maciejewski (1996) previously interpreted two faults in the 200 Area that are approximately coincident with the 200 East Fault and the Apollo Boulevard fault. All three faults are interpreted to be northeast trending normal faults downthrown to the northwest. Based on the Phase I geophysical surveys, the 200 East fault has an inferred vertical displacement of 80 to 100 ft (24.38 to 30.48 m), and the Apollo Boulevard Fault has vertical displacement of 40 to 60 ft (12.19 to 18.29 m). Local fault displacement depends on internal block faulting (Maciejewski, 1996).

Two additional structural features identified in the Phase I geophysical surveys were the northwest trending area of downfaulted bedrock referred to as the 200-D graben and the north-northwest trending Road G offset which crosses Apollo Boulevard near the Road G intersection (Figure 3.1). The 200-D graben is oriented perpendicular to the trend of the 200 East fault and the Apollo Boulevard fault. This feature is well defined in geophysical cross-sections (NASA, 2013; Appendix B, Line K), creating limestone bedrock that is fractured in a block-like fashion within the orthogonal system.

The shallowest bedrock in the 200 Industrial Area was located in previous soil borings at SWMU 4, the Clean Room Discharge Pipe (10 – 14 ft; 3.05 – 4.27 m bgs) and just to the southeast across Road L in well 200-F (17 ft; 5.18 m bgs). This information confirms the existence of the primary bedrock high in the vicinity of the 200 Area West Closure between the 200 East fault and the Apollo Boulevard fault. Bedrock elevations drop in all directions away from this location, including to the east toward the 200 Area East Closure and the GSA. Lower bedrock elevations in wells 200-G (55 ft; 16.76 m bgs) and 200-H (74 ft; 22.56 m bgs) located east of 200-F provide evidence of the decreasing bedrock elevations to the east toward the strike of the 200 East Fault (Figure 3.1).

4.0 Scope of Activities

The scope of activities is developed based on project data quality objectives (DQOs) and other requirements of Permit Attachment 17. Deviations from the Permit requirements are discussed in Appendix B. Section 4.1 of this IWP discusses the DQO process, Section 4.2 describes the sampling plan, and Section 4.3 describes the investigation-derived waste (IDW) plan.

4.1 Data Quality Objective Process

The investigation methodology was developed based on "Guidance on Systematic Planning Using the Data Quality Objectives Process" (EPA, 2006) and the 200 Area Corrective Action Requirements of the Permit (NMED, 2009; Section V.B.6.a). The data acquisition plan (i.e., sampling design) is based on the DQO process.

4.1.1 Problem Statement

The problem statement is summarized in the Permit (NMED, 2009; Section V.B.6.a.i), which states that the IWP shall address investigation of contamination that was historically released to the subsurface and that potentially is a source of ongoing groundwater contamination. NASA submitted the IWP for Phase I of the 200 Area investigation prior to March 30, 2012 in accordance with the NMED NOA for an accelerated 200 Area IWP schedule submitted on October 6, 2011. The accelerated schedule supersedes the schedule established in Permit Attachment 16 (Investigation Work Plan Submittal Schedule).

4.1.2 Decision Statement and Alternative Actions

The primary decision is whether additional corrective actions are warranted at this site due to the presence of a residual contamination source(s). Alternative actions for the decisions include:

- Consider a "Corrective Action Complete" status determination.
- If needed, perform a CME to identify remedial options for mitigation of source(s) of continuing contamination or human health risk.

4.1.3 Decision Inputs

Concentrations of COCs measured in vadose zone soil, soil vapor, and groundwater are primary inputs to the decision. COCs for this investigation have been identified using two primary information sources:

- Detailed information pertinent to the operational history and use of chemicals documented in the 200 Area HIS (NASA, 2012 [b]) through a variety of historical documents and reports, personnel interviews, and personnel questionnaires.
- Comprehensive analytical data sets for samples collected from previous 200 Area investigations that include soil, soil vapor, and groundwater. Analytical methods selected for this investigation will be used to quantify COC concentrations at or below NMED soil screening levels (SSLs) whenever possible (NMED, 2012[a]).

4.1.4 Study Boundaries

This investigation addresses and is limited in the vertical extent to the vadose zone (i.e., the unsaturated area between ground surface and the water table) beneath and immediately surrounding the 200 Area USTs, SWMUs, and adjacent areas including two significant arroyos to the northeast and southwest (GSA) of the industrialized 200 Area (Figure 2.3). The boundaries of the study were extended for the Phase I investigation using an 1,800 ft (548.61 m) x 4,500 ft (1,371.53 m) shallow soil vapor grid (Figure 3.1) to provide a comprehensive evaluation of the 200 Area and define any additional AOIs that may warrant investigation through the installation of soil borings (NASA, 2013). Information acquired during the performance of the Phase I and Phase II investigations will be evaluated in conjunction with existing data derived from previous investigations that include groundwater monitoring well analytical results.

One of the primary constraints to drilling and sampling in the 200 Area are the existing network of aboveground and buried utilities, buildings, and other structures. Several locations within the industrialized 200 Area, particularly in the vicinity of the former USTs (the closed 200 East and 200 West HWMUs are not easily accessed by conventional drilling equipment due to the existing buildings and structures. For the SWMUs surrounding the 200 Area, including the former main burn pit and discharge pipes, the relatively steep local topography may also inhibit drilling equipment access. Although four of the five 200 Area SWMUs have been previously investigated using soil borings (SWMU 4 – Clean Room discharge pipe, SWMU 5 – Scape Room discharge pipe, SWMU 6 – Building 203 discharge pipes, and SWMU 7 – South Highbay discharge pipe), the maneuverability of the drilling rig within these areas on the slopes surrounding the 200 Area buildings was difficult. The alluvial vadose zone in the 200 Area typically varies between 15 to 100 ft (4.57–30.48 m) bgs. Selection of the size and type of drilling equipment will be based on subsurface geologic conditions and vehicle accessibility within and around the Closures, SWMUs, and AOIs.

Another constraint is related to subsurface geology. Based on previous soil boring and well installations across the area, cobbles and boulders are common within the coarse-grained coalescent alluvial fan deposits. These make collection of representative soil samples difficult, with previously reported soil sample recoveries as low as 20% using hollow stem augers equipped with split spoon samplers (NASA, 1996). Standard coring techniques also typically experience very low recoveries and problems with sidewall sloughing and collapse due to the extremely dry and relatively coarse grained nature of the alluvium. Rotary techniques have the potential to contaminate samples through the use of drilling fluids or air. Experience with rotosonic coring techniques during the 600 Area Closure investigation (October 2009 through January 2010) indicated that the method may be altogether incapable of penetrating some particularly difficult formations at depths below 80 feet (24.38 m) with or without the addition of drilling fluids including water. Small drill rigs (i.e., direct-push or mini-sonic rigs) are incapable of penetrating the difficult lithologies known to exist near the SAM front beyond a depth of a few feet.

During the 600 Area and 300 Area Closure field investigations (performed November 2010 through January 2011), a modified heavy-duty sampling core barrel was used with an air-rotary casing hammer drilling strategy. This boring installation technique allowed for improved soil sample recovery (typically 20–50%) with minimal boring collapse. It was concluded that only a limited number of drilling and sample collection approaches can be employed within the WSTF industrialized areas.

The proximity of the project area to the active testing facilities also imposes logistical constraints. Current operations at the 200 Area include laboratories and support facilities for propulsion system and components testing. The adjacent 250, 270, and 800 Areas were constructed to perform hazardous testing of hardware safely with access to essential utilities and control facilities. For safety purposes, access to selected areas of the investigation site could be periodically restricted during testing and other hazardous operations. Field activities will be closely coordinated with the 200 and 800 Areas in accordance with an internal communications matrix to minimize schedule impacts to testing and investigation activities.

4.1.5 Decision Rule

The purpose of this investigation is to measure vadose zone contamination within the 200 Area and to determine if observed concentrations within the vadose zone soils exceed applicable regulatory criteria. The strategy is to comprehensively address the industrialized portion of the 200 Area and adjacent areas, with a focus on the locations known to have the greatest potential for contamination. In accordance with NMED soil screening guidance (NMED, 2012[a]) and the Permit (NMED, 2009), validated analytical results from soil samples collected during the investigation will be compared to the appropriate risk-based screening level as described in Permit Attachment 15 (e.g., New Mexico soil screening levels (SSLs) or EPA Regional SSLs) for direct exposure of construction workers. Where multiple contaminants are detected, the cumulative effects of those contaminants will be considered as described in the guidance.

There are many uncertainties associated with the use of soil vapor data, and there are no current applicable regulatory criteria for the state of New Mexico. NASA evaluated the concentrations of site-specific soil vapor contaminants and conditions associated with the contaminants, and proposed potential regulatory criteria, which are currently being evaluated by NMED. NASA will consider the utilization of these site-specific regulatory criteria based on NMED feedback regarding their applicability at WSTF. The collection of soil vapor data from multiple depths and multiple locations across the study area using MSVGM wells will support a quantitative evaluation of potential soil vapor contamination. The potential for vapor intrusion to nearby 200 Area buildings using concentrations in soil vapor and conservative attenuation factors will also be assessed as part of the investigation. Any estimated indoor air concentrations will be compared to regulatory screening levels for a residential scenario.

Project DQOs are summarized as follows: If COC concentrations in vadose zone soils exceed the cleanup levels as described in Permit Attachment 15 for direct exposure routes under the construction worker scenario, then move to the corrective measures evaluation phase. Otherwise, consider a "Corrective Action Complete" status determination. If this investigation fails to fully determine the nature and extent of contamination, additional site characterization may be required even if the DQOs are achieved.

4.2 Sampling Tasks

4.2.1 Sampling Design

The sampling design must fulfill the project DQOs. The first DQO requires contaminant concentration data from subsurface soil samples. The second DQO requires collection of soil vapor data for the volatile COCs in areas most likely to be impacted by vapor phase contamination. Sections 4.2.2 through 4.2.4 provide a detailed discussion of the project sampling design for soils, soil vapor, and groundwater. Table 4.1 summarizes the sampling and analyses that will be performed under this Phase II IWP. A detailed discussion of drilling methods and soil boring locations proposed for the investigation can be found in Section 5.2.

4.2.2 Soil Sampling Plan

Because the COCs were collectively disposed of in a liquid waste stream, their distribution is expected to be relatively homogenous in areas where ponding water conditions existed (e.g. inside the former tank locations, within a burn pit, or in drainage depressions adjacent to discharge pipes). For this investigation, nine soil boring locations (200-SB-01 through 200-SB-09; Figure 4.1) are positioned to address data gaps in the vadose zone below the known 200 Area USTs and SWMUs. Five additional soil boring locations (200-SB-10 through 200-SB-14; Figure 4.1) will be completed based on the results of the Phase I geophysical survey and shallow soil vapor survey.

Two borings are planned in the vicinity of each of the former two UST locations (for a total of four in those two locations), one in the vicinity of each of five identified SWMUs (four of which have been previously investigated), and five borings to be installed within the four additional AOIs defined in the 200 Area Phase I investigation (Figure 3.1). A total of 14 soil borings are anticipated to be installed to 2 ft (0.61 m) below the depth of the alluvium/bedrock contact based on the impracticality of sampling and/or remediation within the bedrock below this depth.

The physical configuration of the 200 Area constrains the position of the borings at the UST locations as required by Section V.B.6.a.ii of the Permit (NMED, 2009). For the two former Clean Room tank locations on the west side of Building 200, building construction activities have been performed over the locations of the former tanks. Two alternative boring locations are proposed approximately 50 ft (15.24 m) to the southwest of the tanks at a downgradient location as indicated by the dip in the local bedrock surface. The issues of drilling depth and modification of drilling locations based on existing 200 Area buildings was addressed during the conference call between NASA and NMED on December 14, 2011.

Any resultant drilling rig access issues will be addressed as necessary. The Phase I evaluation of the previously unidentified potential release areas within the 200 Area HIS (NASA, 2012[a]) and a broader investigation area that incorporated the 200 Area and portions of the adjacent 100, 600, and 800 Areas provided sufficient data to characterize the extent of contamination from the 200 Area in accordance with 40 CFR 264.101. Soil borings proposed based on the Phase I investigation were specifically designed to provide additional information on the extent of potential vadose zone contamination outside of known 200 Area USTs and SWMUs to the depth of bedrock.

The investigation borings will be installed from ground surface to 2 ft (0.61 m) below the depth of bedrock, if possible.. No drilling fluids will be utilized during the casing hammer drilling process. Based on drilling experience for similar geological environments, it is unlikely that a continuous core can be collected without introducing drilling fluid (water) to the boring. Even with the addition of water, the ability for a continuous core rig to drill to bedrock is unlikely based on the experience at the 600 Area Closure investigation (NASA, 2011[a]). As a result, it is recommended that soil samples be attempted over three discrete intervals for each boring using the air rotary drilling method described in Section 5.1. The sampling intervals will be determined using the anticipated depth to bedrock for each boring based on past investigative information and any specific lithological observations made during boring installation. This method will allow the sampling of undisturbed cores over short depth intervals without using drilling fluids that could interfere with the chemical analysis. This sampling process proved to be successful during the 300 Area Closure Investigation (NASA, 2011[b]). Additional soil samples may be attempted based on pertinent geological conditions or observations (discolored soil, revised depth to bedrock, etc.).

Borings 200-SB-01 and 200-SB-02 located adjacent to the former Clean Room UST on the west side of Building 200 will be drilled first in order to obtain preliminary analytical data for waste characterization according to the investigation-derived waste procedures (Appendix C). The remaining borings will be drilled in numerical order, or as close to numerical order as is possible. Adjustments to the numerical sequence may be made in order to install borings in a manner that minimizes any disruption of the 200 Area testing and personnel activities.

To address project DQOs, soil samples will be collected from near ground surface, at an intermediate depth, and near the bottom of the boring. The depth to bedrock beneath the 200 Area is expected to vary between approximately 20 ft (6.10 m) and 120 ft (36.57 m). Soil samples will be collected within the top 10 ft (3.05 m) of the boring, and subsequently at intermediate and deep locations that will be based on the projected depth of bedrock and any unique lithological characteristics observed during boring installation. The deepest sample will be collected near the bottom of the boring as close to the bedrock surface as feasible, taking into account issues of sample quality, sample recovery, and the position of the water table if encountered unexpectedly. Drilling and sampling procedures are discussed in Section 5.2.

Soil samples collected from the borings will be analyzed for the suite of the COCs using standardized analytical methods approved for use at WSTF. Hexavalent chromium was not historically used for operations in the 200 Area but was included in the analysis within soil borings adjacent to the 200 Area East and West Closure USTs and the Clean Room discharge pipe SWMU based on Permit Section V.B.6.a.iii. Table 4.1 summarizes planned samples and analytical methods.

4.2.3 Soil Vapor Well Installation

An MSVM well will be installed inside the override casing within each soil boring (MSVM wells 200-SV-01 through 200-SV-14). Each well will comprise between one and three sample ports that will be placed with the objective of providing vertical delineation of vapor concentrations in the vadose zone. Expected soil boring depths will range from 20 ft (6.10 m) up to 120 ft (36.57 m). Sample ports will be located at approximately equidistant intervals at a spacing that most effectively covers the vadose zone. When practical, port depths will be approximately coincident with the locations of the soil samples attempted during boring installation. The uppermost port will be located at approximately 10 ft (3.05 m) bgs and the lowermost port will be located immediately above the bedrock surface. A middle port (if required, depending on the depth to bedrock) will be strategically placed at an intermediate interval with the potential for modification if a horizon of specific interest is identified during lithological logging of the boring. A generalized construction design for an MSVM well is presented in Figure 4.2. Anticipated soil vapor port locations are included in Table 4.1. Prior to installation, each MSVM well location and design will be submitted to NMED for review and approval.

Each soil vapor port in an MSVM well will consist of narrow ($^{1}/_{4}$-in. nominal) diameter stainless steel tubing attached to a 12-in. length soil vapor implant/filter (sampling port). The tubing will be secured to the outside of a stainless steel cable guideline with a stainless steel weight on the bottom. The end of each length of tubing will be secured at the specified monitoring port depth and attached to the 12-in. implant using a Swagelok stainless steel fitting. The tube from each soil vapor sampling port will be labeled at the surface with the appropriate port depth information. The surface connection for each sampling port will consist of a Swagelok stainless steel fitting.

Once the sampling ports have been installed, annular materials will be emplaced according to the NMED-approved well diagram. Annular materials will be installed in stages by adding requisite volumes of annular materials into a calculated volume of boring. A tremie pipe may be used to prevent bridging. The over-ride casing will be pulled gradually as the annular materials are added to prevent boring collapse and compromise of the MSVM ports. Boring depth will be sounded periodically during the backfilling procedure, and the various footages for annular materials recorded in the well construction diagram. Any bridging of annular materials during emplacement will be addressed and resolved prior to the emplacement of additional materials.

Hydrated bentonite chips will be placed in the bottom of the boring below the base port. Annular materials at each subsequent soil vapor monitoring zone will consist of approximately 5 ft (1.52 m) of Colorado Silica sand (10/20 mesh) centered on each soil vapor sampling port. A maximum of 10 ft (3.05 m) of hydrated bentonite will be installed above and below the sand between monitoring zones. The thickness of hydrated bentonite may need to be modified depending on the depth of bedrock and space available for annular completions within the well. A slurry of cement and bentonite powder will be installed though the tremie pipe to separate the bentonite layers and create the final seal between sampling zones. Above the uppermost soil vapor monitoring zone, a maximum of 10 ft (3.05 m) of hydrated bentonite will be installed to approximately 2 ft (0.61 m) bgs. The thickness of this plug may be reduced based on the depth of the top port. Cement will then be installed to the surface (Figure 4.2).

Following MSVM well and annular material installation, a protective outer steel wellhead will be installed at surface to protect the multi-port well materials. The wellheads outside industrialized areas and away from vehicular traffic will be centered on a 4-foot-square (1.5 m^2) cement pad, constructed at ground level with a surface that slopes away from the center, and surrounded by bollards if required. For MSVM wells installed within areas open to vehicular traffic, the wellheads will be completed within a below-grade vault and capped with a protective wellhead. A brass cap will be installed at each well. A survey will be conducted in accordance with the requirements for surveying site attributes listed in Permit Attachment 17, Section 2.2.f. Coordinates and elevation will be recorded in the applicable well files. Soil vapor sampling of these wells is discussed in Section 5.2.4.

MSVM wells will be developed following the completion of the last project well installed. The wells will then be allowed to equilibrate for four weeks before commencing sampling activities. Soil vapor samples will be collected as described in Section 5.2.4. As part of the Phase II investigation, a single set of MSVM well samples will be collected, analyzed, and evaluated. These wells will be designated for plugging and abandonment at a future date upon NMED approval.

4.2.4 Groundwater Sampling Plan

Groundwater is not expected to be encountered during the 200 Area vadose zone investigations based on the large amount of information available from previous subsurface investigations and well installations. Groundwater occurs under confined conditions within fractured Pennsylvanian limestones, shales, and sandstones of the Panther Seep Formation at unpredictable depths of between 110 – 180 ft (33.53 – 54.86 m) bgs, typically at several tens of ft below the bedrock surface. When groundwater is encountered during drilling in the 200 Area, it is typically below a lithological confining layer, and may rise several tens of ft in the borehole toward the bedrock surface. If groundwater is encountered, it will be allowed to stabilize overnight in the boring. A piezometric level will be recorded the next morning, and a bailer will be lowered into the boring to collect a grab sample of the groundwater. Water quality parameters will be measured and grab samples will be submitted for the list of COCs specified in Table 2.1.

NMED will be notified if groundwater is encountered in any of the soil borings, and a potential groundwater sampling zone will be designed as an additional component to the MSVM well design. Wells designed to monitor groundwater in conjunction with soil vapor (MSVGM well) will include a two-inch Schedule 40 PVC groundwater monitoring well with a 15 ft (4.57 m, 0.010-inch slot) screen straddling (five ft [1.52 m] above and 10 ft [3.05 m] below) the water table. Colorado Silica sand (10/20 mesh) will be placed in the bottom of the boring to 2 ½ ft (0.76 m) above the deepest soil vapor monitoring zone, covering the screen. Emplacement of the remaining annular materials and well completion will follow the procedures for the MSVM installation described above. Any groundwater samples collected will be analyzed for the COCs specified in Table 2.1.

4.3 Investigation-Derived Waste Plan

As required in Permit Attachment 20 (Section 20.2.13), the IDW Plan is provided as Appendix C. The IDW Plan provides a description of the potential wastes that will be generated from the 200 Area investigation as well as procedures for waste management, waste characterization, and waste disposition. Wastes that may be generated as part of the 200 Area investigation include: saturated and unsaturated soil in the form of soil cuttings or within soil core samples; groundwater; used sampling equipment; personal protective equipment (PPE); plastic sheeting; rags; miscellaneous debris contaminated by boring soil or fluids; and, water and soap solutions used for equipment decontamination.

