National Aeronautics and
Space Administration

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P.O. Box 20
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October 30, 2024

Reply to Attn of: RE-24-155

Mr. JohnDavid Nance, Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: Response to Approval with Modifications of the NASA White Sands Test Facility (WSTF) 700 Area Landfill (SWMU 49) Phase II Abbreviated Investigation Work Plan

National Aeronautics and Space Administration (NASA) Johnson Space Center White Sands Test Facility received the New Mexico Environment Department (NMED) *Approval with Modifications 700 Area Landfill Closure (SWMU 49) Phase II Abbreviated Investigation Work Plan* dated July 31, 2024. The approval directed NASA to revise the Work Plan, satisfy two comments, and provide replacement pages no later than October 31, 2024.

On July 31, 2024, NASA notified NMED that due to agency environmental budget restrictions, the schedule for corrective action projects in fiscal years 2024 and 2025 would be severely curtailed. NASA will continue efforts to obtain funding. In recognition of budget constraints for FY25, the earliest this investigation can be performed is in FY26, contingent on the available budget and the status of other corrective action projects. NASA will maintain communication with NMED regarding the corrective action projects and budget and identify any issues that may affect the scope or schedule of those projects.

This submittal includes a printed response table that cross-references NMED's comments as Enclosure 1, printed replacement pages as Enclosure 2, and a CD with the electronic copies of the response table, final report, and redline-strikeout report 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 knowing violations.

If you have any questions or comments concerning this submittal, please contact Antonette Doherty of my staff at 575–202–5406.

Timothy Davis

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Timothy J. Davis
Chief, Environmental Office

3 Enclosures

cc:
Mr. Gabriel Acevedo
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Ms. Melanie Sandoval
Submitted electronically via NASA Box

700 Area Landfill Closure (SWMU 49) Phase II Abbreviated Investigation Work Plan

Introduction	This abbreviated investigation work plan (AIWP) describes the approach for a Phase II investigation of the 700 Area Landfill at the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF; Figure 1). The Phase II AIWP is provided in accordance with the requirements of *700 Area Landfill Closure (SWMU 49) Phase I* (Phase I) *Investigation Report* (IR) submitted to the New Mexico Environment Department (NMED) on April 29, 2022 (NASA, 2022) and approved on February 10, 2023 (NMED, 2023a). The WSTF 700 Area Landfill is identified as solid waste management unit (SWMU) 49 in the Resource Conservation and Recovery Act (RCRA) Permit (Permit; NMED, 2023b). The landfill began operation between 1963 and 1965; the last waste was received on October 27, 1997. The specific wastes and their quantities disposed of in the landfill are not well documented, although evidence of the nature of the waste is available in spill reports and employee interviews for the deposition of hazardous substances (historical information summary [HIS]; NASA, 2017). The landfill was designed to contain solid waste for disposal within excavated cells or trenches and has previously been described as a "modified landfill" (NASA, 1978), a sanitary landfill, and a "Class B landfill," which was "a sanitary landfill serving a population of less than 3,000" (NASA, 1991). The 700 Area Landfill is located in Section 26, Township 20 South, Range 3 East within the remote northeast part of WSTF (Figure 2) and is a 24-acre trapezoid-shaped piece of land with the long axis-oriented northwest-southeast. Access to the 700 Area is provided by gravel roads (Road P and Cereus Drive) from Apollo Boulevard, the main paved access road through WSTF. The Second Tracking and Data Relay Satellite Ground Terminal located approximately a half-mile to the west northwest of the landfill represents the most proximal facility. Design and operational details for the landfill are provided in the HIS (NASA, 2017). The only structures present in the immediate vicinity of the 700 Area Landfill include conventional and multiport groundwater monitoring wells located upgradient and downgradient of the landfill and methane gas monitoring wells inside the landfill perimeter (Figure 3). A total of 26 original cells were documented at the landfill based on historical photographs, personnel interviews, and surface topographic features. Trenches were initially excavated at the southeast side of the landfill close to the entrance on the southeast side and moved progressively northwest. The Closure cap cover is generally 2 to 3 feet (ft) in total thickness and includes a geosynthetic clay liner (GCL) located above the trenches inserted between 2 inches (in.) of select fill (screened to one quarter inch and less in diameter) above and below to prevent any large rocks from damaging its integrity. The base of the cap consists of a minimum 10-in. layer of compacted local fill that is covered by the select fill and GCL. The select fill is overlain by a minimum of 10-in. of uncompacted screened local material (topsoil) to complete the cap (NASA, 2017). The Phase I IR (NASA, 2022) includes a summary of the 700 Area Landfill