5.0 Investigation Methods

5.1 Background

The 200 Area laboratories and testing facilities are located in a relatively complex geological area adjacent to the SAM that is covered approximately by the extent of the shallow soil vapor grid 1,500 ft (548.61 m) x 4,500 ft (1,371.53 m) (0.24 mi^2; 0.62 km^2). Quaternary alluvium capping Pennsylvanian (Panther Seep) to Permian (Hueco) limestone bedrock is relatively thin (as little as 17 ft [5.18 m]), and increases to depths of up to 120 ft (36.58 m) moving away from the central industrialized area after transecting the 200 Area block faults that displace bedrock downward to the northwest and southeast.

The 200 East fault, Apollo Boulevard fault, and 200 West fault, along with subsidiary fractures, and bedding plane solution channels along the strike of limestone beds appear to be the best conduits for groundwater migration in bedrock beneath the 200 Area, southwest from the 200 Area, and subsequently west toward the JDMB under the influence of a steep hydraulic gradient of 0.05 ft/ft. VOCs are inferred to have infiltrated alluvium to the bedrock surface and continued until they encountered faults and associated fractures on primarily the northwest and southeast sides of the faulted 200 Area block. Contaminants may have also infiltrated limestone bedrock through discreet bedding plane solution channels (described in PCC reports, NASA, 1995 – 2009) that strike to the northeast and dip to the northwest.

In order to perform a thorough evaluation of the entire 200 Area including historical activities documented in the industrialized 200 Area (NASA, 2012[a]), a preliminary phased investigation was proposed. The distribution of contaminants was evaluated relative to the location of bedrock structures and the distribution of shallow soil vapor during the Phase I investigation performed in the field between October and November 2012. Results of Phase I of the investigation are provided in the accompanying 200 Area Phase I StatusReport (NASA, 2013). Four additional AOIs were subsequently confirmed based on the results of the Phase I investigation.

5.2 Phase II

Phase II of the investigation will include the installation of soil borings at or near the former locations of the 200 Area USTs and 200 Area SWMUs 4 through 7 and 9 (Figure 4.1). Five additional borings will also be installed to investigate the four AOIs identified during the Phase I evaluation. This section addresses the planned borings and activities related to the acquisition and evaluation of field data during Phase II. Drilling locations, methods, sampling, and quality assurance/quality control (QA/QC) procedures required to achieve the project DQOs are presented in this section.

5.2.1 Proposed Soil Borings

Two borings are planned at, or in the vicinity of, each of the former two UST locations and one in the vicinity of each of five identified SWMUs (four of which have been previously investigated). Additionally, five borings are planned at AOIs identified during the Phase I data evaluation (Figure 4.1). Proposed borings associated with HWMU/SWMUs are presented in Table 5.1. A total of 14 soil borings are planned. Due to the impracticality of sampling and/or remediation in bedrock, all borings will be advanced to approximately 2 ft (0.61 m) below the depth of the alluvium-bedrock contact, if possible. Though the borings are not expected to encounter groundwater, NMED will be notified if groundwater is encountered or other evidence suggests the presence of groundwater during the investigation.

The issues of modified drilling depths and locations due to proximity of existing 200 Area buildings were addressed during the conference call between NASA and NMED on December 14, 2011. The present day infrastructure of the 200 Area constrains the locations of borings through the 200 Area West Closure and the former locations of the Clean Room USTs. A building extension (LabCon) was constructed over the two former Clean Room UST locations on the west side of Building 200. This prevents access and the installation of a soil boring through each of these locations as required in Permit Section V.B.6.a.ii. Alternate locations for soil borings (SB) 200-SB-01 and 200-SB-02 are proposed approximately 50 ft (15.24 m) to the southwest of the former tank locations. The proposed soil boring locations are as close to the former tank locations as possible and downgradient (based on the dip of the local bedrock surface) of the 200 Area West Closure.

5.2.2 Stratex Drilling and Sampling Method

Permit Section V.B.6.a.ii states that the preferred drilling method for soil borings in the 200 Area is hollow stem auger or other NMED-approved drilling methods. Significant difficulties have been encountered in the past when using a hollow stem auger in geologic conditions similar to those found in the 200 Area. Small boulders and cobbles anticipated in the coarse and unconsolidated alluvium overlying 200 Area bedrock will likely yield low soil sample and soil core recovery percentages as a result of penetration refusal. Rotosonic drilling was employed as an alternative to the hollow stem auger during the 600 Area Closure Investigation but was discontinued because of similar difficulties and overall incompatibility with the geologic conditions.

The Stratex (air-rotary) drilling method was selected for this investigation because of its proven success onsite and its compatibility with the expected geologic conditions and overall investigation objectives. NMED approved the Stratex drilling method for use during the 600 Area Closure Investigation (NASA, 2011[a]) and 300 Area Closure Investigation (NASA, 2011[b]) after geologic conditions were found to be incompatible with the rotosonic drilling method. Drilling conditions at the 200 Area are expected to be at least as challenging as the conditions encountered during these previous investigations.

Stratex drilling uses compressed air as the fluid to clean the boring of cuttings during bit advancement. A casing-drive hammer drill rig of sufficient size (approximately 45,000 lbs and dimensions of approximately 10 ft x 40 ft [3.05 m x 12.19 m]) to attempt core barrel samples and achieve potential target depths will be utilized with the appropriate supporting equipment (pipe truck, support vehicles, and forklift). The drilling rig will be positioned strategically to access the 14 soil boring locations identified on Figure 4.1. A 9 $^{5}/_{8}$-inch (0.24 m) diameter casing is advanced behind the bit to prevent borehole collapse. A detailed geologic borehole log cannot be produced using this method because cuttings will include chips from the bottom of the borehole and slough from above the bit. Water will not be introduced during drilling to clean the boring of cuttings, which is preferred when collecting samples for geochemical analyses. Previous soil samples collected in the 200 Area from historical Phase I 1986 –

1987 and Phase II (1996) soil boring investigations have provided geotechnical data that will be incorporated into an evaluation of the data gathered during this investigation.

In order to collect undisturbed soil samples at specific depths, the boring will be cleaned of cuttings and a sampling core barrel will be driven approximately two ft (0.61 m) into the undisturbed formation at the bottom of the open borehole using a pneumatic driver head or drop hammer. The percentage of sample recovery will depend on the coarseness of the formation, which can impede or altogether prevent core barrel advancement. Although recoveries of 80% were reported during the 300 Area Investigation, gravel clast diameters may be even larger in the 200 Area due to the proximity to bedrock that crops out adjacent and to the east.

A large proportion of the samples collected during the 300 Area Investigation used a modified sonic sampling core barrel driven by the air rotary rig's drive head. This procedure was used after experiencing significant difficulties in advancing two different types of split-spoon sampling tubes. Samples were extruded by vibrating the core barrel (using the drive head) to allow the sample to fall from the bottom of the core barrel via gravity. The sample was retained in a clear plastic bag for transport to the field sampling table. Despite the relative success of this sampling technique, core barrel refusal occurred in several instances and some sample temperatures were slightly elevated. The highest temperature observed was 125 degrees Fahrenheit (°F) while most samples with elevated sample temperatures measured approximately 100°F.

The use of relatively short pieces of drilling pipe (5 – 10 ft [1.52 – 3.05 m]) will provide sampling opportunities at depths where more favorable sample recovery is encountered in the field. Shorter lengths of drilling pipe are also preferred because of the relatively shallow bedrock in several of the planned borings. Normally, 10- to 20-foot (3.05 to 6.10 m) lengths of drilling pipe are used and sampling can only be conducted when the top of each piece of casing is up to 5 ft (1.52 m) above ground surface. Softer lithology may be indicative of relatively fine-grained units that would be expected to retain moisture and potentially hazardous constituents.

5.2.3 Drilling and Rig Access Procedures

Overhead and underground utilities, traffic, and rig access to GSA were considered while selecting the proposed boring locations. Utility maps of the area were reviewed to ensure the proposed borings would not intersect known underground utilities. The area will also be investigated for previously unidentified underground utilities prior to the commencement of drilling. A site inspection has been conducted at each proposed boring location to ensure that appropriate setback distance between the drilling rig and overhead utilities exists.

Borings 200-SB-1 through 200-SB-6 will be located in high traffic areas (Figure 4.1). Traffic control devices will be used to reduce potential traffic problems and interference with drilling operations. NASA will also attempt to drill these borings on scheduled site personnel off-days to further minimize traffic interference. The proposed locations for 200-SB-1 through 200-SB-4 are immediately adjacent to asphalt roads and are easily accessible. Borings 200-SB-3 and 200-SB-4 will be installed through the 200 Area East Closure asphalt cap. The rig is not expected to damage the Closure cap during boring activities.

Borings 200-SB-5 and 200-SB-6 will be located in drainage ditches. Minor surface leveling will be required at these locations to provide a level surface for the rig and to ensure the integrity of the borings during rain events.

The locations of 200-SB-7 and 200-SB-8 will be on the west slope of GSA. The above-ground 200 Area hazardous waste drain line runs through this area, westward to the ETU. Special care will be taken to ensure that the drain line is not damaged while the rig is accessing these sites. The proposed location of

200-SB-7 is easily accessible from a maintained road to the east of its location. The location for 200-SB-8 is accessible from the south on a road that terminates at the ETU. Minor dirt work will also be required to construct a level surface for the drill rig at both locations. The proposed location for 200-SB-9 is readily accessible from the southwest via a gravel road. Overhead power lines are present in this area and an appropriate setback distance between the rig and the power lines will be maintained during drilling activity.

Phase I soil borings 200-SB-10 through 200-SB-14 are all located in areas peripheral to the 200 Area buildings. Access roads will be constructed for borings 200-SB-10 and 200-SB-11. Boring 200-SB-12 will be located adjacent to the access road for the 200 Area Sewage Lagoons. Boring 200-SB-13 will be accessed from the well 200-SG-2 access road in an area of sloping terrain. Boring 200-SB-14 is readily accessible from the 200 Area parking lot adjacent on the northwest corner of the Apollo Boulevard and Road L intersection.

5.2.4 Sampling Procedures and Requirements

This section describes procedures for vadose zone soil and soil vapor sampling.

5.2.4.1 Sample Collection Procedures

All samples collected for the Phase II 200 Area investigation will be handled in a manner that maintains their integrity. The following procedures will be used before, during, and after sample collection:

- The inside of the soil or soil vapor sample container will not be touched, and dedicated chemical resistant gloves will be donned prior to sample collection to prevent contamination.
- All gasoline or diesel engines will be turned off near and upwind of the sample locations to prevent the introduction of VOCs into the sample and to protect sample integrity.
- All samples will be collected in a manner that will minimize the introduction of foreign material (e.g., dust, rain, and snow).
- Specified holding times, containers, and preservatives will be strictly followed.
- For samples that require temperature preservation, samples will be placed in a cooler with ice immediately following collection.
- Equipment decontamination procedures will be completed before initial use and between individual sample collection locations to prevent contamination and cross-contamination of samples.
- If limited soil sample material is available due to low core recovery, chemical samples will be collected in order of decreasing volatility. The anticipated order, preparation, and analytical methods is as follows: VOCs – SW-846 Method 8260C; hydrazines – SW-846 Method 8315; NDMA – EPA Method 607M; SVOCs – SW-846 Method 8270C – including low level PAH; bromacil – SW-846 Method 8321B; dioxins/furans – SW-846 Method 8280/8290; total metals – most appropriate method; nitrate/nitrite – EPA Method 300.0 or best available; cyanide – SW-846 Method 9012/9013; Perchlorate – EPA Method 6850; chloride – EPA Method 300.0 or best available; and pH – SW-846 Method 9045D. Where applicable, hexavalent chromium – SW-846 Method 7199.
- If groundwater is encountered, and a limited volume of groundwater is available due to low production, samples will be collected in order of decreasing volatility as for the soil samples.

- If limited geotechnical soil sample material is available, prioritization of the following characteristics will be used for testing: grain size, porosity, moisture content, bulk density, organic carbon content, and saturated/unsaturated hydraulic conductivity.
- Sampling equipment will be either single-use pre-cleaned (per EPA protocol as with sample containers) or multiple-use decontaminated as indicated in the applicable site-specific internal procedural documentation and plans following American Society for Testing and Materials (ASTM) D 5088-02 "Standard Practice for Decontamination of Field Equipment Used at Waste Sites" guidance (ASTM, 2008).

5.2.4.2 Field Screening Procedures

The field screening of soil samples for headspace analysis has proven difficult for source area investigations at WSTF. Problems arise primarily from the types of alluvial sample (generally coarse-grained range-front alluvium), poor sample recoveries, and the lack of any residual contaminants given the elevated soil porosity and permeability. If sufficient soil sample is available during borehole installation activities, the analysis of soil vapors derived from soil samples will be attempted via the headspace method for total ionizable volatile compounds (TIVCs) with a portable photoionization detector (PID); MiniRae or similar. The PID will be equipped with a 10.6 electron volt (eV) lamp and will be calibrated daily with isobutylene gas according to manufacturer's instructions.

For headspace analysis, a representative soil sample will be placed in an airtight plastic zip bag immediately following collection. The soil will be agitated and left in the bag for approximately five minutes in a shaded area, after which the head space soil vapors in the bag will be measured for TIVC. The meter readings for TIVC will be recorded in the field lithologic logs. The probability of obtaining meaningful headspace results is low. Any headspace results generated will be used to assist with the selection of soil chemical sample locations either within a core sample, or between soil samples as applicable.

5.2.4.3 Soil Sampling Procedures

Soil samples will be collected during boring installation to characterize the lithological, chemical, and physical (geotechnical) characteristics of the vadose zone (Table 4.1). Soil sampling for chemical and geotechnical parameters will be carried out via the modified sonic core barrel sampling technique described in Section 5.3.2. The coarse alluvial material anticipated in the vadose zone may limit sample recovery as the coarse gravel and cobbles often prevent advancement of the core barrel. Previous 200 Area soil investigations have yielded sample recoveries as low as 20%. Core samples will be extruded and recovered into a new or decontaminated sample container. Following the collection of each sample, the core barrels will be decontaminated as described in subsequent sections.

5.2.4.4 Soil Vapor Sampling Procedures

MSVM wells will be allowed to equilibrate for three to four weeks after final development to allow stabilization of the vadose zone prior to sampling. Soil vapor samples will be collected pursuant to procedures outlined in ASTM D 5314-92, "Standard Guide for Soil Gas Monitoring in the Vadose Zone" (ASTM, 2006). As part of this investigation, a single set of soil vapor samples from each MSVM well will be collected, analyzed, and evaluated. If the NMED requests subsequent or continued soil vapor sampling, a soil vapor monitoring plan will be developed as described in Permit Section V.B.6.c.iv.

In order to obtain a comparable dataset for vertical delineation, sampling of the newly installed MSVM wells will be performed in a constrained timeframe of a few days or less depending on the number of zones to sample. The MSVM wells and the existing network of MSVM and MSVGM wells in the 200 and 600 Areas will be sampled concurrently. Samples will also be collected from pertinent groundwater monitoring wells within a reasonable time after soil vapor sampling unless a routine groundwater monitoring sample has been collected within the last three months.

Soil vapor samples will be collected in laboratory-provided, evacuated, one-liter SUMMA canisters and analyzed for volatiles by EPA Method TO-15. Prior to sampling, the vapor port and ¼-inch diameter stainless steel sampling line will be purged sufficiently to ensure samples are representative of formation vapor. Once the sampling port has been purged, the SUMMA sampling canister inlet port will be opened, allowing soil vapor to fill the canister to ambient pressure. After each sample is collected, the canister valve will be closed, and an identification tag attached to the canister. A chain-of-custody (CoC) form will be completed, and the canisters will be shipped to the contracted laboratory for analysis.

5.2.4.5 Groundwater Sampling Procedures

In the event groundwater is encountered during borehole installation, disposable Teflon®[3] bailers will be used to collect in-situ grab samples from the boreholes during drilling. Additional groundwater samples will also be collected following development, purging, and equilibration activities in the event that a MSVGM well is installed for the investigation (assuming interception of the water table). The MSVGM well design will be submitted to NMED for review and approval prior to installation. MSVGM wells will be allowed to equilibrate for four weeks after both soil vapor and groundwater monitoring zones in the last well are fully developed. Groundwater sampling will be collected pursuant to procedures outlined in the GMP (Groundwater Monitoring Plan) (NASA, 2010). Any groundwater samples collected from the borings will be analyzed for COCs using standardized analytical methods. Hexavalent chromium would only be analyzed for groundwater encountered in the four borings adjacent to the East and West Closures (200-SB-01 through 200-SB-04) because it was not historically used for 200 Area operations.

Prior to sampling any new or existing MSVGM wells as part of this investigation, groundwater will be purged sufficiently to ensure samples are representative of formation water. After each sample is collected, the sample container(s) will be immediately sealed and labeled with pertinent sample information. A CoC form will be completed, and the samples will be shipped to the contracted laboratory for analysis.

5.2.4.6 Sample Containers, Volume, and Preservation

Appropriately prepared and preserved (if required) sample containers for all sample media will be provided by the contracted analytical laboratory. Chemical samples will be containerized according to laboratory instructions. Geotechnical soil samples will be collected in clean plastic sealable bags or buckets.

5.2.5 Sampling Supply Inspection and Acceptance Procedures

Sampling supplies will be inspected for cleanliness and integrity prior to use. Glassware will be checked for nicks, cracks, and breakage prior to use and will be replaced as necessary.

5.2.6 Equipment Decontamination Procedures

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross-contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of

[3] Teflon® is a registered trademark of E.I. du Pont de Nemours & Company Corporation (Dupont).

incompatible substances. One or more decontamination areas will be established in the work area. Decontamination areas will be positioned so as to not interfere with drilling operations while still being easily accessible from the drilling site. Sub-contractor drilling equipment and associated appurtenances are required to be decontaminated before mobilization to WSTF and at the project site prior to the commencement of work. In addition, all downhole drilling equipment will be decontaminated between individual soil borings. All non-dedicated or reusable soil sampling equipment will be decontaminated between samples.

Typically, a small decontamination area is set up for sampling equipment outside the exclusion (drilling) zone and a larger and heavier duty decontamination pad is set up in a central project location for larger drilling equipment. Decontamination areas will be established within the contaminant reduction zone to prevent transfer of contamination outside of the controlled work area. All drilling and sampling equipment including, but not limited to, drill casing, stainless steel sampling tools and core barrels will be thoroughly decontaminated according to site-specific internal procedural documentation.

5.2.7 Field Documentation Procedures

Field personnel will ensure that details of all activities related to Phase II field investigations are documented using a field logbook, field data records, and any required site-specific procedural documentation. Logbook entries will be thorough and sufficiently detailed to allow someone unfamiliar with the investigation to recreate the documented events. Logbooks will have durable pages and be bound and serially numbered. Entries will be made in ink with no erasures. If an incorrect entry is made, the information will be crossed out with a single strike mark, initialed, and dated. Each completed logbook page will be signed by the responsible field individual. Subsequently, each page will be reviewed and signed-off by another environmental professional. Multiple logbooks may be used (e.g. geologist's logbook and sampler's logbook); however, redundancy should be avoided. Logbook entries will include, when applicable, the following information (<u>underlined text below denotes Permit requirement</u>):

- Standard Daily Header:
  - Project name, logbook number, current <u>date</u>.
  - <u>Weather conditions</u>.
  - <u>Team members present (including subcontractors) and their affiliations.</u>
  - <u>Boring/Sampling location identification.</u>
  - Day's task(s).
  - Description of daily safety meeting conducted.
  - <u>Brief description of PPE to be used</u>.
  - <u>Equipment in use (include calibration information, if applicable).</u>
- <u>Daily activities, times conducted, and observations</u>:
  - <u>Site arrival and departure.</u>
  - Drilling (e. g., method, equipment, borehole diameter, footages, drill casing lengths, drilling conditions, all observations of formation water production, rig downtime with reason for delay, etc.).
  - Lithology (e.g., <u>stratigraphy, moisture conditions</u>, formation changes, bedrock depth and type).
  - Decontamination (e.g., method, equipment cleaned, IDW management).

  - Analytical Sampling (e.g., location, type, collection method, ID number(s), time, depth, sampler's name).
  - Well completion (e.g., casing inventory and tally, construction measurements (screen, top of sand, etc.), materials used).
  - Well development (e.g., method, volumes, recovery rates, pump rates).
  - Field monitoring data (e.g., static water levels, PID readings).
  - Reference data sheets or maps, if applicable.
- Daily summary:
  - Action items, materials used, footages, changes or deviations made from planned protocol, visitors and the purpose of their visit, plan for the next day.
  - IDW generated and the method of storage and disposal.
- Signatures (field personnel and logbook reviewer).

At a minimum, field data records will include lithologic logs, well completion diagrams, location surveys, and sample documentation. In the event that groundwater is encountered and a well installed, then well development data will also be recorded. Lithologic logs will be completed by the on-site geologist for each boring installed during the investigation. Soil classification will be determined using the Unified Soil Classification System (USCS) pursuant to ASTM D 2487-10, "Standard Classification of Soils for Engineering Purposes" (ASTM, 2010). Lithologic logs will include general information (e.g., boring or well name, location, dates, depths, and drilling details), USCS description, core depth intervals and recoveries, headspace PID readings, sample locations and ID number, and a detailed lithologic description using standard USCS criteria. Well completion designs for MSVM and MSVGM wells will be drafted following soil boring completion and provided as soon as possible to NMED for review and approval before the commencement of well construction. If development records are required, dates, times, pre/post water levels, method(s), and volume of water removed from the well will be recorded by the on-site field geologist. For record and reporting purposes, finalized versions of lithologic logs, "as-built" well completion diagrams, and development records will be generated using computer software.

For analytical samples, the date, location, depth, sample type and collection method, ID number, sampler, and any circumstances, events, or decisions that could impact sample quality will be documented by the on-site geologist in the field logbook (e.g. adding water for advancement of the drive casing and removal of cuttings). Even though each case may be unique, the geologist's decision must be documented as to conditions that precipitated any "no-go" decisions for suitability of analyses. In addition to the field logbook notes for sampling events, CoC forms will be completed and maintained as investigation documentation.

Evidential records for the entire project will be maintained in paper copy or electronic form and will consist of:

- NMED-approved project IWP with any deviations redlined.
- Site-specific internal procedural documentation or plans.
- Project logbooks.
- Field data records (i.e., lithologic logs, well completion diagrams, location survey).
- Sample CoC forms.
- Correspondence between NASA and NMED.
- Final analytical data packages.

- Reports.
- Miscellaneous – photos, maps, drawings, etc.

5.2.8 Analytical Tasks

NASA contracts off-site analytical laboratories accredited by the National Environmental Laboratory Accreditation Program (NELAP). The analytical tasks required to achieve the project objectives will be awarded to the laboratory that is successful in the competitive bid process. Potential laboratories must respond to comprehensive statements of work (SOWs) developed to meet the project objectives. Analytical standard operating procedures (SOPs), laboratory quality manuals, and other laboratory-specific documentation are provided by the analytical laboratory following award of the contract. These documents will be available for NMED review as required.

5.2.9 Sample Management

Samples will consist of soil boring samples collected during drilling and soil vapor samples collected after boring and MSVM well installation. NASA has an established comprehensive internal procedure for sample management. This procedure provides specific information on sample management and related documentation, including instructions for sample custody forms (internal to NASA and external during shipment), storage, packaging, shipment, delivery tracking, and related recordkeeping.

5.2.10 Field Quality Control Samples

- Field Blank Samples

  Field rinsate (equipment) blanks will be collected at a minimum of once per borehole prior to spudding. Analytical results of field rinsate blanks are used to evaluate the adequacy of the equipment decontamination procedures and the possibility of cross-contamination caused by incomplete decontamination of sampling equipment.

  Trip blanks will be taken for each soil vapor sample shipment to an off-site laboratory. The analytical results of trip blanks shall be reviewed to evaluate the possibility for the introduction of environmental contamination during shipping.

- Field Duplicate Samples

  Field duplicate samples will be collected from select sampling locations at a frequency of 10% of investigation samples. Duplicate samples will be analyzed for the same media and parameters as the primary samples. Duplicate sample locations will be recorded in the field, but will not be disclosed to the laboratory.

  Matrix spike (MS) samples are used to evaluate the effect that a sample matrix has on the accuracy of a measurement. MS samples will be collected at a minimum frequency of 5% of investigation samples.

5.2.11 Laboratory Quality Control Samples

The overall objective for laboratory analysis is to produce data of known and sufficient quality. Appropriate procedures and QC checks will be used so that known and acceptable levels of accuracy and precision are maintained for each data set. All samples will be analyzed by a NELAP-accredited laboratory in accordance with the laboratory quality assurance plan. The use of a NELAP-accredited laboratory ensures that the contract laboratory adheres to standardized analytical protocols and reporting requirements and is capable of producing accurate analytical data.

Method blanks and laboratory quality control samples are prepared and analyzed in accordance with the laboratory's method-specific SOPs. The analytical results of method blanks shall be reviewed to evaluate the possibility of contamination caused by analytical procedures. At a minimum, the laboratory will analyze method blanks and laboratory control samples at a frequency of one in 20 for all batch runs.

5.2.12 Data Management Tasks

- Project Documentation and Records – All facets of the 200 Area Closure Investigation will be documented in detail by the responsible project personnel. Records are retained in the WSTF Environmental Records Management System as part of the facility Operating Record and can be accessed at any time by authorized WSTF personnel.
- Sample Collection and Field Measurements Data Package Deliverables – Sample information and field measurements are recorded in the field logbook by the responsible contractor field personnel. These data packages are reviewed on a regular basis during the investigation by knowledgeable project personnel and are retained in the project file. They are eventually archived in the WSTF Records Management System as part of the facility Operating Record. As required for reporting, these data are also transferred to and archived in operational and historical databases.
- Off-site Laboratory Data Package Deliverables – Data packages from off-site analytical laboratories will consist of two primary components: comprehensive "paper copy" reports, to be submitted as Adobe portable document files (PDF) for review and archiving; and electronic data deliverable (EDD) files to facilitate transfer of chemical analytical data into WSTF's analytical database(s). The paper copy report will include a variety of information, including laboratory name, report date, sample-specific information, analyte names and Chemical Abstracts Service (CAS) numbers, analytical results, QC sample results, data qualifiers and narratives, pertinent analytical notes, laboratory reviewer signatures, and a variety of other information specific to the laboratory and analytical method. The EDD will include the associated electronic data and follow the same review and approval cycle as the paper report.
- Data Assessment, Review, and CAP – A QA/QC specialist will evaluate the sample data, field, and laboratory QC results for acceptability with respect to the project DQOs. Chemical analytical data will be compared with the project quality objectives and evaluated using the data validation guidelines contained in EPA guidance documents, the latest version of SW-846, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," and industry-accepted QA/QC methods and procedures (EPA, 2008).
- Assessment and Response Actions – The conformance of field activities to specifications in the IWP will be evaluated on an ongoing basis while field activities are in progress. Additional verification will be provided through oversight of the field activities by the Environmental Department project lead (PL). If a sample cannot be collected as planned, the PL will be notified and, if possible, an alternate location or sampling method may be selected. The assessment process will include immediate evaluation of any change to the sampling plan so that, if necessary, an alternate field procedure may be quickly established. Daily quality field assessments will be conducted during drilling and sampling activities. Field assessments will be performed by environmental professionals who are not immediate members of the field team. Following completion of field activities, a final review of field activities will be performed by a subject matter expert. Any deviations from the IWP or procedures will be documented.

- The contract laboratory will be required to notify NASA of significant data quality exceptions within one business day of discovery. Sample re-analysis will be performed, if possible. Any issues identified as part of the weekly field inspections will also be communicated to NASA within one business day.
- A NASA Project Manager (PM) or designee will contact NMED as soon as practical to discuss any data quality exceptions that may affect the ability to meet the investigation objectives. The NASA PM or designee will also summarize the results of the discussion with NMED in a memorandum, copies of which will be provided to NMED via fax or electronic mail and included in the project file.
- Data Review Process - A comprehensive review of sample analytical data will be conducted as described in the sections below. Prior to conducting the review, the following information (where required and applicable) will be compiled and provided for the review:
    - The NMED-approved IWP.
    - Field sampling and boring/well installation logs.
    - Laboratory reports.
    - Statements of work and the laboratory quality management plan.
    - EDDs.
    - SOPs.
    - Database tools.
- Data Review Elements:

  Step I: Verification – Verification (review for completeness) is the confirmation by examination and provision of objective evidence that the specified requirements (sampling and analytical) have been completed (EPA, 2005).

  Data verification is the process of determining whether data have been collected or generated as required by the project documents. The process consists of the following categories: 1) verifying that field sampling operations were performed as outlined in the IWP; 2) verifying that the data collection procedures and protocols were followed; 3) verifying completeness to establish that sufficient data necessary to meet project objectives have been collected; and 4) checking that QC sample results meet control limits defined in the analytical methods.

  Step II: Validation – Validation is the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Validation is a sampling and analytical process that includes evaluating compliance with method, procedure, or contract requirements and extends to evaluating against criteria based on the quality objectives developed (EPA, 2005).

  The purpose of validation is to assess the performance of the sampling and analysis processes to determine the quality of specified data. Data validation consists of the following objectives: 1) verifying that measurements (field and laboratory) meet the user’s needs; 2) providing information to the data user regarding data quality by assignment of individual data qualifiers based on the associated degree of variability; and 3) determining whether project quality objectives were met. Data management personnel will perform data validation in accordance with the requirements in this IWP and existing WSTF procedures.

  Step III: Usability Assessment – Usability assessment is the determination of the adequacy of data, based on the results of validation and verification, for the decisions being made. The usability process involves assessing whether the process execution and resulting data meet project quality objectives (EPA, 2005).

The goal of data validation is to determine the quality of each data point and to identify data that are not acceptable to support project quality objectives. Data may be qualified as being unusable or rejected (R), based on established quality review protocols. An explanation of the rejected data will be included in the report. Data qualified as estimated (J) are less precise, or less accurate, than unqualified data but are still acceptable for use. The data users, with support from the contractor Environmental Department data management staff, are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on statistical procedures and other data uses. The report will include available information regarding the direction or magnitude of bias or the degree of imprecision for qualified data to facilitate the assessment of data usability. The data reporting will include a discussion of data limitations and their effect on data interpretation activities.

5.2.13 Safety and Health Procedures

Field activities will be conducted in accordance with requirements of Occupational Safety and Health Administration (OSHA) Standards for Hazardous Waste Operations and Emergency Response ([HAZWOPER]; 29 CFR 1910.120 [a] – [o]). The WSTF site-specific health and safety plan (HASP; last updated in January 2012) and a 200 Area investigation project-specific addendum to the HASP (prepared in March 2012) will be followed in accordance with applicable requirements of the standards. The HASP and addendum will address safety and health issues pertaining to work activities, including known and anticipated hazards associated with project scope of work as well as contingencies for unexpected conditions. The requirements of the HASP and addendum will apply to prime and sub-tier contractors as well as personnel requesting access to controlled areas of the investigation site. Project field personnel are required to be current in HAZWOPER training. In the event that new hazards are encountered that are not addressed by the HASP or addendum, the field team will stop work and contact the contractor Health and Safety Manager (HSM) to develop additional guidance on means to eliminate or mitigate any new threats.

The HASP and 200 Area project-specific addendum will be reviewed and approved by the contractor HSM. As required by 29 CFR 1910.120(b)(4), the HASP and addendum will address:

- A safety and health risk or hazard analysis for each site task and operation found in this work plan.
- Employee training assignments.
- Required PPE to be used by employees for each of the site tasks and operations being conducted.
- Medical surveillance and fitness for duty requirements (based on nature of the project scope and COCs).
- Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration of monitoring and sampling equipment to be used.
- Site control measures in accordance with the site control program.
- Decontamination procedures.
- An emergency response plan for safe and effective responses to emergencies, including the necessary PPE and other equipment.
- Confined space entry procedures.

- A spill containment program.
- Pre-entry briefing. The HASP shall provide for pre-entry briefings to be held prior to initiating any site activity, and at such other times as necessary to ensure that employees are apprised of the HASP and that this plan is being followed.
- Inspections shall be conducted by the HSM or, in the absence of that individual, another individual who is knowledgeable in occupational safety and health.

Project subcontractors must comply with OSHA and EPA standards applicable to this IWP, the HASP, and 200 Area project-specific addendum. Project subcontractor field personnel must be current in HAZWOPER training required under 29 CFR 1910.120(e).

Safety professionals will inspect subcontractor equipment prior to the commencement of work. Any significant health and safety concerns will be identified, and the subcontractor will be allowed to address the concerns. If significant concerns cannot be rectified, this may be cause for termination of the subcontract.

6.0 Current Monitoring and Sampling Programs

Current groundwater monitoring in the vicinity of the 200 Area closures is performed in accordance with the NMED-approved WSTF GMP (NASA, 2010). NASA routinely collects groundwater samples for the analysis of the following primary constituents: VOCs; NDMA, bromacil, and metals. In addition to routine groundwater samples required by the GMP (NASA, 2010), samples for other chemical analyses are frequently collected at many of the groundwater monitoring wells. Because these samples are not a direct requirement of the GMP, the results of these analyses are provided in the appropriate project-specific report.

Shallow soil vapor sampling has been performed in the 200 Area and vicinity since the installation of multiport soil gas wells first took place in November 1997 (wells 200-SG-1 through 200-SG-4; Figure 2.3). Most recently, a comprehensive set of four semi-annual soil vapor sampling events are in progress at the request of NMED, which include the sampling of all 200 Area and 600 Area MSVM wells and any associated groundwater zones within MSVGM wells. These results are tied into the analytical results from adjacent groundwater monitoring wells. Soil vapor data is contoured and interpreted relative to this reporting requirement. The latest sampling event performed was the third semi-annual sampling event for the WSTF 200 and 600 Areas (NASA, 2012[c]).

Results from GMP sampling in and around the 200 Area and from the 200/600 Area semi-annual soil vapor and groundwater data monitoring will be used to support the evaluation of analytical results acquired from vadose zone sampling during this 200 Area investigation. These results will be used collectively to determine the nature and extent of contamination beneath the 200 Area Closures, SWMUs, and adjacent areas.

7.0 Schedule

The 200 Area Phase II investigation field work preparatory activities and subcontractor procurements will commence immediately following receipt of an NMED Notice of Approval (NOA) for this 200 Area IWP. Table 7.1 presents a proposed schedule with an estimated date for the receipt of the IWP and NOA. Several other estimated dates in the schedule depend on initial receipt of the NMED NOA. The proposed schedule extends from initial submittal of this IWP and 200 Area Phase I Status Report to NMED on January 31, 2013 through submittal of the final IR on or before April 30, 2014.

Since this IWP will be executed in the vicinity of active laboratories and testing facilities in the 200 Area, there may be periods where field personnel will not be allowed access to the work area. NASA cannot accurately forecast access limitations in the 200 Area at this time, but may propose an alternate schedule in the future if testing activities impact the field schedule. The installation of specific sections of the Phase II soil borings and MSVM wells within industrialized areas may have to be coordinated around standard business hours. Any concerns relative to the scheduled start up of field work will be discussed and resolved with NMED in advance.

Field lithologic information and well construction diagrams will be provided to NMED after completion of each Phase II soil boring. NMED review and approval of the well construction diagrams is required prior to well installation. Expedited turnaround from NMED will be required in order to avoid short term (or potentially longer term) standby delays. Status briefings will be presented to NMED via teleconference or email as requested.

8.0 References

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Figures

Figure 2.1 **200 Area Showing HWMU Closures and SWMUs**

(SEE NEXT PAGE)

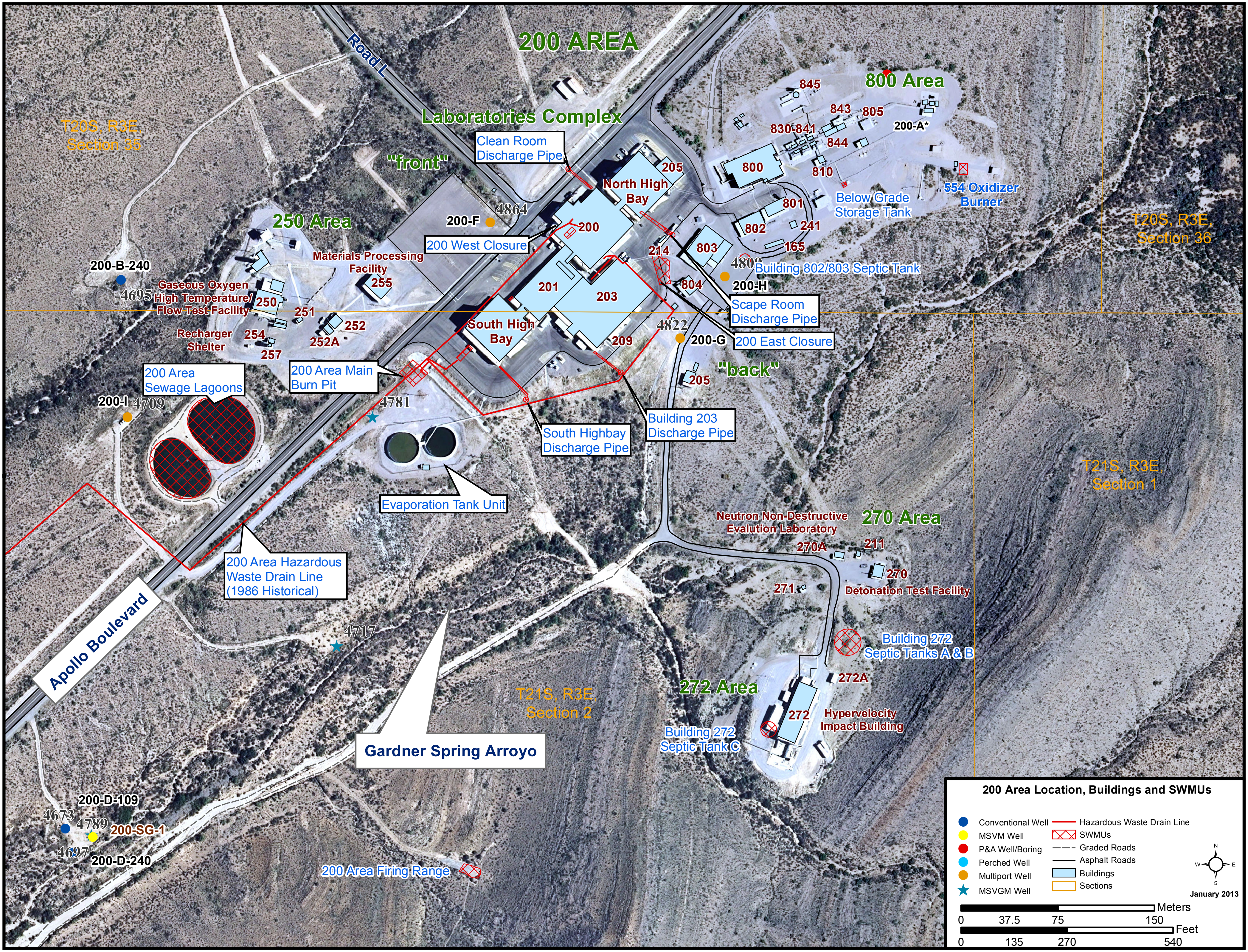
200 AREA
Road L
Laboratories Complex
"front"
"back"
T20S, R3E, Section 35
T20S, R3E, Section 36
T21S, R3E, Section 1
T21S, R3E, Section 2
800 Area
845
843
805
830-841
844
200-A*
800
810
205
Clean Room Discharge Pipe
North High Bay
Below Grade Storage Tank
554 Oxidizer Burner
801
802
241
165
4864
200-F
200 West Closure
200
803
214
480
Building 802/803 Septic Tank
200-H
804
250 Area
Materials Processing Facility
255
200-B-240
4695
Gaseous Oxygen High Temperature/ Flow Test Facility
250
251
252
252A
Recharger Shelter
254
257
201
203
South High Bay
209
4822
200-G
Scape Room Discharge Pipe
200 East Closure
200 Area Main Burn Pit
200 Area Sewage Lagoons
200-I
4709
4781
205
Building 203 Discharge Pipe
South Highbay Discharge Pipe
Evaporation Tank Unit
Neutron Non-Destructive Evalution Laboratory
270 Area
270A
211
270
271
Detonation Test Facility
200 Area Hazardous Waste Drain Line (1986 Historical)
Apollo Boulevard
4717
Building 272 Septic Tanks A & B
272A
272 Area
272
Hyperverlocity Impact Building
Building 272 Septic Tank C
Gardner Spring Arroyo
200-D-109
4673
4789
200-SG-1
4697
200-D-240
200 Area Firing Range
200 Area Location, Buildings and SWMUs
Conventional Well
MSVM Well
P&A Well/Boring
Perched Well
Multiport Well
MSVGM Well
Hazardous Waste Drain Line
SWMUs
Graded Roads
Asphalt Roads
Buildings
Sections
N
W
E
S
January 2013
Meters
0
37.5
75
150
Feet
0
135
270
540

Figure 2.2 **Site Conceptual Exposure Model**

(SEE NEXT PAGE)