Introduction (cont.)	background including operational history, potential wastes, previous monitoring results, a preliminary site conceptual exposure model, exposure pathways, and potential receptors.
Regulatory Background	NASA is currently implementing Post-Closure Care (PCC) requirements at the 700 Area Landfill in accordance with the PCC plan submitted to and approved by the NMED Solid Waste Bureau (SWB) on August 22, 1997. At the same time and specific to subsequent investigation of the landfill, the WSTF RCRA Permit (NMED, 2023, p81) requires the development and submission of an investigation work plan (IWP) that addresses the projected work to be performed. Initially, the due date for submittal of the IWP for the 700 Area Landfill was December 30, 2015 (NMED, 2009). On November 17, 2015, NASA submitted a *Class 1 Permit Modification Request* (NASA, 2015) to the NMED HWB requesting a new due date for submittal of the IWP and HIS of December 29, 2017. NMED approved the Permit Modification Request on December 16, 2015 (NMED, 2015). NASA submitted the *NASA WSTF SWMU 49 (700 Area Landfill) Phase I IWP and HIS* on December 28, 2017 (NASA, 2017), which was disapproved by NMED on November 29, 2018 (NMED, 2018). NASA submitted the *Response to NMED Disapproval SWMU 49 (700 Area Landfill) Phase I IWP and HIS* on March 28, 2019 (NASA, 2019a) and received NMED's *Approval with Modifications SWMU 49 (700 Area Landfill) Phase I IWP and HIS* on June 6, 2019 (NMED, 2019). NASA responded to the Approval with Modifications on August 8, 2019 (NASA, 2019b). On October 19, 2021, NASA submitted a *Discussion Relative to the Phase IA and Phase IB Soil Vapor Survey (SVS) Component of the Ongoing 700 Area Landfill Phase I Investigation* (NASA, 2021a). NMED responded with the *Disapproval 700 Area Landfill (SWMU 49) Phase I Investigation Soil Vapor Survey* on November 12, 2021 (NMED, 2021). NASA submitted the *Revised Discussion Relative to the Phase IA and Phase IB SVS Component of the Ongoing 700 Area Landfill Phase I Investigation* on December 21, 2021 (NASA, 2021b), which was approved by NMED on February 11, 2022 (NMED, 2022). NASA conducted the Phase I field investigation between September 2019 and March 2022 and incorporated shallow soil vapor survey (SVS) and surficial geophysical survey techniques to provide improved conceptualization of the 700 Area Landfill. The *700 Area Closure (SWMU 49) Phase I Investigation Report (IR)* was submitted to NMED on April 29, 2022 (NASA, 2022) and approved on February 10, 2023 (NMED, 2023a).
Phase I Investigation	The 700 Area Closure Phase I investigation (NASA, 2022) provided additional information on the 26 individual trenches originally identified in the HIS (NASA, 2017). The SVS provided an improved conceptualization of the 700 Area Landfill by providing the distribution of volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPH) in soil vapor of the shallow vadose zone. The geophysical surveys collectively provided information relative to the dimensions of each of the waste disposal trenches, the location of metallic waste within the

Phase I Investigation (cont.)	trenches, and subsurface geology with respect to the alluvial-bedrock interface at a depth. The Phase I investigation extended across the 700 Area Landfill and adjacent surrounding areas. The primary target area was traversed by a standardized field survey grid (Figure 4) constructed using 90-foot (ft) x 90-ft grid cells as the base grid for the shallow SVS survey and suite of four geophysical surveys comprising: electromagnetic induction (EMI), vertical magnetic gradiometry (VMG), active multichannel analyses of surface waves (AMASW; used to replace ground penetrating radar); and an enhanced passive seismic survey (PSS). Individual geophysical survey line spacings using the standardized grid varied, and the final traverse lines for each survey were developed at the recommendation of the geophysical subcontractors. Phase I was focused on the upper 20 to 25 ft of the vadose zone that incorporated the individual landfill trenches. The qualitative shallow SVS was used to map the distribution of soil vapor VOCs and TPH in the shallow subsurface across the 700 Area Landfill and adjacent areas in the low nanogram (ng; one billionth of a gram) range. Passive sampling modules were set at the nodes of the 90-ft x 90-ft grid cells and were suspended in shallow soil borings for 15 days at depths of 25 to 30 in. below the depth of the low conductivity GCL. For comparative purposes, modules were also suspended inside the casing of 10 screened methane monitoring wells and three groundwater monitoring wells (Figure 3). A sparse distribution of low concentrations for contaminants of potential concern (COPC) near the limit of quantitation for the majority the Environmental Protection Agency (EPA) 8260C compounds restricted the ability to achieve the original objectives of the survey. Summaries of the shallow SVS results for COPCs were presented as isoconcentration maps for six analytes selected based on either frequency of detection and/or significance relative to the known list of COPCs present at the 700 Area Landfill (NASA, 2019a). These comprised: 1,1,2-trichlorotrifluoroethane (Freon®[1] 113); 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; chloromethane; tetrachloroethene (PCE); and trichloroethane (TCE). Qualitative passive shallow soil vapor concentration maps are provided in the Phase I IR (NASA, 2022). The qualitative shallow SVS distributions for the six analytes did not identify a significant number of elevated concentrations across the footprint of the landfill trenches. The highest concentrations were typically associated the SVS modules suspended within the inside of monitoring well casings that were directly exposed to vapor above contaminated groundwater. Freon 113 and TCE concentrations in soil vapor were inferred to be related to a groundwater volatilization origin. The EMI survey was performed to establish spatial distribution of soil conditions within the landfill; the AMASW survey to delineate the dimensions of landfill trenches; and the VMG survey to locate and map the distribution of metallic objects. Individual survey grids were developed by the geophysical subcontractor during the planning phase for each field survey. The fourth geophysical survey

[1] Freon is a registered trademark of The Chemours Company FC, LLC.

Phase I Investigation (cont.)	comprised a PSS that was used to improve characterization of the deeper vadose zone including the bedrock surface below the landfill. The EMI, VMG, and AMASW geophysical surveys confirmed the presence and dimensions of all but one of the previously documented 26 trenches. Correlation with geographic information system map data of the landfill trenches, provided in the original HIS (NASA, 2017) was strong, which yielded a high degree of confidence in the results obtained. Updated lateral trench extents and depths were well represented by the AMASW survey data that was coupled with the magnetic data from the EMI and VMG surveys for comprehensive representation of the data (Figure 5). Confirmed landfill trenches were labeled A through Y with three additional depressions identified as Z, AA, and AB. Trenches were generally located subparallel to each other in a northeast-southwest direction and had typical dimensions of approximately 12 to 22 ft (depth) x 20 ft (width) x 300 to 600 ft (length). Two trenches were oriented northwest-southeast (X and Y), and two trenches were significantly smaller in length (V and Z at approximately 50 ft). In addition to the shallow vadose zone investigation, the alluvial-bedrock interface at depths between 110 ft and 180 ft below ground surface (bgs) was evaluated using the enhanced PSS and integrated with known depths from monitoring well boreholes. The strike of previously inferred faults below the landfill footprint based on borehole data generally aligns with the change in depth to bedrock observed in the interpreted PSS results.
Purpose	The purpose of the Phase II investigation is to perform a subsurface investigation to below the depth of the landfill trenches and adjacent shallow vadose zone of the 700 Area landfill through the installation of soil borings, soil chemical and geotechnical sampling and analysis, MSVM well installation, and soil vapor chemical sampling and analysis. Groundwater chemical sampling and analysis will be evaluated using the existing monitoring well network. Phase II will provide quantitative analytical results relative to the distribution of VOCs, semi-volatile organic compounds, and other analytes historically associated with landfill activities in the subsurface (NASA, 2017). The investigation will allow evaluation of the concentrations of specific COPCs that may be present in the 700 Area Landfill. Quantitative soil, groundwater, and soil vapor analytical data will also support determination of the nature and extent of any contamination identified and the potential pathways of releases to soil or groundwater. Once quantified analytical data have been received and validated, these data will be evaluated in accordance with procedures detailed in the Risk Assessment (RA) Guidance to support the characterization of site risk to human and ecological receptors and to the environment. Characterization of the risk will support conclusions presented in the IR and decisions regarding follow-on activities. Corrective action activities for the 700 Area landfill will be determined following submittal and NMED review of the Phase II IR. In the interim, NASA will continue with ongoing PCC activities until a final resolution for the landfill is determined based on evaluation of the collective results from the Phase I and