Site Conceptual Exposure Model

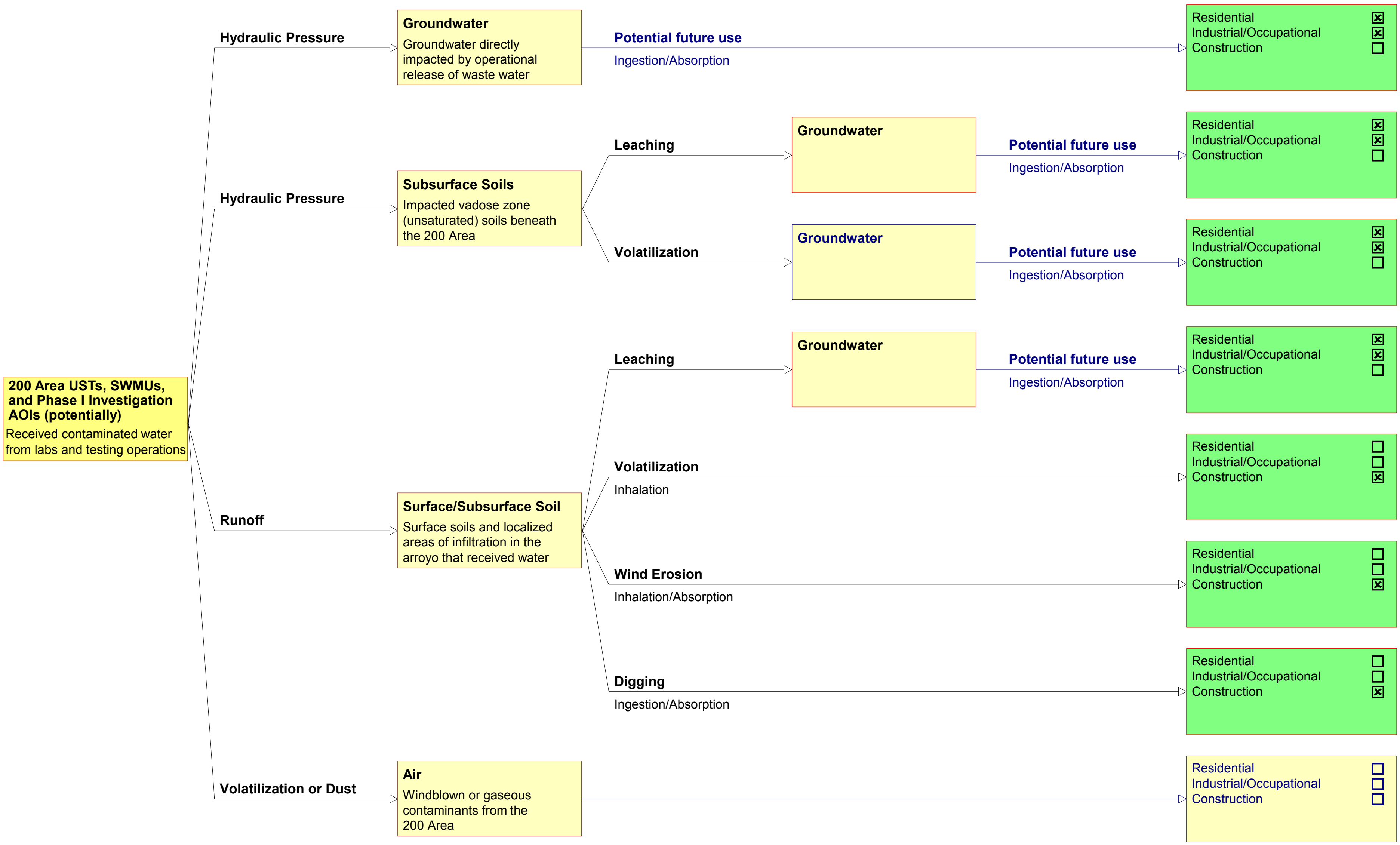

Figure 2.3 Previous Investigation Locations of Borings, Wells, and Soil Vapor Points

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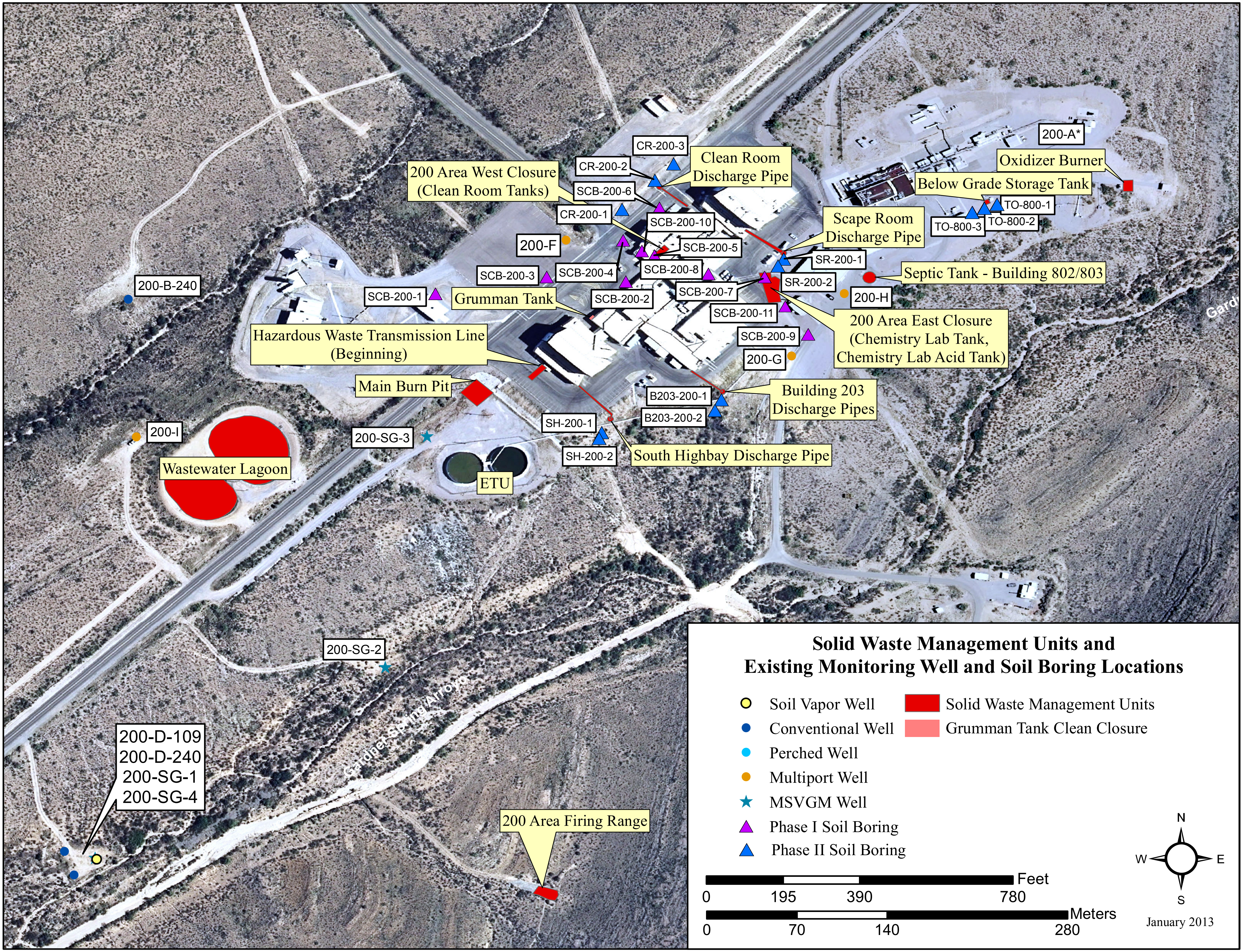

CR-200-3
CR-200-2
Clean Room Discharge Pipe
200 Area West Closure (Clean Room Tanks)
SCB-200-6
CR-200-1
SCB-200-10
SCB-200-5
200-F
SCB-200-8
SCB-200-3
SCB-200-4
SCB-200-7
SCB-200-2
SCB-200-1
Grumman Tank
SCB-200-11
SCB-200-9
200-A*
Oxidizer Burner
Below Grade Storage Tank
TO-800-1
TO-800-2
TO-800-3
Scape Room Discharge Pipe
SR-200-1
SR-200-2
Septic Tank - Building 802/803
200-H
200 Area East Closure (Chemistry Lab Tank, Chemistry Lab Acid Tank)
200-G
Building 203 Discharge Pipes
B203-200-1
B203-200-2
SH-200-1
SH-200-2
South Highbay Discharge Pipe
200-B-240
Hazardous Waste Transmission Line (Beginning)
Main Burn Pit
200-I
200-SG-3
Wastewater Lagoon
ETU
200-SG-2
Gardner Spring Arroyo
Gard
200-D-109
200-D-240
200-SG-1
200-SG-4
200 Area Firing Range
Solid Waste Management Units and
Existing Monitoring Well and Soil Boring Locations
Soil Vapor Well
Conventional Well
Perched Well
Multiport Well
MSVGM Well
Phase I Soil Boring
Phase II Soil Boring
Solid Waste Management Units
Grumman Tank Clean Closure
Feet
0 195 390 780
Meters
0 70 140 280
N
W
E
S
January 2013

Figure 3.1 **200 Area Faults**

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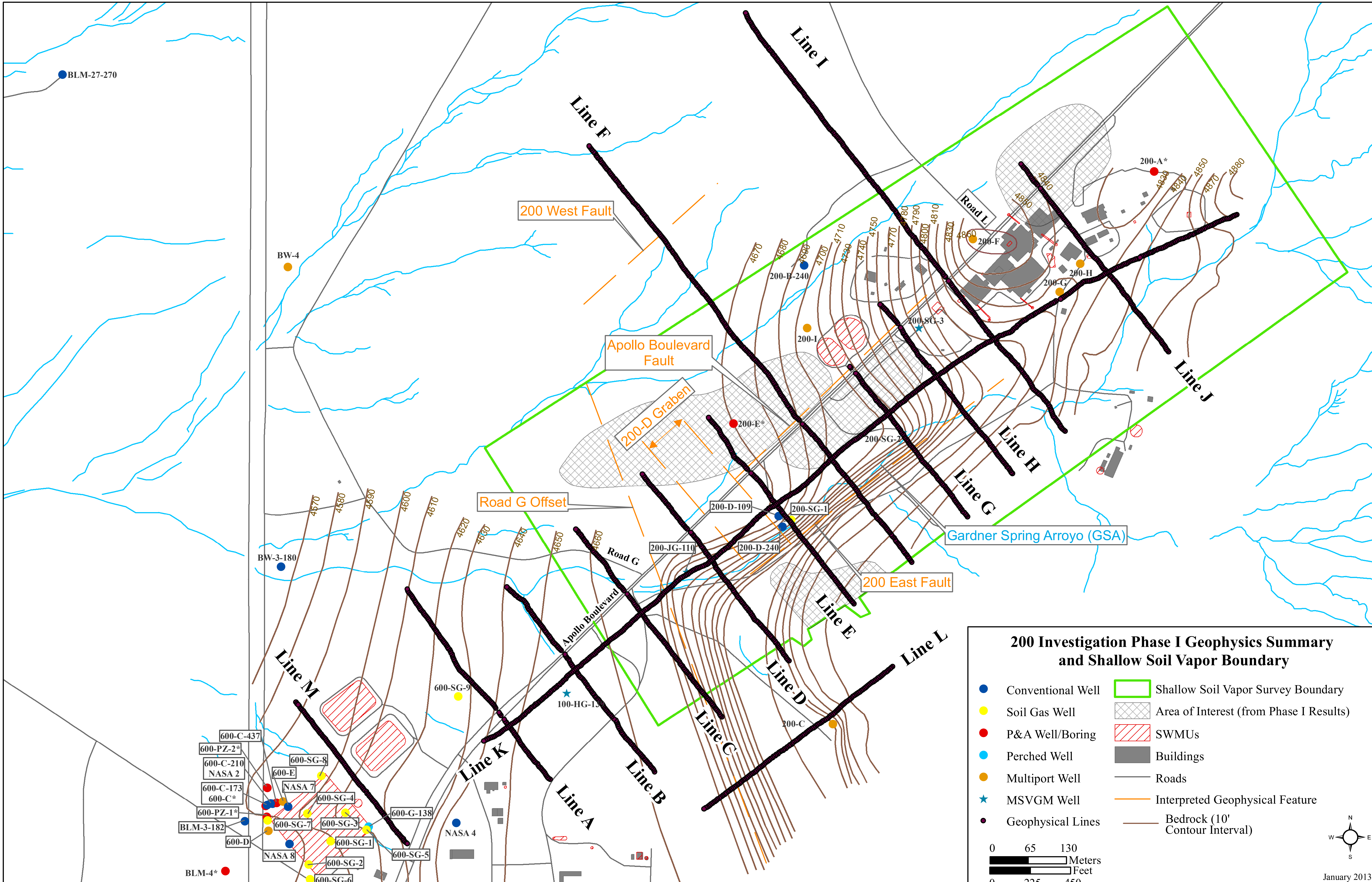
200 Investigation Phase I Geophysics Summary
and Shallow Soil Vapor Boundary
Conventional Well
Soil Gas Well
P&A Well/Boring
Perched Well
Multiport Well
MSVGM Well
Geophysical Lines
Shallow Soil Vapor Survey Boundary
Area of Interest (from Phase I Results)
SWMUs
Buildings
Roads
Interpreted Geophysical Feature
Bedrock (10' Contour Interval)
Meters
Feet
0 65 130
0 225 450
January 2013
Line A
Line B
Line C
Line D
Line E
Line F
Line G
Line H
Line I
Line J
Line K
Line L
Line M
200 West Fault
Apollo Boulevard Fault
200-D Graben
Road G Offset
200 East Fault
Gardner Spring Arroyo (GSA)
Road L
Road G
Apollo Boulevard
BLM-27-270
BW-4
BW-3-180
BLM-4*
200-A*
200-B-240
200-C
200-D-109
200-D-240
200-E*
200-F
200-G
200-H
200-I
200-JG-110
200-SG-1
200-SG-2
200-SG-3
100-HG-13
600-SG-9
NASA 4
600-C-437
600-PZ-2*
600-C-210
NASA 2
600-E
600-SG-8
NASA 7
600-C-173
600-C*
600-SG-4
600-PZ-1*
600-SG-7
600-SG-3
600-G-138
BLM-3-182
600-D
600-SG-1
NASA 8
600-SG-2
600-SG-5
600-SG-6

Figure 4.1 Proposed Soil Boring Locations

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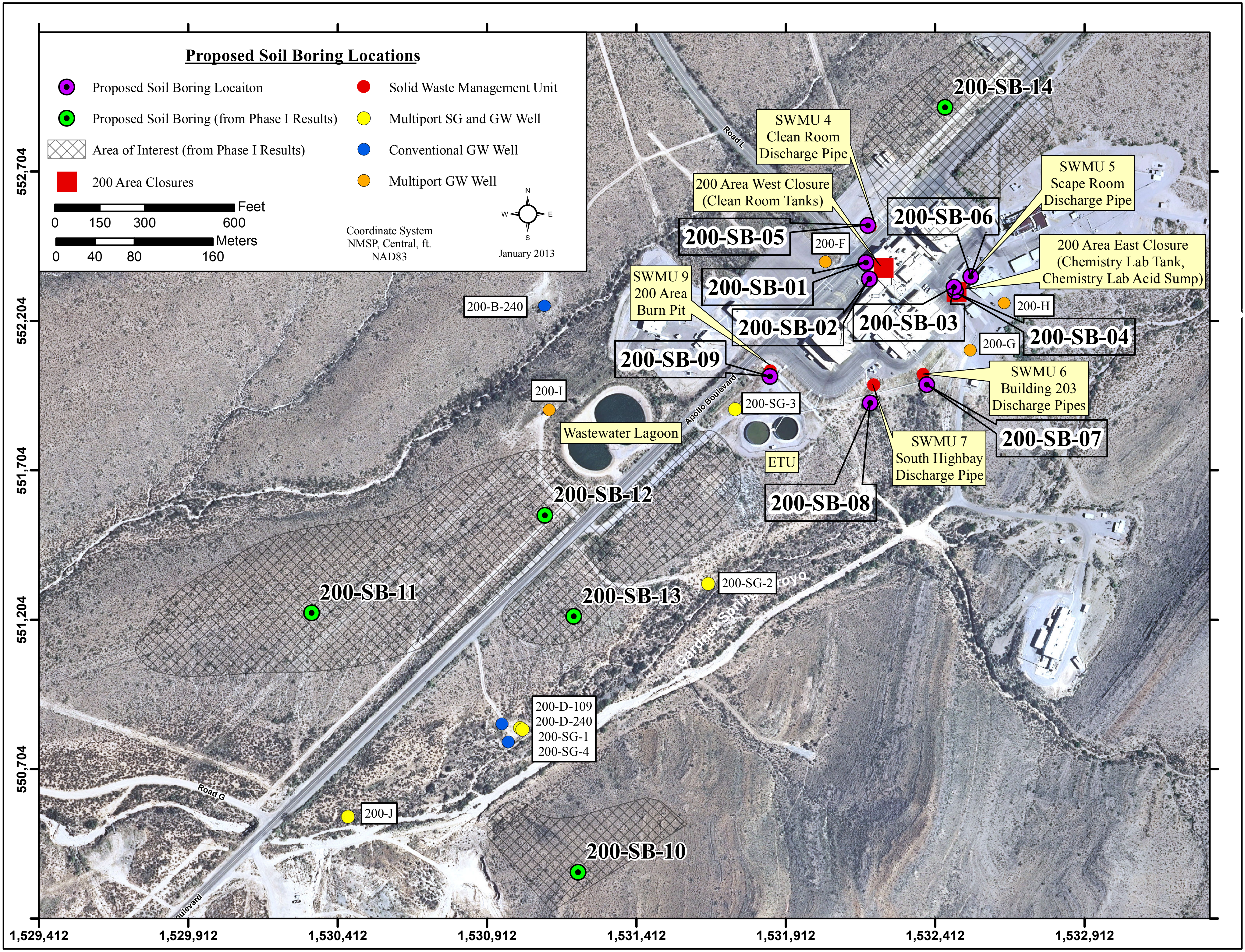
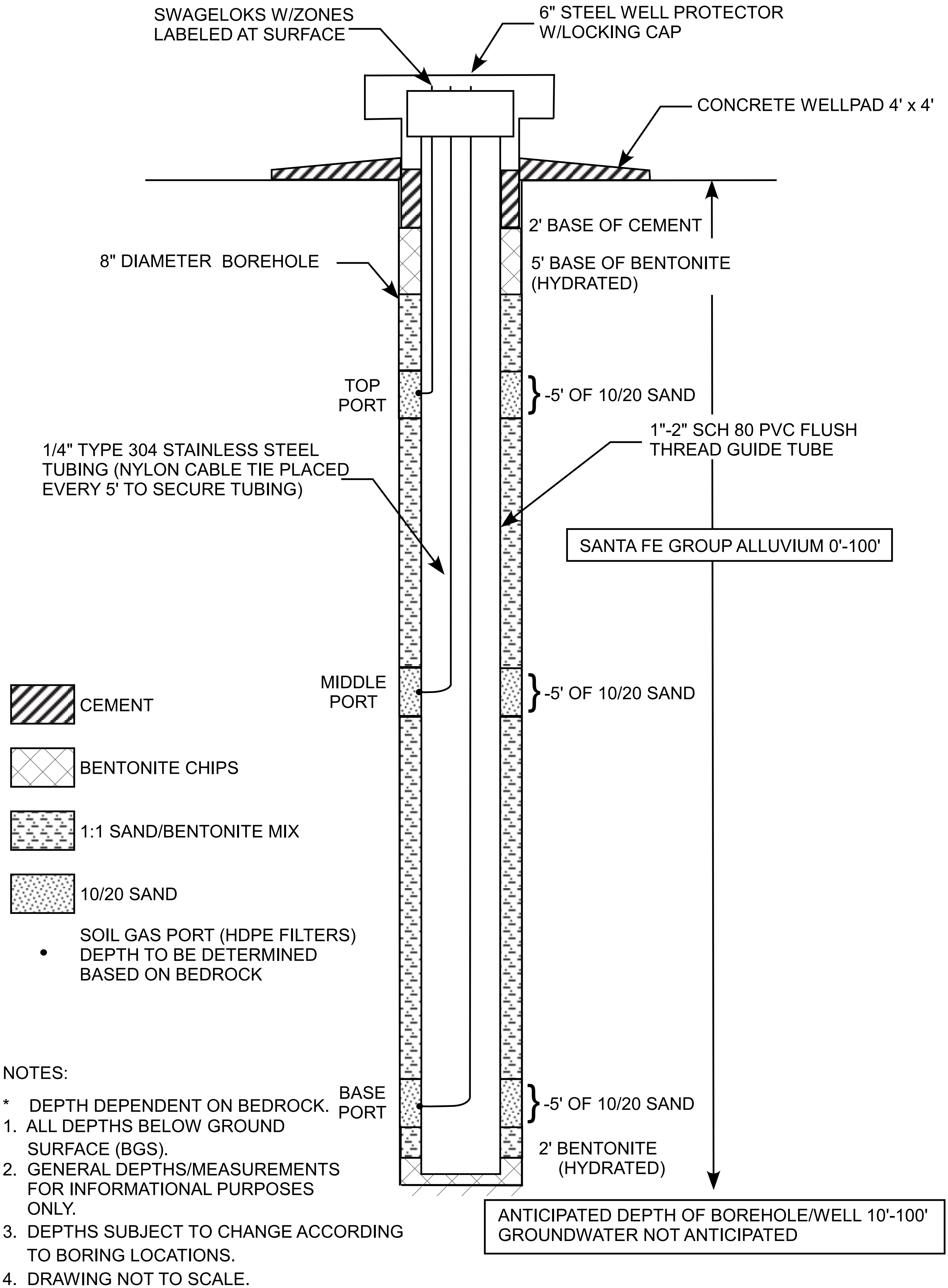


Proposed Soil Boring Locations
Proposed Soil Boring Locaiton
Proposed Soil Boring (from Phase I Results)
Area of Interest (from Phase I Results)
200 Area Closures
Solid Waste Management Unit
Multiport SG and GW Well
Conventional GW Well
Multiport GW Well
Feet
0 150 300 600
Meters
0 40 80 160
Coordinate System
NMSP, Central, ft.
NAD83
January 2013
N
S
E
W
200-SB-14
SWMU 4
Clean Room
Discharge Pipe
200 Area West Closure
(Clean Room Tanks)
SWMU 5
Scape Room
Discharge Pipe
200-SB-05
200-SB-06
200-F
200 Area East Closure
(Chemistry Lab Tank,
Chemistry Lab Acid Sump)
SWMU 9
200 Area
Burn Pit
200-SB-01
200-B-240
200-SB-02
200-SB-03
200-H
200-G
200-SB-04
200-SB-09
SWMU 6
Building 203
Discharge Pipes
200-I
200-SG-3
Wastewater Lagoon
Apollo Boulevard
ETU
SWMU 7
South Highbay
Discharge Pipe
200-SB-07
200-SB-08
200-SB-12
200-SB-11
200-SB-13
200-SG-2
200-D-109
200-D-240
200-SG-1
200-SG-4
Road G
Road L
200-J
200-SB-10
552,704
552,204
551,704
551,204
550,704
1,529,412
1,529,912
1,530,412
1,530,912
1,531,412
1,531,912
1,532,412
1,532,912

Figure 4.2 **General Construction Diagram for an MSVM Well**

(SEE NEXT PAGE)



General Construction Diagram for an MSVM Well

Tables

Table 1.1 Revised Corrective Action Schedule

Activity/Submittal	New Submittal Schedule
200 Area Closure IWP	March 30, 2012[1, 2]
600 Area Closure Soil Vapor Extraction Pilot Test Report	May 31, 2012
300 Area Closure Investigation report	Second phase of field work deferred until after submittal of the 200 Area IWP. Date to be determined by NMED.
400 Area Closure IWP	NASA-WSTF will respond to comments on a schedule to be determined by NMED.
400 Area Closure Field Work	Deferred until after submittal of the 200 Area IWP. Date to be determined by NMED.