Purpose (cont.)	Phase II investigations and determination of site risk in accordance with the site RA Guidance. Comparable investigation approaches (geophysical surveys, shallow soil vapor surveys, soil sample geochemical and geotechnical analysis, groundwater sampling and analysis, soil vapor sampling and analysis) have been used to evaluate other landfills in New Mexico (e.g., City of Albuquerque, 2023). The final resolution will determine the path forward with respect to future disposition of the landfill. Projected strategies may potentially include: • The excavation and removal (with soil backfill) of any hazardous material identified and transport off-site to approved disposal facilities; • Application for landfill closure per NMED approval with no further action (NFA) status; or • Long Term Monitoring (LTM) under NMED guidance with or without Closure cap modification. The network of groundwater and MSVM wells projected to be in place following the Phase II investigation will allow detailed monitoring of concentrations in groundwater and soil vapor with respect to NMED regulatory criteria.
Geology and Hydrology	The 700 Area Landfill is located in soils composed of coalescent alluvial fans locally dissected by small drainages at surface in an area between 4,800 to 5,000 ft above mean sea level in elevation. The relatively flat topography is typical the western pediment of the San Andres Mountains (SAM). The surface elevation decreases from east to west moving down topographic gradient from the SAM into the southern Jornada del Muerto Basin. The shallow dissecting drainages up to a few feet in depth flow during periods of heavy rainfall and primarily trend east to west in accordance with the local surface gradient (Figure 2). The surface geology consists of Quaternary piedmont slope facies of the Camp Rice Formation, part of the widespread upper Santa Fe Group alluvium (Seager, 1981) derived from the adjacent SAM. The piedmont slope alluvial deposits originated from Bear Canyon, a major east-west-trending transverse canyon in the southern SAM located 1 mile (mi) to the east southeast of the landfill. Alluvium comprises of coarse and variably sized gravel clasts within a sand, silt, and clay matrix. Alluvium is primarily unconsolidated, poorly sorted, and locally contains discontinuous cemented caliche horizons up to a few inches in thickness. The closest bedrock outcrops are located to the east southeast in the Bear Canyon area and comprise Pennsylvanian to Permian age limestone, sandstone, siltstone, and shale. Subsurface bedrock lithologies at a depth in the vicinity of the 700 Area Landfill comprise Permian Hueco Limestone and Tertiary Orejon Andesite. Two styles of geologic deformation are present (Seager, 1981). The older and less prevalent deformation consists of west to northwest-trending folding and faulting associated with the Late Cretaceous to Early Tertiary Laramide Orogeny. This compressional deformation is present to the east southeast in Bear Canyon in the Bear Peak Fold and Thrust Zone. Thrust faults of the Bear Peak Fold and Thrust zone are interpreted to extend northwestward along strike in the subsurface and pass north of the northern boundary of the landfill. The second more recent deformational style consists of extensional northwest-trending Late Tertiary Basin

Geology and Hydrology (cont.)	and Range normal faulting. Basin and Range normal faulting that commenced between 26 and 32 million years ago continues to the present. Line of cross-section A-A' is identified in Figure 2 and provided in Figure 6. The local bedrock forms an eroded surface based on existing borehole lithological and geophysical data that decreases in elevation and increases in depth below ground surface from east to west across the landfill from 110 ft (well 700-J-200) to 180 ft (well 700-D-186) in the direction of dip of the pediment slope. Subsurface normal faults in the vicinity of the landfill have been inferred from seismic reflection data, PSS data, and borehole lithologic and geophysical logs (NASA, 2022). Two inferred northwest-striking normal faults are located in bedrock in the vicinity of the landfill with displacements of approximately 50 ft that downfault a small block of Orejon Andesite into Hueco Limestone at depth. Limestone is located on the northeast and southwest sides of the fault block (intercepted by wells 700-J-200 and 700-D-186, respectively). Adjacent and to the west of the landfill, a third normal fault (potentially the extension of the Hardscrabble Hill Fault) significantly drops the Paleozoic limestone to depth below the base of well 700-H installed in andesite by at least 530 ft as indicated by the thickness of andesite intercepted. The subsurface normal faults may be related to an early period of extensional basin-range faulting, with beveling of the surface before deposition of the alluvium. The local aquifer is hosted within the Hueco Limestone and Orejon Andesite bedrock, typically at a depth of 30 ft below the bedrock surface. There is little to no primary porosity in the bedrock and groundwater flow is within secondary bedding solution channels and fractures within the limestone, and secondary fractures within the andesite. Monitoring wells in the vicinity of the 700 Area Landfill (700-J-200, 700-A-253, 700-D-186, 700-H, and 700-B-510; Figure 6) are screened below the static potentiometric surface in order to maximize groundwater flow from fractured zones. The wells are conventional single screen wells and are located in the uppermost aquifer with the exception of 700-H, which consists of three Westbay®[2] sampling ports designed for vertical characterization along a deeper aquifer profile. The details of these well construction designs are discussed in the site-wide Groundwater Monitoring Plan (NASA, 2023). Groundwater flow is from east to west based on groundwater depth measurements with relatively steep groundwater gradient of 0.1 ft/ft and a velocity of 0.3 to 1.6 ft per day (NASA, 2022). The volume of flow in bedrock is restricted based on low hydraulic conductivities within the aquifer determined from slug testing at monitoring wells 700-H and 700-B-510, and a dry borehole installed at the 700-G location (Figure 2).
Survey Grid and Field Staking	The original Phase I survey grid provided in Figure 4 (NASA, 2022) will be re-staked in order to target specific locations identified for the Phase II investigation. Additional stakes will be added in the field to mark the footprint of trench boundaries and the locations of the proposed Phase II soil borings to support the logistics associated with the movement of heavy equipment.

[2] Westbay is a registered trademark of Nova Metrix Ground Monitoring (CANADA) LTD.