[1] Permit modification is not required because this date predated the deadline in the Permit
[2] Phase I IWP was submitted on this date.

Table 1.2 200 Area SWMUs

Unit ID No.	Unit Type/Description
SWMU 4	200 Area Clean Room discharge pipe
SWMU 5	200 Area Scape Room discharge pipe
SWMU 6	200 Area Building 203 discharge pipes
SWMU 7	200 Area South Highbay discharge pipe
SWMU 9	200 Area burn pit

Table 2.1 Preliminary List of COCs for the 200 Area Vadose Zone Investigation	
Constituent	**Sample Type**
Chloride	ANION
Cyanide	CYANIDE
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	DIOXINS/FURANS
Heptachlorodibenzo-p-dioxins (HpCDD), Total	DIOXINS/FURANS
Octachlorodibenzofuran (OCDF)	DIOXINS/FURANS
Octachlorodibenzo-p-dioxin (OCDD)	DIOXINS/FURANS
Hydrazine	HYDRAZINE
Monomethylhydrazine (MMH)	HYDRAZINE
Unsymmetrical Dimethylhydrazine (UDMH)	HYDRAZINE
Aluminum	METALS
Antimony	METALS
Arsenic	METALS
Barium	METALS
Beryllium	METALS
Boron	METALS
Cadmium	METALS
Calcium	METALS
Chromium (Total)	METALS
Chromium (VI)	METALS
Cobalt	METALS
Copper	METALS
Lead	METALS
Mercury	METALS
Molybdenum	METALS
Nickel	METALS
Selenium	METALS
Silver	METALS
Strontium	METALS
Thallium	METALS
Tin	METALS
Vanadium	METALS
Zinc	METALS
Bromacil	BROMACIL
N-Nitrosodimethylamine	NITROSAMINES
Nitrate	NITROGEN
Nitrite	NITROGEN
Perchlorate	PERCHLORATE
Bis(2-ethylhexyl) Phthalate	SVOA
Di-n-butyl Phthalate	SVOA
1,1,1-Trichloroethane	VOA
1,1,2-Trichloroethane	VOA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	VOA
1,1-Dichloroethene	VOA
1,2-Dichloro-1,1,2-trifluoroethane (Freon 123a)	VOA
1,2-Dichloroethane	VOA
2,2-Dichloro-1,1,1-trifluoroethane (Freon 123)	VOA
2-Butanone (Methyl Ethyl Ketone)	VOA
2-Propanol	VOA

Table 2.1 Preliminary List of COCs for the 200 Area Vadose Zone Investigation

Constituent	Sample Type
Acetone	VOA
Benzene	VOA
Bromodichloromethane	VOA
Bromoform	VOA
Chlorobenzene	VOA
Chloroform	VOA
Chloromethane	VOA
Dibromochloromethane	VOA
Dichlorofluoromethane (Freon 21)	VOA
Methyl tert-Butyl Ether	VOA
Methylene Chloride	VOA
m-Xylene & p-Xylene	VOA
Tetrachloroethene (PCE)	VOA
Toluene	VOA
Trichloroethene (TCE)	VOA
Trichlorofluoromethane (Freon 11)	VOA

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area								
Soil Boring ID and Location[1]	Borehole Depth*	Number of Samples	Sample Collection Summary					
			Soil Vapor Laboratory[2]	Soil Chemical[3]	Soil Geotechnical[4]	Duplicates[5]	Spikes[5]	Blanks[6]
200-SB-01	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	X			Field Duplicate		Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Hexavalent Chromium, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		X		Field Duplicate		
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			X			
200-SB-02	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	X					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Hexavalent Chromium, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		X				
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			X			
200-SB-03	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	X					Rinsate Blank

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area								
Soil Boring ID and Location[1]	**Borehole Depth***	**Number of Samples**	**Sample Collection Summary**					
			Soil Vapor Laboratory[2]	**Soil Chemical[3]**	**Soil Geotechnical[4]**	**Duplicates[5]**	**Spikes[5]**	**Blanks[6]**
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Hexavalent Chromium, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**			Matrix Spike	Trip Blank
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
200-SB-04	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**			Field Duplicate		Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Hexavalent Chromium, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**		Field Duplicate		
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
200-SB-05	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area								
Soil Boring ID and Location[1]	**Borehole Depth***	**Number of Samples**	**Sample Collection Summary**					
			Soil Vapor Laboratory[2]	**Soil Chemical[3]**	**Soil Geotechnical[4]**	**Duplicates[5]**	**Spikes[5]**	**Blanks[6]**
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Hexavalent Chromium, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**				Trip Blank
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
200-SB-06	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**				
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
200-SB-07	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**			Field Duplicate		Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**		Field Duplicate		

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area								
Soil Boring ID and Location[1]	**Borehole Depth***	**Number of Samples**	**Sample Collection Summary**					
			Soil Vapor Laboratory[2]	**Soil Chemical[3]**	**Soil Geotechnical[4]**	**Duplicates[5]**	**Spikes[5]**	**Blanks[6]**
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
200-SB-08	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**				
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
200-SB-09	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**			Matrix Spike	
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
#200-SB-10	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**			Field Duplicate		Rinsate Blank

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area								
Soil Boring ID and Location[1]	**Borehole Depth***	**Number of Samples**	**Sample Collection Summary**					
			Soil Vapor Laboratory[2]	**Soil Chemical[3]**	**Soil Geotechnical[4]**	**Duplicates[5]**	**Spikes[5]**	**Blanks[6]**
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**		Field Duplicate		Trip Blank
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
#200-SB-11	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**				
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
#200-SB-12	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**				

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area									
Soil Boring ID and Location[1]	**Borehole Depth***	**Number of Samples**	**Sample Collection Summary**						
			Soil Vapor Laboratory[2]	**Soil Chemical**[3]	**Soil Geotechnical**[4]	**Duplicates**[5]	**Spikes**[5]	**Blanks**[6]
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
#200-SB-13	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**					Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**				
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			
#200-SB-14	Bedrock	Soil vapor laboratory (3) Parameters: VOCs	**X**			Field Duplicate		Rinsate Blank Trip Blank
		Soil chemical (3) Parameters: VOCs, Hydrazines, NDMA, SVOCs, Bromacil, Dioxins/Furans, Metals (total), Nitrate/Nitrite, Cyanide, Perchlorate, Chloride, and soil pH		**X**		Field Duplicate		
		Soil Geotech (1-3) Parameters: Soil Classification, Particle Size, Gravimetric Moisture Content, Bulk Density, Porosity, Saturated Hydraulic Conductivity, and Unsaturated Hydraulic Conductivity, Organic Carbon			**X**			

<table>
<tr><th colspan="9">Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area</th></tr>
<tr><th rowspan="2">Soil Boring ID and Location[1]</th><th rowspan="2">Borehole Depth*</th><th rowspan="2">Number of Samples</th><th colspan="6">Sample Collection Summary</th></tr>
<tr><th>Soil Vapor Laboratory[2]</th><th>Soil Chemical[3]</th><th>Soil Geotechnical[4]</th><th>Duplicates[5]</th><th>Spikes[5]</th><th>Blanks[6]</th></tr>
<tr><td colspan="4">Maximum Sample Totals:

Soil Vapor Parameters: VOCs (42 samples)

Soil Chemical Parameters: VOCs (42 samples), Hydrazines (42 samples), NDMA (42 samples), SVOCs (42 samples), Bromacil (42 samples), Dioxins/Furans (42 samples), Hexavalent Chromium (15 samples), Metals-total (42 samples), Nitrate/Nitrite (42 samples), Cyanide (42 samples), Perchlorate (42 samples), Chloride (42 samples), and soil pH (42 samples)

Parameters: Soil Classification (14-42 samples), Particle Size (14-42 samples), Gravimetric Moisture Content (14-42 samples), Bulk Density (14-42 samples), Porosity (14-42 samples), Saturated Hydraulic Conductivity (14-42 samples), and Unsaturated Hydraulic Conductivity (14-42 samples)</td><td colspan="5">Sample Blank/Duplicate Totals:

1 x trip blank for each soil vapor shipment (estimated 1 sample)

1 x trip blank (VOCs using distilled water in a 40 mL vial) for each soil boring (estimated 14 samples)

1 x rinsate blank per soil boring (estimated 14 samples)

1 x rinsate blank or field blank per groundwater well (estimated 5 samples)

Field Duplicates + Matrix Spikes Samples:

Soil Vapor Parameters: VOCs (5+0 samples)

Soil Chemical Parameters: VOCs (5+2 samples), Hydrazines (5+2 samples), NDMA (5+2 samples), SVOCs (5+2 samples), Bromacil (5+2 samples), Dioxins/Furans (5+2 samples), Hexavalent Chromium (4+0 samples), Metals-total (5+2 samples), Nitrate/Nitrite (5+2 samples), Cyanide (5+2 samples), Perchlorate (5+2 samples), Chloride (5+2 samples), and soil pH (5+2 samples)</td></tr>
</table>

Table 4.1 Summary of Planned Sampling and Analytical Methods for the 200 Area								
Soil Boring ID and Location[1]	Borehole Depth*	Number of Samples	Sample Collection Summary					
			Soil Vapor Laboratory[2]	Soil Chemical[3]	Soil Geotechnical[4]	Duplicates[5]	Spikes[5]	Blanks[6]

Notes:

* Soil borings to be drilled to bedrock. Bedrock depths vary from 25' to 145'.

\# Supplemental soil boring contingent on analytical results from soil vapor survey and previous borings (200-SB-01 to 200-SB-09).

1 Refer to Figure 4.1 for soil boring locations.

2 Samples to be collected at: shallow surface (upper 10'); intermediate depth of borehole; and borehole TD (EPA Method TO-15 or best available equivalent as stated in the RCRA Permit (NMED, 2009).

3 Samples to be collected at: shallow surface (upper 10'); intermediate depth of borehole; and borehole TD. Anticipated order, preparation, and analytical methods: VOCs – SW-846 Method 8260C; hydrazines – SW-846 Method 8315; NDMA – EPA Method 607M; SVOCs – SW-846 Method 8270C – including low level PAH; bromacil – SW-846 Method 8321B; dioxins/furans – SW-846 Method 8280/8290; total metals – most appropriate method; nitrate/nitrite – EPA Method 300.0 or best available; cyanide – SW-846 Method 9012/9013; Perchlorate – EPA Method 6850; chloride – EPA Method 300.0 or best available; and pH – SW-846 Method 9045D. Where applicable, hexavalent chromium – SW-846 Method 7199.

4 Minimum one geotechnical sample per soil boring. Geotechnical samples will be collected for each primary lithologic change up to a maximum of 3. Geotechnical samples will be collected for: soil classification and particle size distribution by laser analysis; volumetric moisture content; bulk density; porosity; saturated hydraulic conductivity; organic carbon content; and unsaturated hydraulic conductivity.

5 Duplicates and Spikes: 1 x field duplicate per 10 samples, 1 x matrix spike per 20 samples, no matrix spikes collected for soil vapor.

7 Field blanks: 1 x trip blank for each soil boring and soil vapor shipment and 1 x rinsate blank per boring.

Table 5.1 Proposed Boring Locations

Soil Boring Identification	Location	HWMU/SWMU
200-SB-01	Clean Room UST (#1)	HWMU
200-SB-02	Clean Room UST (#2)	HWMU
200-SB-03	Chemistry Laboratory Tank	HWMU
200-SB-04	Chemistry Laboratory Acid Sump	HWMU
200-SB-05	Clean Room discharge pipe	SWMU 4
200-SB-06	Scape Room discharge pipe	SWMU 5
200-SB-07	Building 203 discharge pipe	SWMU 6
200-SB-08	South Highbay discharge pipe	SWMU 7
200-SB-09	200 Area burn pit	SWMU 9
200-SB-10	Phase I Investigation – AOI I	N/A
200-SB-11	Phase I Investigation – AOI II	N/A
200-SB-12	Phase I Investigation – AOI II	N/A
200-SB-13	Phase I Investigation – AOI III	N/A
200-SB-14	Phase I Investigation – AOI IV	N/A

Table 7.1 Proposed Schedule for the 200 Area Investigation

Task	Start	Complete	Notes
Submit 200 Area IWP and HIS to NMED	3/30/12	3/30/12	Date submitted to NMED
NMED IWP Comments Provided	5/29/12	5/29/12	NOD with comments
Review Comments, Submit Updated IWP to NMED	5/29/12	6/20/12	Resubmitted 200 Area IWP (Phase I) to NMED as requested
Notice of Approval from NMED	6/28/12	6/28/12	Approval date
NASA performs Project Planning and Procurement	6/28/12	8/10/12	Duration for geophysical line setup, soil boring grid setup, procurements
Phase 1 Field Work (Geophysics and Shallow Soil Gas) Data Processing and Evaluations	9/3/12	11/30/12	Duration for performance of geophysical surveys and Phase 1a and 1b soil grids, plus data evaluation
Submit Phase I Status Report and Phase II IWP to NMED	1/31/13	1/31/13	Estimated date
NMED Phase II IWP Comments Provided (Estimate)	4/1/13	4/1/13	Estimated date
Review Comments, Submit Updated Phase II IWP to NMED	4/2/13	4/29/13	Estimated duration
NASA performs Project Planning and Procurement	4/30/13	9/3/13	Estimated duration
Phase II Field Work	9/3/13	12/31/13	Estimated duration
Data Compilation, Review, and Development of the 200 Area Investigation Report	1/2/14	4/30/14	Expected duration for investigation report development
Submit 200 Area Investigation Report to NMED	4/30/14	4/30/14	Expected date

Appendix A Previous Site Investigations

200 Area Previous Investigation Summary

1.0 Geophysical Investigations (1986 – 1988)

Approximately 42 line miles of local shallow seismic reflection data were collected at WSTF in the mid- to late 1980s. Seismic reflection traverses included the 200 Area and adjacent areas on the eastern side of the traverses. Geophysical data were collected at WSTF to enhance the interpretation of the subsurface bedrock structure and present a synthesis of WSTF's structural geology within the Draft RCRA Facility Investigation Report (NASA, 1996) and for subsequent investigation reports submitted to the NMED. Gravity and density models developed by Maciejewski (1996, 1998) are used to provide information where seismic data coverage is less reliable, and this was tied in to regional data from a previously published model (Gilmer, et. al., 1986).

2.0 Shallow Soil Gas Investigation (1986)

A two-phase shallow soil gas investigation was conducted at WSTF in the 200, 300, 400 and 600 Areas as part of a comprehensive contamination assessment at WSTF during October and November 1986 (NASA, 1986; NASA, 1989). The objectives of this investigation were to characterize the distribution of VOCs in the shallow vadose zone throughout the WSTF source areas, ensure proper design of closures under interim status, and to optimize the location of future soil borings and groundwater monitoring wells. NASA originally hired Tracer as the subcontractor for this study due to their claim that they could provide a general idea of the extent of the groundwater plume at WSTF by using the shallow soil gas technique.

2.1 Phase I

Phase I of the 1986 shallow soil gas investigation consisted of studies designed to evaluate potential releases from the HWMUs and SWMUs in the WSTF industrial areas, including the 200 Area. A total of 63 soil gas samples were collected in the 200 Area by hydraulically driving a 0.75-inch diameter hollow galvanized steel probe to depths ranging from 1 – 5 ft (averaging 2.5 ft), depending on subsurface soil conditions. Approximately five to ten liters of soil gas were then extracted with a vacuum pump. Gas samples were obtained by inserting a hypodermic needle through a section of silicon rubber tubing connecting the soil probe and vacuum pump. Reporting limits for soil gas contaminants of concern (COCs) ranged from 0.002 to 0.02 micrograms per liter (µg/L). Samples were analyzed in a mobile laboratory equipped with a gas chromatograph immediately upon collection. The soil gas investigation indicated low concentrations of VOCs, including 1,1,1-trichloroethane (TCA), TCE, PCE, and Freon 113 at low µg/L levels (Table A.1).

The study defined an elongate northeast-southwest oriented VOC plume best represented by Freon 113, which displayed the highest and most widespread concentrations. The VOC plume is located adjacent to the 200 Area buildings and is approximately coincident with GSA (Figure A.1). Hazardous waste releases at the UST Closures were inferred to have migrated vertically through relatively porous alluvium toward the shallow bedrock (< 30 ft). The mechanisms involved consisted of downward solvent migration and lateral discharge of solvent-contaminated surface runoff. Solvent migration along the bedrock surface or solvent runoff to the east of the 200 East Closure may have entered the GSA and been transported southwest toward the well 200-D area. Both TCE and TCA contamination were found to be restricted to soils below the asphalt and concrete-covered portions of the 200 Area. TCE concentrations were greater than TCA levels by approximately one to two orders-of-magnitude. The highest TCE concentration (62 µg/L) was in the vicinity of the Clean Room tanks. TCA concentrations ranged from < 1-3 µg/L near the buildings on the northwest side of the 200 Area. Trace concentrations of TCA were detected at locations southwest of the 200 Area, which may reflect off-gassing related to aquifer contamination.

Low soil gas concentrations of PCE were primarily restricted to the area adjacent to the 200 Area buildings. Concentrations were generally less than 10 µg/L. A peak of 18 µg/L was detected adjacent to the Clean Room USTs. The Freon 113 plume (Figure A.1) extended south-southwest from the 200 Area. The maximum concentration was 740 µg/L; however, concentrations predominantly ranged from 40-250 µg/L. Other solvent plumes were significantly more confined in distribution than the Freon 113 plume. Freon 113 is characterized by a high liquid/gas partitioning coefficient which may also be responsible for its wider distribution (NASA, 1989). In response to the results of the Phase I investigation work, WSTF developed a more comprehensive Phase II soil gas investigation.

2.2 Phase II

Phase II of the 1986 shallow soil gas investigation consisted of an expanded investigation covering nearly 20 square miles in which discrete locations were sampled for nine halogenated VOCs including chlorinated methanes, ethanes, ethenes, and chlorofluorocarbons. A separate evaluation of WSTF HWMU closures for aromatic and total hydrocarbons was also completed during Phase II.