Closure Cap Preparation and Protection	The Closure cap surface is sparsely to moderately vegetated with desert shrubs and grasses, some of which may impede easy progression of equipment along planned survey lines. To ensure adequate access for drilling equipment, some vegetation may be mowed or mechanically removed as performed in the past for the Phase I investigation (NASA, 2022). Phase II subsurface soil boring locations require the installation of one to four-inch diameter soil borings that will be cored through the landfill Closure cap to facilitate subsurface soil sampling and soil vapor well installations. The locations selected for the installation of soil borings will be assessed individually to determine the required surface preparation to allow for access of drilling equipment while ensuring the cap is protected. Table 1 summarizes the potential sources of damage to the cap and the planned protection strategies. The wire fencing surrounding the perimeter of the landfill will be removed prior to the inception of drilling to afford direct access to each soil boring location from a peripheral dirt road outside the landfill boundary (Figure 4). Equipment movement planning will include access route maps for each soil boring with careful avoidance of the trench footprints. Access to the interior landfill will utilize only the native soil formation bridges between trench footprints. Any rutting from movement of the drilling equipment that could potentially damage the cap will be minimized through the use of plastic ground protection mats (DuraDeck®[3] or equivalent).
Drilling Approach	Sonic drilling is proposed for the installation of shallow (3 ft) and multi-depth (up to 30 ft) vertical soil borings, the collection of chemical and geotechnical soil samples, and the completion of MSVM wells through unconsolidated alluvium without the use of drilling fluids. Available space between the landfill trench footprints is limited, and extreme care will be taken during mobilization of the sonic rig. Soil borings will be positioned as close as is feasible to the locations adjacent to the trenches with consideration of the size of the drilling equipment. The core barrel diameter used for the multi-depth soil borings will have a diameter of approximately four inches to allow for a sufficient volume of soil to facilitate sampling, reduced potential temperatures within the soil sample, and to allow sufficient annular space for the installation of MSVM wells. Sonic drilling involves advancement of a core barrel using vibration, rotation, and a downward force to install soil borings and collect soil samples from the undisturbed alluvial formation. The sonic drilling rig has a hydraulically powered oscillator, which generates adjustable high-frequency vibrational forces. The sonic head is attached directly to the drill pipe or outer casing, sending vibrations down through the drill pipe to the bit. Once the core barrel has been advanced, a secondary override casing will be advanced down to the same depth as the inner core barrel to keep the borehole from collapsing. Once the core barrel is removed, the soil core will be extruded from the core barrel by gravity-aided vibration, into chemically resistant containers (e.g., polyethylene sleeves), minimizing the disturbance of the soil core and ensuring the collection of the most representative soil samples. To minimize the effects that heating of the core barrel may have on

[3] DuraDeck is a registered trademark of Signature Systems Group, LLC.

Drilling Approach (cont.)	soil sample quality, a lower vibration frequency will be used where feasible, short runs of one to two ft will be driven where soil samples are to be collected, and four-in core barrels will be deployed.
Soil Borings	The Phase II investigation is subdivided into two components; Phase IIa (weighted shallow soil borings within trench footprints and multi-depth vertical borings adjacent to trenches defined on the basis of Phase I results [NASA, 2022]); and Phase IIb (conditional angled soil borings defined on the basis of Phase IIa results). PHASE IIa SOIL BORINGS (8 + 32) Based on the results presented in the Phase I investigation (NASA, 2022) total of eight shallow soil borings inside trench footprints and 32 multi-depth soil boring locations comprising 24 within the 700 Area Landfill boundary and eight peripheral and outside the landfill are proposed for the Phase IIa investigation (Figure 7, Table 2). The eight shallow soil borings proposed within trenches are paired with eight of the 24 soil borings within the landfill boundary. In order to weight the locations of the Phase IIa soil borings in the vicinity of the landfill trench footprints, specific areas of interest were established on the basis of: • Trench age (preference given to older trenches active between the mid-1960s and late-1980s prior to the implementation of stringent waste management practices [NASA, 2017]). • Shallow soil vapor survey data concentration maps (preference given to relatively higher concentrations for six primary COPCs [NASA, 2022]). • Trench depth (preference given to deeper trenches as depicted by AMASW data [NASA, 2022]). • Trench magnetic anomalies as identified by EMI and VMG data (NASA, 2022). Following selection, specific areas of interest were further evaluated to identify eight primary locations likely to present the greatest opportunity for subsurface contamination. Soil boring locations were biased to coincide with these primary locations (Table 2) that incorporate the paired shallow soil borings within the trench footprint and a vertical soil boring adjacent the trench. Additional soil borings were used to address the other specific areas of interest and provide coverage across the landfill for the purpose of generating soil and soil vapor concentration maps. Shallow Soil Borings Above Primary Weighted Locations (8) Eight shallow soil borings will be installed at a depth of 3 ft bgs at the primary weighted locations within the footprint of specific trenches to quantitatively evaluate shallow soil vapor conditions above the trench contents (Figure 8, Table 2). No soil samples will be collected because the lithology comprises imported Closure cap materials above the trenches. Single-port soil vapor wells will subsequently be installed at each location with a sample port depth that is