Eighty-one additional soil gas points were analyzed for halocarbons in the 200 Area using the same methodology described for Phase I. Phase II findings for the original analytes (Freon 113, TCA, TCE, and PCE) were also within Phase I concentration ranges. Table A.1 lists the Phase I and Phase II analytes, including benzene, toluene, ethyl benzene, and xylene (BTEX), which were identified in low concentrations. In addition, methylene chloride (0.01-0.4 µg/L) was detected west and southwest of the 200 Area. Results were sporadic, at low concentrations, and were determined to be at least partially the result of contamination of the portable gas chromatograph injector tubes (NASA, 1989). A single point (approximately 500 ft south of the 200-D well cluster), tested positive for carbon tetrachloride at the 0.005 µg/L minimum reporting limit. Chloroform and dichlorofluoromethane (Freon 21) were not detected in the 200 Area.

The locations of the former 200 Area Burn Pit and GSA discharge pipes were investigated for possible petroleum hydrocarbon contamination during the Phase II soil gas investigation. A total of 134 points were sampled and analyzed. The total hydrocarbon parameter is the summation of all hydrocarbons detected in the sample. It is used in petroleum hydrocarbon analyses because BTEX are the most volatile and degradable components in gasoline and may not be present in old spills. The BTEX analytical method has limited use as an indicator of groundwater contamination when depths to groundwater exceed 20 ft as in the 200 Area (NASA, 1989).

Areas of slightly elevated total hydrocarbon concentrations existed immediately down gradient from both the abandoned burn pit (7.5 µg/L) and the discharge pipe (11 µg/L) SWMUs. In the vicinity of the GSA discharge pipes, benzene concentrations ranged from < 0.02-8.0 µg/L, toluene (< 0.02 – 7.0 µg/L), ethyl benzene (< 0.02 – 0.2 µg/L), xylene(s) (< 0.02 – 5.0µg/L), and total hydrocarbons (0.2 – 46 µg/L). Maximum concentrations were located beneath the employee parking lot. Total hydrocarbon concentrations generally decreased with distance from these concentration highs (NASA, 1989). BTEX concentrations in the vicinity of the burn pit SWMU were generally below detectable levels. Poor sampling conditions and potential for false positive values reduced the confidence in collected data, yielding inconclusive interpretations of shallow vadose zone contamination at the 200 Area SWMUs (NASA, 1989).

3.0 Phase I Soil Boring Investigation (1986 – 1987)

Previous soil boring investigations at the WSTF 200 Area were also conducted in two phases using hollow stem auger drilling. Soil samples were collected using split-spoon samplers under difficult sampling conditions within the range-front alluvial gravels. The soil boring investigations and results are summarized in the Draft RFI Report (NASA, 1996), and the Well 200-D Area Vadose Zone Investigation Report (NASA, 2004). The historical soil boring data collected in the 200 Area includes both chemical and geotechnical sampling. These data will be used to supplement the new data collected from the proposed 200 Area investigation in order to comprehensively determine whether residual sources of contamination exist in the vadose zone.

The Phase I soil boring field investigation was performed at WSTF between November 1986 and January 1987 (NASA, 1987) to support the evaluation and design of closures in the WSTF industrial areas. Phase I activities in the 200 Area consisted of 11 soil borings that ranged in depth from 13.5 to 49 ft bgs that corresponded to the variable depths of bedrock or auger refusal (Figure A.2). Data collected from these borings was used to evaluate soil conditions in proximity of the former locations of the Laboratory and Clean Room USTs and the area hydrologically and topographically downgradient of the 200 Area Closures. Analytical data were used to help assess the integrity of the 200 Area USTs and to determine their contribution to soil contamination.

Alluvial deposits in the 200 Area comprised unconsolidated, unstratified, moderately-graded sandy to clayey gravels. Individual soil units ranged from one to 14 ft thick. Finer-grained clay horizons extended up to four ft in thickness and 150 ft in lateral extent. The soil lenses formed as coalescent alluvial fan deposits over bedrock and dip gently to the southwest and southeast (toward well 200-D) away from a bedrock high at the 200 Industrial Area. Caliche of pedogenic origin occurs as laterally continuous and variably indurated or cemented carbonate horizons. The thickness of individual caliche horizons ranges from approximately one to 10 ft. The 200 Area soil moisture content was low, ranging from 1.35-18.58%. Soils also displayed a correspondingly low unsaturated hydraulic conductivity that ranged from 3.1×10^{-3} to 7.4×10^{-6} centimeters per second (cm/sec). Porosity ranged from 43% (fine grained well-graded sand) to 31.9% (poorly-graded sand).

Soil boring analytical results summarized in Table A.2 show low concentrations of COCs in the vicinity of each of the two UST closures. TCE (0.01 to 0.23 milligrams per kilogram [mg/kg]), Freon 113 (0.017 to 0.15 mg/kg), and TCA (0.014 to 0.11 mg/kg) concentrations showed high variability with depth and areal location. PCE (0.005 to 0.21 mg/kg) was restricted to the upper 10 ft bgs in soil borings near the west closure. Analytical concentrations are compared to NMED soil screening levels (NMED, 2009) as required by the Hazardous Waste Permit A slight correlation between COCs and lithology was noted. Lithologic horizons with higher percentages of clay and silt showed relatively higher contaminant concentrations. Results of the soil boring samples were used to support NMED approval for the 200 Area Closures in 1989.

4.0 Phase II Soil Boring Investigation (1994 – 1995)

Phase II of the WSTF soil boring field investigation was performed between October 1994 and June 1995. This phase targeted potential releases within the WSTF industrial areas and included four 200 Area SWMUs (SWMUs 4 through 7) identified in the NMED Permit (Figure A.2). Two soil borings were installed at each of the discharge pipes associated with Building 203, the South Highbay, and the Scape Room. Three soil borings were installed in the vicinity of the Clean Room discharge pipe. All soil borings were advanced to the bedrock surface.

Samples from these soil borings indicated low COCs concentrations in the vicinity of the discharge pipes (Table A.2). Trace levels of methylene chloride and acetone were present and interpreted as laboratory contaminants (NASA, 1996). Trace concentrations of benzene (Clean Room, South High Bay and Scape Room discharge pipes) and toluene (Clean Room discharge pipe) were the only COCs detected during the Phase II investigation. Trace concentrations of both COCs approximated laboratory detection levels. Their occurrence was sporadic, and no correlation with depth, areal location, or lithology was observed. Previous 200 Area vadose zone investigations failed to identify a continued vadose zone source of contamination to the local aquifer (NASA, 1996).

5.0 Well 200-D Area Vadose Zone Investigation (1997)

The Well 200-D Area vadose zone field investigation consisted of the installation of three MSVGM wells in 1997 to evaluate the potential existence of a residual vadose zone contaminant source in the vicinity of groundwater monitoring wells 200-D-109 and 200-D-240 (NASA, 2004). The 200-D monitoring well cluster was identified as a primary target for vadose zone investigations because it has historically contained the highest concentrations for TCE on site (2,600 parts per billion [ppb] in 1996 from shallow well 200-D-109, screened at the water table). TCE concentrations in groundwater have since dropped an order of magnitude and are typically in the 200 – 220 ppb range.

A summary of the analytical results for soil chemical samples collected during the well 200-D area soil boring installation activities is provided in Table A.3. Only a limited number of contaminants were observed to exceed the practical quantitation limits achieved by the analytical laboratory.

The three MSVGM wells were installed at the 200 Area within GSA in the vicinity of the 200-D well cluster. GSA has a strong influence on surface water recharge and groundwater recharge in the area. The 200 Area MSVGM monitoring wells include three well locations (200-SG-1 through 200-SG-3). Following the loss of the port at 60 feet (18.29 m) due to blockage in well 200-SG-1 during installation, well 200-SG-4 was installed approximately 7.6 feet (2.32 m) from 200-SG-1. Wells 200-SG-1 (3 ports), 200-SG-2 (3 ports), 200-SG-3 (5 ports), and 200-SG-4 (1 port) combine for a total of 12 soil gas ports/zones. The wells consist of 2-inch diameter Schedule 40 PVC screened at the groundwater table, with a set of ¼-inch diameter Type 304 stainless steel tubes fitted with ¼-inch diameter HDPE filters on the end comprising each soil gas port. Soil boring and well installation details are provided in NASA (2004).

The 200 Area MSVGM wells were originally sampled 11 times on a primarily quarterly schedule from January 1998 to December 2000. Results of these sampling events are provided in the Well 200-D Area Vadose Zone Investigation Report (NASA, 2004). Some problems were encountered with the early collection of soil gas data as follows : 1) variability in the number and concentrations of HC and VOC analytes detected; 2) inconsistency in method detection limits and dilution factors leading to dilution and, therefore, apparent “disappearance” of many analytes; 3) loss of sample integrity due to loss of canister pressure; 4) Relative Percent Difference (RPD) values > 40%; 5) indications of laboratory instrument contaminant carryover apparent in field blank results; 6) laboratory reporting issues; and 7) change in laboratory instrumentation. The other primary factor limiting soil gas data utility was the lack of groundwater analytical results for ground truth correlation.

6.0 200 Area Vadose Zone Soil Gas Investigations (1998 – Present)

The 200 Area MSVGM wells remain in good functional condition since the first sampling event performed in January 1998). The original MSVGM wells have been supplemented by an additional MSVGM well in the area (200-JG-110) installed in September 2011.All of the 200 Area MSVGM wells were last sampled in November 2011 (NASA, 2012) as part of the NMED-requested 200/600 Area soil gas and groundwater data evaluation reporting, which was part of NMED's approval with modifications for the 600 Area Closure Report (NMED, 2011).

A contour map showing the distribution of the Freon 113 soil gas plume that shows the highest soil gas concentrations is provided in Figure A.3. The contour map showing the distribution of TCE that represents the compound with the greatest concern relative to health risk is provided in Figure A.4. A summary of the results of the latest soil gas sampling event performed in November 2011 are provided in Table A.4. The six VOCs listed (Freon 11, Freon 113, Freon 123, Freon 123A, TCE, and PCE) represent the compounds with the greatest concentrations and/or greatest associated health risk. Soil gas concentrations are observed to have significantly higher concentrations in the 200 Area (GSA) than the adjacent 600 Area located approximately 0.5 miles to the southwest. No regulatory soil gas action levels are currently available for the State of New Mexico.

7.0 Groundwater Investigation (1987 – Present)

Prior to approval of NASA's Groundwater Monitoring Plan (GMP) (NASA, 2010) site-wide groundwater monitoring and sampling was conducted in accordance with the WSTF Post-Closure Care (PCC) Groundwater Monitoring Program and the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Groundwater Monitoring Program starting in 1987. NASA routinely collected PCC and RFI groundwater samples for the analysis of the following primary constituents: halogenated VOCs; volatile organic compounds; NDMA, DMN, and bromacil; several semi-volatile constituents; total phenolics; sulfide; OCDD; and metals. Maximum concentrations of detected compounds in groundwater monitoring wells in the vicinity of the 200 Area Closure are listed in Table A.5.The current NMED-approved GMP identifies the specific samples that are collected at each groundwater monitoring well at WSTF. In addition to WSTF's routine groundwater samples, samples for other chemical analyses are frequently collected at many of the groundwater monitoring wells.

The most distinctive feature of the groundwater contaminant chemistry in the 200 Area is the highest historical concentrations of TCE on site. TCE levels were highest in the early 1990's (2,600 ppb in well 200-D109 on 4/22/93). TCE concentrations have declined steadily over time in the 200 Area, and the maximum concentration is now approximately 220 ppb also in well 200-D-109. Nitrosamines have not been historically encountered within the 200 Area at significant concentrations. Groundwater contaminations presented on Time-Concentration plots within Annual Post-Closure Care reports (NASA 1995 – 2009) indicate patterns of declining contaminant concentrations from 200 Area sources over time. Groundwater contaminants are interpreted to be moving downgradient to the southwest in GSA under the influence of a steep hydraulic gradient (0.05/ft/ft), and subsequently west toward the main axis of the WSTF groundwater contaminant plume.

8.0 References

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Table A.1 Summary of Shallow Soil Gas Investigation Analytical Results

Soil Gas Constituent	Phase I Soil Gas Results Range in µg/L	Phase II Soil Gas Results Range in µg/L*
1,1,1-Trichloroethane (TCA)	< 0.002 - 3	0.02 - 2.0
Trichloroethene (TCE)	< 0.002 - 62	0.005 -3.0
Tetrachloroethene (PCE)	< 0.002 -18	0.006 - 0.6
Freon 113	0.1 - 740	0.006 – 760
Freon 11	NA	0.005 - 9.0
Freon 21	NA	ND
Methylene chloride	NA	0.01 - 0.4
Chloroform	NA	ND
Carbon tetrachloride	NA	0.005
Benzene	NA	< 0.02 -8.0
Toluene	NA	< 0.02 -7.0
Ethylbenzene	NA	< 0.02 -0.2
Xylene(s)	NA	< 0.02 -5.0
Total Hydrocarbon	NA	0.2 – 46

Notes:
*Concentration ranges for sample locations exhibiting values above minimum reporting limit
Reporting limits range from 0.002 – 0.02 µg/L
NA – Not Analyzed
ND – Not detected

Table A.2 Summary of Phase I and Phase II Soil Boring Investigation Analytical Detections

Location	Analyte	Average Concentration (mg/kg)	Maximum Concentration (mg/kg)	Reporting Limit (mg/kg)	NMED Industrial Soil Screening Level (mg/kg)	Comments
Phase I Investigation – Background Concentrations						
200 Area	1,1 DCE	0.01	0.047	0.006	350	Reported irregularly at 0 to 25 feet.
	Freon 113	0.045	0.1	0.05	339,000	
	TCA	0.0267	0.058	0.029	77,100	
	TCE	0.005	0.011	0.003	253	
Phase I Investigation – Results						
200 Area East and West UST Closures	1,1 DCE	0.017	0.35	0.006	350	Reported irregularly at 0 to 25 feet.
	Freon 11	0.006	0.14	0.005	6,760	
	Freon 113	0.017	0.15	0.05	339,000	
	TCA	0.014	0.11	0.029	77,100	
	TCE	0.01	0.23	0.003	253	
	PCE	0.005	0.21	<0.001	36.4	
Phase II - Results						
Building 203 Discharge Pipe	None	-	-	-	-	-
Clean Room Discharge Pipe	Benzene	<0.001	0.001	0.001	85.4	Reported only at 5 feet.
	Toluene	0.004	0.01	0.005	57,900	Reported from 0 to 14 feet.
South Highbay Discharge Pipe	Benzene	<0.001	0.001	0.001	85.4	Reported irregularly 0 to 10 feet.
Scape Room Discharge Pipe	Benzene	<0.001	0.002	0.001	85.4	Reported irregularly 0 to 10 feet.

Table A.3 Summary of Soil Chemical Analytical Results for MPSVGM Wells

Sample ID (Well and Depth)	Volatile Organics (mg/kg)	NDMA (µg/kg)	Chromium (mg/kg)	Comments
200-SG-1-30	<PQL	<11 (PQL)	5.2	
200-SG-1-60	Acetone 0.0058 (J, B) Butanone 0.0045 (J)	<11 (PQL)	8.5	Traces of laboratory-related VOC (flagged)
200-SG-1-70	<PQL	<11 (PQL)	10.2	
200-SG-2-80	<PQL	<11 (PQL)	12.4	
200-SG-3-30	<PQL	<11 (PQL)	10.8	
200-SG-3-50	<PQL	<11 (PQL)	4.9	
200-SG-3-60	<PQL	<11 (PQL)	7.5	

Notes:

B - Detected in method or reagent blank.

J - Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.

PQL - Practical Quantitation Limit (VOC PQLs range from 5.4-22.0 µg/kg).

Summary derived from LAS Preliminary Sample Results received January 16, 1998 (NASA, 2004).

Table A.4 Maximum Concentration of Primary Constituents in Soil Gas and Groundwater (Nov. 2011)

Constituent	200 Area Well With Maximum Measured Soil Gas Concentration	Soil Gas Concentration ($\mu g/m^3$)	600 Area Well With Maximum Measured Soil Gas Concentration	Soil Gas Concentration ($\mu g/m^3$)	Ratio $C_{200\ Area}$ / $C_{600\ Area}$	200/600 Area Well with Maximum Measured Groundwater Concentration	Groundwater Concentration (µg/l)	Henry's Law Coefficient (dimensionless, volumetric basis)	Equivalent Calculated Soil Gas Concentration in Equilibrium with Groundwater ($\mu g/m^3$)
Freon 11	200-SG-1	**23,000**	600-SGW-3	1,400	16	200-SG-1	76	4.00E-00	304,000
Freon 113	200-SG-3	**4,200,000**	600-SGW-7	1,800,000	2	200-SG-1	550	2.20E+01	12,100,000
Freon 123	---	ND	---	ND	NA	---	ND	1.41E+00	NA
Freon 123A	200-SG-1	3,300	600-SGW-5	**3,400**	0.11	200-SG-1	5.6	1.41E+00	7,896
TCE	200-SG-4	**180,000**	600-SGW-5	13,000	14	200-D-109	280	4.00E-01	112,000
PCE	200-SG-4	**15,000**	600-SGW-5	240	63	200-D-109	17	7.20E-01	1,224,000

Bold value is the larger of the two soil gas concentrations

$C_{200\ Area}$ – Concentration of soil gas constituent in the 200 Area

$C_{600\ Area}$ – Concentration of soil gas constituent in the 600 Area

Table A.5 Maximum Groundwater Concentrations for Detected Compounds - 200 Area Monitoring Wells					
Analyte	**Wellname**	**Event_Date**	**Sample_Type**	**Result**	**Units**
Perchlorate	200-D-240	19-Nov-04	PERCHLORATE	13.7	µg/L
Chloride	200-I-185	05-Nov-01	CHLORIDE	260	mg/L
Nitrate	200-I-185	22-Dec-04	NO2,NO3	4.4	mg/L
Acid Soluble Sulfide	200-F-420	01-May-09	SULFIDE	8.1	mg/L
Phenolics, Total Recoverable	200-G-340	03-Oct-07	PHENOLICS	5.3	µg/L
Total Alkalinity	200-I-300	03-Jun-98	ANIONS	292	mg/L
Alkalinity, Bicarbonate as CaCO3	200-C-170	12-May-11	ANIONS	260	mg/L
Fluoride	200-I-300	03-Jun-98	ANIONS	2.7	mg/L
Sulfate	200-G-495	19-Sep-11	ANIONS	1600	mg/L
Cyanide	200-G-495	26-Mar-08	CYANIDE	0.076	mg/L
Bromacil	200-I-185	13-May-05	NDMA	4.93	µg/L
N-Nitrodimethylamine	BW-4-355	17-Dec-97	NDMA	0.79	µg/L
N-Nitrosodimethylamine	BW-4-355	17-Dec-97	NDMA	0.94	µg/L
1,1,1-Trichloroethane	200-D-109	17-Jan-97	HVOA	0.45	µg/L
1,1,2,2-Tetrachloroethane	200-G-175	23-Apr-99	HVOA	0.79	µg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	200-SG-1	19-Sep-05	VOA	2000	µg/L
1,1,2-Trichloroethane	200-D-109	01-Feb-07	VOA	0.32	µg/L
1,1-Dichloroethane	BW-4-355	20-Aug-99	HVOA	0.88	µg/L
1,2-Dichloro-1,1,2-trifluoroethane	200-I-300	07-Nov-04	VOA	20	µg/L
1,2-Dichloroethene	200-B-240	02-May-00	VOA	1.2	µg/L
1,4-Dioxane	200-G-340	25-Sep-97	VOA	170	µg/L
2,2-Dichloro-1,1,1-trifluoroethane	BW-4-270	08-Jan-03	HVOA	4.1	µg/L
2-Butanone	BW-4-455	18-Dec-98	VOA	9.3	µg/L
2-Propanol	200-F-420	16-May-05	VOA	120	µg/L

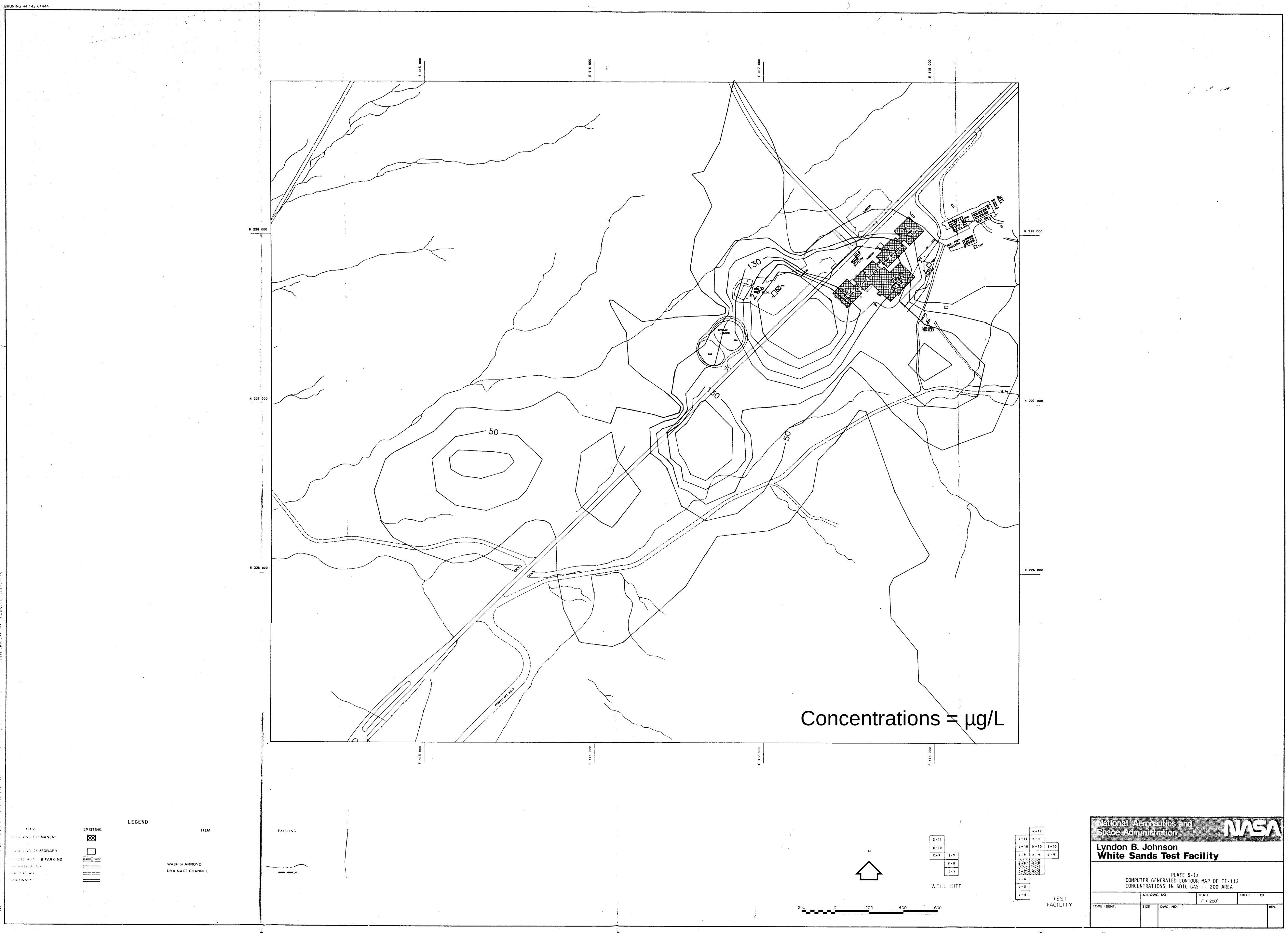
Table A.5 Maximum Groundwater Concentrations for Detected Compounds - 200 Area Monitoring Wells					
Analyte	**Wellname**	**Event_Date**	**Sample_Type**	**Result**	**Units**
Acetone	200-D-240	27-Mar-98	VOA	190	µg/L
Acrolein	200-F-225	17-Mar-98	VOA	2.9	µg/L
Acrylonitrile	200-G-420	03-Jun-04	VOA	17	µg/L
Benzene	200-I-490	16-Dec-97	VOA	1.3	µg/L
Bromodichloromethane	200-B-240	24-Oct-05	HVOA	0.11	µg/L
Bromoform	200-G-420	22-Sep-08	VOA	0.84	µg/L
Bromomethane	200-B-240	22-Jan-97	HVOA	2.1	µg/L
Carbon disulfide	200-H-331	08-Aug-00	VOA	0.62	µg/L
Chlorobenzene	BW-4-455	16-Jan-08	HVOA	1.7	µg/L
Chloroethane	200-G-495	25-Oct-00	VOA	1.6	µg/L
Chloroform	BW-4-355	20-Aug-99	HVOA	1.8	µg/L
Chloromethane	200-G-175	04-Nov-99	HVOA	9.2	µg/L
cis-1,2-Dichloroethene	200-D-109	01-Feb-07	HVOA	1.9	µg/L
cis-1,3-Dichloropropene	200-G-340	30-Oct-00	HVOA	0.75	µg/L
Dibromochloromethane	200-G-175	04-Oct-07	HVOA	0.9	µg/L
Dichlorofluoromethane (CFC 21)	200-F-225	28-Nov-06	HVOA	11	µg/L
Dichloromethane	200-I-490	23-Nov-10	HVOA	1.3	µg/L
Ethylbenzene	200-G-495	15-Sep-09	HVOA	0.32	µg/L
Iodomethane	200-G-420	13-Mar-07	VOA	2.6	µg/L
m&p Xylenes	200-B-240	26-Sep-07	HVOA	3.2	µg/L
Methyl tert-Butyl Ether	200-B-240	30-Sep-09	VOA	0.61	µg/L
Methylene chloride	200-D-240	26-Sep-96	VOA	18	µg/L
o-Xylene	200-B-240	26-Sep-07	HVOA	1.3	µg/L
Propionitrile	200-I-795	16-Sep-06	VOA	3.4	µg/L
Styrene	200-H-225	09-Jul-97	VOA	4.7	µg/L

Table A.5 Maximum Groundwater Concentrations for Detected Compounds - 200 Area Monitoring Wells					
Analyte	**Wellname**	**Event_Date**	**Sample_Type**	**Result**	**Units**
Tetrachloroethene	200-D-109	01-Oct-99	VOA	39	µg/L
Tetrahydrofuran	200-I-795	17-Aug-05	VOA	53	µg/L
Toluene	200-G-175	30-Oct-98	VOA	4	µg/L
trans-1,2-Dichloroethene	200-B-240	31-Oct-00	HVOA	3.5	µg/L
Trichloroethene	200-D-109	19-Jul-96	HVOA	2,600	µg/L
Trichlorofluoromethane	BW-4-355	26-Nov-96	HVOA	300	µg/L
Trichloromethane	200-H-433	21-Jun-96	HVOA	0.2	µg/L
Vinyl chloride	200-I-675	11-Aug-09	HVOA	2.3	µg/L
Aniline	200-F-225	28-Nov-06	SVOA	1.9	µg/L
bis(2-Ethylhexyl) phthalate	200-SG-1	15-Sep-10	SVOA	13	µg/L
Diethyl phthalate	200-F-225	27-Oct-99	SVOA	7	µg/L
Di-n-butyl phthalate	200-G-175	29-Sep-08	SVOA	7.4	µg/L
MCPP	200-G-175	10-Sep-99	HERB	300	µg/L
1,2,3,4,6,7,8-Hepta CDD	200-H-225	04-Mar-10	Dxns/Frns	2.28	pg/L
1,2,3,4,6,7,8-Hepta CDF	200-G-175	19-Mar-07	Dxns/Frns	6.2	pg/L
1,2,3,4,7,8,9-Hepta CDF	200-H-225	04-Mar-10	Dxns/Frns	1.4	pg/L
2,3,4,6,7,8-Hexa CDF	200-H-225	04-Mar-10	Dxns/Frns	1.16	pg/L
2,3,4,7,8-Penta CDF	200-H-225	04-Mar-10	Dxns/Frns	1.37	pg/L
2,3,7,8-Tetra CDF	200-G-175	24-Mar-10	Dxns/Frns	1.67	pg/L
Heptachlorodibenzofurans (HpCDF), Total	200-F-225	11-May-06	Dxns/Frns	2.13	pg/L
Heptachlorodibenzo-p-dioxins (HpCDD), Total	200-F-225	11-May-06	Dxns/Frns	7.803	pg/L
Octa CDD	200-F-370	03-May-10	Dxns/Frns	45.4	pg/L
Total Tetra CDD	200-G-175	24-Mar-10	Dxns/Frns	0.82	pg/L
Total Tetra CDF	200-F-225	05-May-09	Dxns/Frns	14.4	pg/L
Aluminum	200-F-225	11-May-06	METALS	0.0879	mg/L
Antimony	200-H-225	15-Aug-99	METALS	0.0056	mg/L

Table A.5 Maximum Groundwater Concentrations for Detected Compounds - 200 Area Monitoring Wells					
Analyte	**Wellname**	**Event_Date**	**Sample_Type**	**Result**	**Units**
Arsenic	200-I-675	16-Sep-06	METALS	0.0457	mg/L
Barium	200-I-185	02-Jun-98	METALS	0.097	mg/L
Beryllium	200-H-225	09-Aug-01	METALS	0.0018	mg/L
Boron	200-D-240	29-Mar-10	METALS	0.74	mg/L
Cadmium	200-I-300	23-Mar-98	METALS	0.0084	mg/L
Calcium	200-G-495	19-Sep-11	METALS	560	mg/L
Chromium	200-D-109	01-Oct-99	METALS	0.092	mg/L
Cobalt	200-H-225	01-Feb-00	METALS	0.0056	mg/L
Copper	200-G-420	17-Sep-09	METALS	0.018	mg/L
Iron	200-I-675	15-Jun-98	METALS	2.4	mg/L
Lead	200-I-490	07-Aug-07	METALS	0.0446	mg/L
Magnesium	200-G-495	15-Sep-09	METALS	177	mg/L
Manganese	200-G-220	20-Sep-06	METALS	0.0789	mg/L
Mercury	200-D-109	22-Aug-11	METALS	0.0005	mg/L
Molybdenum	200-G-495	15-Sep-09	METALS	0.075	mg/L
Nickel	200-G-495	15-Sep-09	METALS	0.067	mg/L
Potassium	200-G-495	15-Sep-09	METALS	11.2	mg/L
Selenium	200-G-175	30-Mar-09	METALS	0.0155	mg/L
Silver	200-H-433	16-Sep-98	METALS	0.0099	mg/L
Sodium	200-F-370	22-Apr-08	METALS	410	mg/L
Strontium	200-G-420	17-Sep-09	METALS	18.3	mg/L
Thallium	200-H-433	06-Sep-06	METALS	0.0041	mg/L
Tin	200-F-225	12-Mar-02	METALS	1.27	mg/L
Vanadium	200-G-220	01-Oct-07	METALS	0.0057	mg/L
Zinc	200-G-495	15-Sep-09	METALS	11.1	mg/L

Figure A.1 Freon 113 Shallow Soil Gas Contour Map – 200 Area

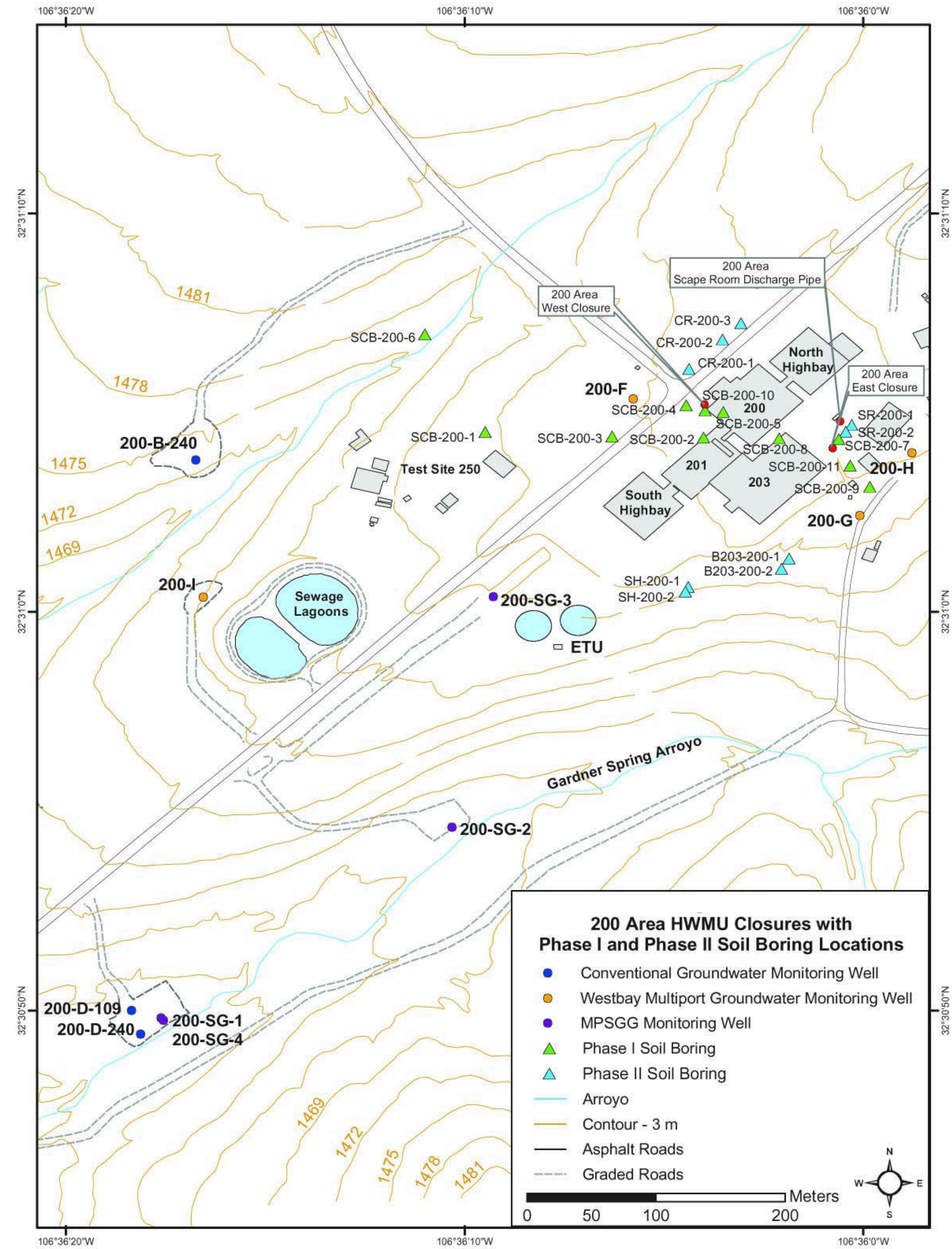
(SEE NEXT PAGE)



Freon 113 Shallow Soil Gas Contour Map - 200 Area

Figure A.2 200 Area HWMU Closures with Phase I and II Boring Locations

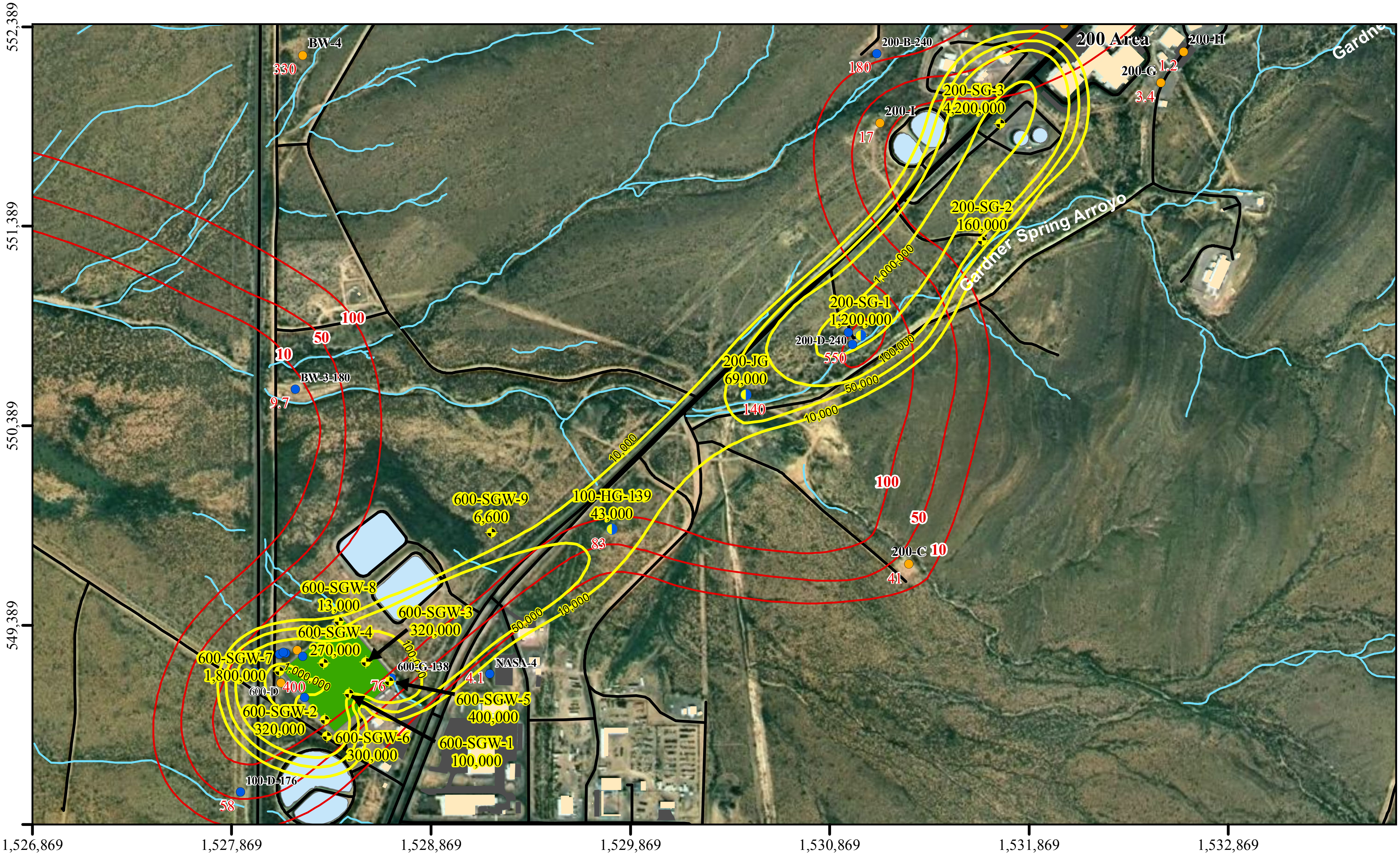
(SEE NEXT PAGE)



106°36'20"W
106°36'10"W
106°36'0"W
32°31'10"N
32°31'0"N
32°30'50"N
200 Area
Scape Room Discharge Pipe
200 Area
West Closure
200 Area
East Closure
CR-200-3
CR-200-2
CR-200-1
SCB-200-10
SCB-200-4
SCB-200-5
SCB-200-3
SCB-200-2
SCB-200-8
SCB-200-11
SCB-200-9
SCB-200-7
SCB-200-6
SCB-200-1
SR-200-1
SR-200-2
North
Highbay
South
Highbay
200
201
203
200-F
200-H
200-G
200-B-240
200-I
Test Site 250
Sewage
Lagoons
200-SG-3
ETU
B203-200-1
B203-200-2
SH-200-1
SH-200-2
Gardner Spring Arroyo
200-SG-2
200-D-109
200-D-240
200-SG-1
200-SG-4
1481
1478
1475
1472
1469
200 Area HWMU Closures with
Phase I and Phase II Soil Boring Locations
Conventional Groundwater Monitoring Well
Westbay Multiport Groundwater Monitoring Well
MPSGG Monitoring Well
Phase I Soil Boring
Phase II Soil Boring
Arroyo
Contour - 3 m
Asphalt Roads
Graded Roads
Meters
0
50
100
200
N
S
E
W

Figure A.3 Fourth Quarter 2011 200-600 Area Freon 113 Concentrations

(SEE NEXT PAGE)



Fourth Quarter 2011 200-600 Freon 113 Concentrations

Freon 113 SG Concentration (ug/m^3)	Conventional Well	Roads
Freon 113 GW Concentrations (ppb)	Multiport Westbay® Well	Arroyos
Multiport Soil Gas Well	600 Area Closure	Buildings
Multiport Soil Gas & GW Well	Ponds	Parking