Soil Borings (cont.)	coincident to the soil sampling location. The 3 ft target depth within the closure cap is located below the GCL at approximately 2 ft bgs (NASA, 2022). Multi-depth Soil Borings Adjacent to Weighted Locations (24) A total of 24 multi-depth vertical soil borings will be installed inside the 700 Area Landfill boundary to depths up to 30 ft bgs. Vertical soil borings will be installed adjacent to the footprint of individual trenches based on the specific areas of interest to a depth of 2 ft below the bottom of the adjacent trench to facilitate the collection of soil samples. Three soil sample depths are proposed at each vertical soil boring related to the trench depth determined from the Phase I investigation (Figure 5): mid-trench; bottom-trench; and sub-trench. The proposed soil boring locations and sample depths are provided in Figure 8 and Table 2. Multi-depth Peripheral Soil Borings Outside Landfill Boundary (8) Eight peripheral vertical soil borings will be installed upgradient (2 locations), on the sides (2 locations), and downgradient (4 locations) outside the 700 Area Landfill boundary (Figure 7, Table 2). These soil boring locations will be used to complement the multi-depth soil borings inside the landfill boundary and provide a supplemental analytical dataset for soil and soil vapor samples outside the landfill for statistical comparison. Three soil sample depths are proposed following the same strategy as soil borings installed within the landfill footprint (mid-trench, bottom-trench, and sub-trench). The depth peripheral soil borings are based on the average trench depth of 14 ft. Three-port MSVM wells will be installed at each location with sample port depths that correspond to the soil sampling locations. PHASE IIb SOIL BORINGS Phase IIb soil borings are planned conditionally based on the quantitative sampling results from the Phase IIa soil and soil vapor samples. NASA proposes the Phase IIb investigation be planned as a follow up field effort following submittal and NMED review of a Phase IIa investigation report. Angled Soil Borings Below Phase IIa Anomalies A preliminary pilot test will be performed in the vicinity of the 700 Area Landfill on completion of the Phase IIa drilling and soil vapor well installation activities. The pilot test will comprise the installation of two angled soil borings outside and adjacent to the landfill area. Results of the angled borehole pilot test will be included in the Phase IIa investigation report. If the installation of the two angled soil borings is unsuccessful and not deemed to be feasible, this will preclude the installation of any Phase IIb angled soil borings, and vertical borings will be installed. Should results of the pilot test indicate angled borings are feasible the following activities will be completed. Based primarily on the quantitative soil and soil vapor results from the eight shallow and 24 multi-depth soil boring locations inside the 700 Area Landfill boundary, a set of angled soil borings will be installed adjacent to anomalous locations. Angled soil borings are planned with the objective of collecting a soil sample from directly below the trench locations

Soil Borings (cont.)	considered to be anomalous. Angled sonic drilling presents an opportunity to potentially collect soil samples at between 40 and 60 ft directly below the base of the target trench locations. Based on subcontractor capabilities, angled soil borings are planned at an angle between 15 to 25 degrees from the vertical in conjunction with a step-off from the target of between 15 to 20 ft outside the adjacent trench wall. The exact location of the soil boring in the field may be influenced by rig access and Closure protection practices. Due to the coarse nature of native alluvial gravels, probable inaccuracy in the exact trench depths defined geophysical surveys, and the potential for the angled drill stem to deflect in its path during installation (large cobbles), extreme care will be taken during any attempted angled soil boring installations. Because angled soil borings have not been previously attempted in the alluvial gravels at WSTF, the feasibility of completing a soil vapor port within this type of soil boring is to be determined during the pilot test. Should installation of angled borings be infeasible, vertical borings will be installed to collect soil samples adjacent to the anomalous trench locations identified by the Phase IIa investigation. Vertical borings will be advanced, and samples collected, at least 5 ft below the deepest detected contamination to meet the Permit, Section 4.2.3.1, Drilling, minimum requirements for site characterization. Sampling for vertical delineation of subsurface contamination encountered will be collected at locations that will maintain the existing integrity of the landfill at locations most likely to yield the most representative site characterization data. The locations and depths of the Phase IIb borings will be determined based on a full evaluation of soil chemical data generated by the Phase IIa investigation.
Soil and Soil Vapor Quality Assurance/Quality Control Procedures	Soil and soil vapor samples will be collected in accordance with Permit Section 4.2.6 (NMED, 2023b) and shall be representative of the media and site conditions being investigated. Quality Assurance/Quality Control (QA/QC) samples will be collected to monitor the validity of the collection procedures and shall follow the following sampling protocols: • field duplicates shall be collected at a rate of 10%; • equipment blanks shall be collected from all sampling apparatus at a frequency of 10% for chemical analysis; • equipment blanks shall be collected at a frequency of one per day if disposable sampling equipment is used; • field blanks shall be collected at a frequency of one per day for each media; and • reagent blanks shall be used if chemical analytical procedures requiring reagents are employed. Soil samples and soil vapor samples will be shipped to accredited independent off-site laboratories for chemical analyses of the complete list of COPCs identified in this AIWP. Following receipt of all chemical analytical data, qualified NASA personnel will review and manage these data in accordance with established WSTF procedures. Data validation will be performed by experienced