ND = Non-Detect
Detection Limits =
1.6 - 3,500 ug/m^3
0.31 - 3.1 ppb

Scale: 0, 500, 1,000, 2,000 Feet

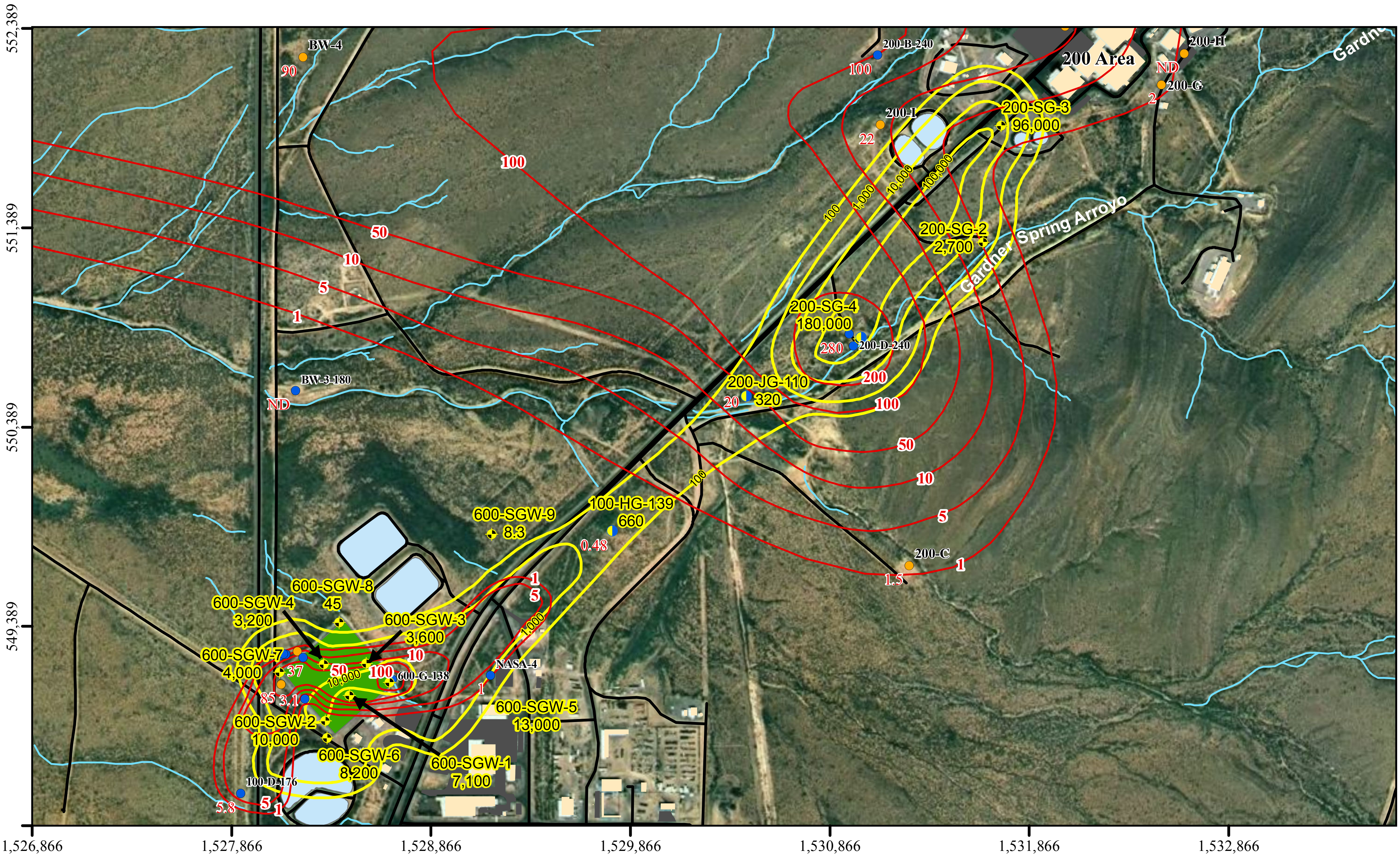
N, W, E, S

Coordinante System
NMSP, Central Zone, Feet
NAD83

March 2012

Figure A.4 Fourth Quarter 2011 200-600 Area TCE Concentrations

(SEE NEXT PAGE)



Fourth Quarter 2011 200-600 Area TCE Concentrations

(yellow line)	TCE SG Concentrations (ug/m^3)	(blue dot)	Conventional Well	(black line)	Roads
(red line)	TCE GW Concentrations (ppb)	(orange dot)	Multiport Westbay® Well	(light blue line)	Arroyos
	Multiport Soil Gas Well		600 Area Closure		Buildings
	Multiport Soil Gas & GW Well		Ponds		Parking

ND = Non-Detect
Detection Limits =
0.63 - 2,000 ug/m^3
0.19 - 0.63 ppb

March 2012

Feet: 0, 500, 1,000, 2,000

N, E, S, W

Coordinante System
NMSP, Central Zone, Feet
NAD83

Appendix B Deviations from the Permit

200 Area IWP Sampling Plan Deviations

The NMED Permit provides a number of detailed requirements related to drilling and sampling methods and locations, numbers, and depths for sample collection (Section V.B.6.c.ii – iv) (NMED, 2009). The Permit also allows alternative methods to be proposed in the 200 Area IWP for NMED review and approval. Table B.1 presents a summary of the specific requirements from the Permit with a discussion of how each requirement was implemented in this IWP. NASA has provided technical justifications for deviations from the original Permit conditions.

Reference

NMED. Hazardous Waste Permit, EPA ID No. NM8800019434, to United States National Aeronautics and Space Administration for the White Sands Test Facility Located in Doña Ana County, New Mexico, issued by the New Mexico Environment Department Hazardous Waste Bureau, November, 2009.

Table B.1 Permit Requirements and Implementation in the 200 Area IWP

Permit Section	Requirement	Implementation in IWP
V.B.6.a.ii(1)	One boring shall be advanced through the locations of the former USTs to minimum depths of 25 feet below the deepest detected contamination as detected by field screening or previous investigations.	Two soil borings will be advanced immediately adjacent to the former locations of the two West Closure (Clean Room) USTS that have been covered by a 50-foot west extension of Building 200. Soil borings will be installed to bedrock.
V.B.6.a.ii(2)	Use hollow-stem auger	Rotary Drilling with Air is necessary due to site-specific geology.
V.B.6.a.ii(3)	Re-drill if encounter auger refusal	Refusal is not expected with selected drilling methods. Should refusal occur, an alternate boring will be considered (if practical) and discussed with NMED prior to spudding.
V.B.6.a.ii(4)	Field screening for VOCs	Field screening via the headspace method will be conducted where feasible based on sample recovery. See Permit Section V.B.6.a.iii(3) for practicality issues.
V.B.6.a.ii(5)	Design for vapor monitoring well construction	A general vapor monitoring well design is included in this IWP. Detailed well designs will be provided to NMED before installation for review and approval.
V.B.6.a.iii(1)	Soil samples at 5-foot intervals to total depth	Geologic conditions are not expected to allow predictable sampling intervals based on previous 200 Area investigations. Soil samples will be attempted at the top, middle, and bottom of each boring where soil borings exceed 50 feet in depth. Shallower borings may be subject to less than three samples due to the potentially shallow depth to bedrock (<20 feet).

Table B.1 Permit Requirements and Implementation in the 200 Area IWP		
Permit Section	**Requirement**	**Implementation in IWP**
V.B.6.a.iii(1)	Soil sample collected at the maximum depth of each boring	A soil sample will be collected from an interval at the base of the boring area where recovery is sufficient.
V.B.6.a.iii(2)	Use split-barrel soil samplers with brass sleeves	Experience within the WSTF source area vadose zone suggests that this approach will be ineffective with poor (15%) to no recovery. Soil samples will be collected with a decontaminated split-barrel sampler (unlined) or a modified sonic core barrel.
V.B.6.a.iii(2)	Cover brass sleeve ends with Teflon tape or foil	See above. Sampler will be unlined. Sample preservation will be achieved via prompt sample collection and laboratory-specified field preservation where appropriate.
V.B.6.a.iii(3)	Screen soil samples for VOC per PA-17	Soil samples will be screened for VOCs via the headspace method where practical. The suggested method was ineffective when attempted for the recent 300 and 600 Area projects under similar drilling conditions.
V.B.6.a.iii(4)	A detailed boring log with field screening results shall be maintained	A lithologic boring log will be maintained for each borehole; however, the air rotary drilling method (if used) will not allow precise or detailed lithologic descriptions. If air rotary method is used, cuttings will still be logged, recorded on the log, and a small representative sample preserved in trays for each 10-foot advancement of the boring.
V.B.6.a.iii(5)	Analysis for perchlorate, hexavalent chromium NDMA/DMN, nitrate and nitrite, VOCs, SVOC, and RCRA metals	These compounds are all included. In addition, analyses for metals, hydrazine, cyanide, dioxins and furans will be performed.
V.B.6.a.iii(6)	The samples displaying the greatest field screening evidence of VOC concentrations shall be selected from each borehole for submittal to the analytical laboratory for analysis of the analytes listed in Item 5 above. If field screening evidence of contamination is not observed in a boring, the sample obtained from five feet below the previously removed UST base shall be submitted for laboratory analysis of the analytes listed in Item 5 above.	Boring locations are selected for their location in or near the previously removed UST. Headspace screening of soil samples will be used to screen sample locations (recovery permitting). The uppermost soil sample collected within the upper 10 feet will be located directly below the level of the UST base (recovery permitting).

Table B.1 Permit Requirements and Implementation in the 200 Area IWP		
Permit Section	**Requirement**	**Implementation in IWP**
V.B.6.a.iii(7)	The soil sample obtained from maximum depth will be submitted for lab analysis	A sample will be collected from the bottom interval of the boring (recovery permitting) and submitted for analysis. If no sample is available following a second attempt to collect the sample (equipment permitting), the deepest sample will be from the sample interval above (recovery permitting).
V.B.6.a.iv(1)	Vapor samples collected during drilling	This vapor sampling method was attempted, but was demonstrated to be impossible during rotosonic drilling for the 600 Area Closure Investigation. An alternate vapor monitoring strategy has been devised. Vapor samples will be collected using vapor monitoring ports installed at up to four horizons in each MSVM or MSVGM well (depending on the well total depth) in lieu of this procedure.
V.B.6.a.iv(2)	Vapor samples collected at same location as soil samples	See V.B.6.a.iv(1).
V.B.6.a.iv(2)	Use inflatable packer to isolate 3-foot interval	See V.B.6.a.iv(1).
V.B.6.a.iv(2)	Purge five times the annular space for vapor sampling	See V.B.6.a.iv(1).
V.B.6.a.iv(2)	Use PID equipped with an 11.7 eV lamp or combustible gas indicator	See V.B.6.a.iv(1).
V.B.6.a.iv(2)	Use PID data to select samples for laboratory analysis	See V.B.6.a.iv(1).
V.B.6.a.iv(3,4)	Submit long-term vapor monitoring and sampling work plan if required	An initial round of vapor samples following vapor well installation and equilibration of the formation is identified in this IWP. The requirement for a long-term monitoring and sampling plan will be addressed if required by NMED following this investigation.
V.B.6.a.v	Submit work plan for installation of groundwater monitoring wells if evidence suggests presence of groundwater	Groundwater is not anticipated above bedrock within the vadose zone beneath the 200 Area based on several previous investigations performed in the area. The installation of MSVGM wells can be performed if groundwater is unexpectedly encountered within a soil boring. Well design review and approval by NMED will be required prior to any MSVGM well installations.

Appendix C IDW Plan

200 Area Investigation-Derived Waste Plan

1.0 Waste Description

Historically, wastes generated in the 200 Area during the course of testing and evaluation processes at WSTF have included spent solvents, spent metals cleaning solutions, process waste from performing chemical analysis and metallurgical testing, and the disposal of off-spec products. Wastes from these and other activities were historically fluids discharged into the Chemistry Lab UST, Chemistry Lab Acid Sump, Clean Room UST, and potentially the SWMUs listed in Table 1.2 of the 200 Area IWP. Section 2.2 of the 200 Area IWP summarizes the constituents of concern that could potentially be present in investigation-derived waste (IDW).

During the drilling and sampling activities for the 200 Area investigations, a variety of IDW is expected to be generated. The types of wastes expected to be generated include unsaturated or saturated soil (soil cuttings or soil cores) and groundwater (potentially).The term most commonly applied to extracted soil cuttings or soil cores and groundwater is environmental media (RO 11434).

2.0 Waste Characterization (Acceptable Knowledge)

Contaminated environmental media is considered to meet the definition of a RCRA solid waste at the time it becomes actively managed. The term “Active Management” is defined by EPA as “physically disturbing the accumulated wastes within a management unit” (September 1, 1989, 54 FR 36597; August 18, 1992; 57 FR 37298). As a result, contaminated environmental media is considered to be a solid waste and is therefore subject to the RCRA hazardous waste identification and management requirements at the time that it is removed from a soil boring or borehole. Contaminated environmental media is subject to regulation under the EPA’s “contained-in policy” (RO 11195, 11434 and 11593).

Based on NASA’s 200 Area Historical Information Summary (NASA, 2012[a]), spent solvents (meeting the listing description of a listed hazardous waste per 40 CFR Part 261 Subpart D) carrying EPA Waste Codes F001 and F002 were generated and discharged. The summary also determined that other listed waste such as off-spec propellants (hydrazines) were generated and discharged. However, only the degradation by-product N-nitrosodimethylamine (NDMA) has been detected in the 200 Area Groundwater monitoring wells. Therefore, pending completion of sampling and analysis, IDW is a generator declared hazardous waste (40 CFR Part 262.11[c][2]) carrying EPA Waste Codes F001 and F002.

In addition to contaminated environmental media, non-dedicated disposable sampling equipment; personal protective equipment; plastic sheeting, rags, and other debris contaminated by contact with soil or fluids; and water and soap solutions used to wash and decontaminate equipment will be generated. Debris containing contaminated environmental media is also subject to regulation under the EPA’s “contained-in policy.” Therefore, the contaminated debris when discarded as solid waste is a generator declared hazardous waste (40 CFR 262.11[c][(2]) carrying EPA Waste Codes F001 and F002.

3.0 Waste Management

IDW will be accumulated and placed into containers and will be managed in accordance with WSI 22-SW-0005 incorporating 40 CFR Part 262.34. This includes, but is not limited to, container content labels, accumulation start dates, hazardous waste labels, and Department of Transportation (DOT) container specifications. The accumulation start date for all IDW will be the date that the waste is generated (removed from the ground) or when the decision is made to discard contaminated debris (materials that are no longer usable).

Two less-than-90-day waste management units will be established in the field within the perimeter of the 200 Area to manage IDW, one in the industrialized area adjacent to the 200 Area buildings, and one in GSA to the south of the 200 Area (refer to Figure 2.2 of the 200 Area IWP). Per 40 CFR § 264.1080(b)(5) subpart CC standards do not apply to waste management units that are used solely for on-site storage of hazardous waste that is placed in the unit as a result of implementing remedial activities required under the corrective action authorities of RCRA.

The following IDW will be managed and accumulated in accordance with WSI 22-SW-0005.E incorporating 40 CFR Part 262.34:

- Used personal protective equipment, plastic sheeting, and other debris will be containerized in DOT compliant drums or bulk containers (roll-offs, Super Sacks[1], or similar).
- Soils, cuttings, and returns (unsaturated or saturated due to water from dust minimization) generated during drilling and sampling will be containerized in DOT compliant drums or bulk containers (Roll-offs, Super Sacks, or similar). Any liquids that separate may be decanted off and accumulated in DOT compliant drums.
- Decontamination fluids, muddy water, etc will be either absorbed and managed with the unsaturated soils, or containerized in DOT compliant drums.
- Wastes typically associated with equipment maintenance (e.g., grease, contaminated rags, oil, WD-40®[2], diesel, soil contaminated with hydraulic fluids, etc.) may also be generated and will be managed as a hazardous waste.
- Any inadvertent spills onto the soil (e.g. discharged IDW decon. water to grade) are also considered IDW and will be containerized in DOT compliant drums or bulk containers (roll-offs, Super Sacks, or similar). All spills will be documented and evaluated for Reportable Quantity Notifications per WSTF procedures. All spills will be handled immediately in order to minimize the volume of waste generated.

Dust generated during drilling activities (windblown or otherwise) will not be managed as waste. Visible dust in the air is expected. A cyclone separator (air rotary rig), water misting, or other means will be used to minimize project field personnel exposure to physical dust hazards. Provisions for worker respiratory protection will be provided in the Health and Safety Plan in accordance with 29 CFR 1910.120[e].

4.0 Waste Characterization (Sampling and Analysis)

Final waste characterization for the IDW will be completed in accordance with Attachment 12: *Waste Analysis Plan* of the NASA WSTF Hazardous Waste Permit (NMED, 2009) incorporating the 200 Area IWP and the 200 Area Investigation Sampling and Analysis Plan. The constituents of concern and analytical parameters are summarized in Section 2.2 of the 200 Area IWP.

The listed determinations and toxicity characteristic determinations for the IDW will be based on the analytical data generated from the primary investigation samples (i.e. samples collected from the boreholes). To evaluate the toxicity characteristic, the total concentration of each reported constituent may be divided by 20 to determine the maximum theoretical leachate concentration that could result from performing the toxicity characteristic leaching procedure (TCLP – EPA Method 1311). These concentrations will be compared to the values listed in 40 CFR Part 261.24 Subpart C (Table 1) to

[1] Super Sack® is a registered trademark of Better Agricultural Goals Corporation DBA/ B.A.G. Corp.

[2] WD-40® is a registered trademark of WD-40 Manufacturing Company.

determine if the waste exhibits the characteristic of toxicity. Alternatively, NASA may perform TCLP analysis on representative soil samples to evaluate the toxicity characteristic.

5.0 "No Longer Contained-In" Determination

For environmental media that are identified as containing listed wastes per 40 CFR Part 261 Subpart D, a request for a "no longer contained-in" determination may be submitted to the NMED Hazardous Waste Bureau (63 FR 28622).

To perform a "no longer contained-in" determination, the analytical data generated from borehole sampling may be compared to the applicable 40 CFR Part 268 Treatment Standards and the New Mexico Environment Department (NMED) Soil Screening Levels (SSLs) to determine whether the material poses an unacceptable risk. If contaminant concentrations are found to not pose an unacceptable risk, then NMED may determine that the wastes can be managed as no-longer containing listed wastes. Written approval of NASA's request for a "no longer contained-in" determination from NMED would be required to document such a determination.

6.0 Waste Disposal

For IDW (soils) that either meet the listing description of a listed hazardous waste per 40 CFR Part 261 Subpart D or exhibit the characteristic of a hazardous waste per 40 CFR Part 261 Subpart C, "Land Disposal" notifications, disposal facility profiles, and hazardous waste manifests will be completed as required. Waste will be transported for treatment and disposal at a permitted RCRA Treatment, Storage, and Disposal Facility.

IDW (groundwater) may be treated at the Mid-Plume Interception and Treatment System or the evaporation treatment unit in accordance with NASA's Hazardous Waste Operating Permit. In the event that the IDW (Groundwater) cannot be treated at either of these units, Land Disposal notifications, disposal facility profiles, and hazardous waste manifests will be completed as required. Waste will be transported for treatment and disposal at a permitted RCRA Treatment, Storage, and Disposal Facility.

Upon receipt of an NMED "no longer contained-in" determination, soil (environmental media) will be spread on the ground in the vicinity of the borings, but in an area that will not be readily accessible to routine traffic or easily subject to runoff. Also, IDW debris that is determined to be non-hazardous waste will be disposed of as solid waste.

In the event that IDW contains hazardous constituent(s) above industrial SSLs or the applicable 40 CFR Part 268 Treatment Standards, then NASA will discuss disposal options with NMED. Soil samples sent to the analytical laboratories will be disposed of by the laboratories as environmental samples in accordance with each individual laboratory's procedure.

7.0 References

40 CFR Part 262, Standards Applicable to Generators of Hazardous waste– Part 268, Land Disposal Restrictions. Code of Federal Regulations, Current Edition.

EPA. Solid Waste and Emergency Response, Training Module EPA530-K-05-011 (5305W). September 2005.

NASA. 200 Area Historical Information Summary. NASA Johnson Space Center White Sands Test Facility, Las Cruces, NM. March 2012 (a).

NASA. 200 Area Investigation Sampling and Analysis Plan. NASA Johnson Space Center White Sands Test Facility, Las Cruces, NM. March 2012 (b).

NMED. Hazardous Waste Permit (Permit Attachment 12), EPA ID No. NM8800019434, to United States National Aeronautics and Space Administration for the White Sands Test Facility Located in Doña Ana County, New Mexico, issued by the New Mexico Environment Department Hazardous Waste Bureau, November 2009.

U.S Environmental Protection Agency –RCRA Online ([R0 11195, 11434 and 11593)

RO 11195 Groundwater Contaminated with Hazardous Waste Leachate 11/13/1986

RO 11434 Environmental Media Contaminated with RCRA-listed Hazardous Waste 6/19/1989

RO 11593 Contained-in Policy 3/26/91

NMED. Technical Background Document for Development of Soil Screening Levels. New Mexico Environment Department, Santa Fe, NM. June 2006. ftp://ftp.nmenv.state.nm.us/hwbdocs/HWB/guidance_docs/NMED_June_2006_SSG.pdf

FR. “Mining Waste Exclusion.” 54 Federal Register (FR) 36597. September 1, 1989.

FR. “Identifying and Listing of Hazardous Waste, CERCLA Hazardous Substance Designation, Reportable Quantity Adjustment, Coke By-Products Wastes.” 57 FR 37298. August 18, 1992.

FR. “Soil Treatment Standards.” 63 FR 28622. May 26, 1998.

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