Soil and Soil Vapor Quality Assurance/Quality Control Procedures (cont.)	data management personnel upon receipt to ensure data met project objectives. Data will be reviewed for QA/QC compliance to ensure representativeness and comparability and to determine if systematic bias exists. Laboratory reports will be thoroughly evaluated to assess data quality exceptions and apply quality flags, note these exceptions, and evaluate the impact to the quality of the project data. Specific information related to soil and soil vapor chemical analyses will be provided with the field investigation results within the IR, and QA reports will be provided for all data sets as appendices.
Soil Sampling	Table 2 includes a summary of the proposed soil boring nomenclature, reference to the individual soil boring sample locations shown in Figure 7, sample depths, the criteria for soil boring selection, and the estimated total number of projected soil samples (96). Duplicate soil samples will be collected at a rate of 10% of the total locations. No soil samples will be collected for the shallow 3 ft soil borings above the footprint of the trenches that consist of imported Closure cap construction materials. Three chemical soil samples will be collected from each of the 32 proposed vertical soil borings using 4-in. diameter sonic core barrels. Soil samples will extend over one-ft intervals at locations dependent on the total trench depth mapped during the Phase I investigation. For example, using an average trench depth of 14 ft, the following three soil samples will be collected. • Mid-trench representing the central trench at 7 ft bgs. • Bottom-trench representing the location coincident with the bottom of the trench at 14 ft bgs. • Sub-trench representing the location 10 ft below the base of the trench at 24 ft bgs. Soil samples will be collected for analysis for the comprehensive suite of COPCs listed with the analytical methods in Table 3 compiled based on the historic 700 Area Landfill activities (NASA, 2017; NASA, 2022). Results from the soil sample analysis will be included in each respective MSVM well completion reports. Geotechnical soil samples will be collected at a rate of approximately 10% of the chemical soil samples identified in Table 2 to provide native soil geotechnical conditions at the 700 Area Landfill. These samples will be used to supplement the sitewide database of geotechnical samples and provide parameters that may be required to support future engineering planning and the determination of the final disposition of the landfill.
MSVM Well Installation and Initial Development	Following the advancement of the soil borings and collection of soil samples to the projected total depths, either a one port (shallow soil borings) or three port (multi-depth soil borings) soil vapor well will be installed inside the over-ride casing at each location (Figure 7, Table 2). Soil vapor sample port depths will be coincident with the soil sample locations within each soil boring to afford a comparative evaluation between the soil and soil vapor analytical data.

MSVM Well Installation and Initial Development (cont.)	The generalized construction design for single-port soil vapor wells and three-port MSVM wells and location relative to landfill trenches is provided in Figure 8. Soil vapor sample ports are designed with the objective of providing the vertical delineation of soil vapor concentrations in native alluvial formation adjacent to each soil sample location. MSVM port locations correspond to shallow supra-trench (3-ft bgs), mid-trench, bottom-trench, and sub-trench locations as listed in Table 2. Soil vapor port positions may be modified slightly during the design phase if a location of specific interest is justified during lithological logging of the borehole (for example visible discoloration of the native soils). Individual soil vapor ports will consist of a 12-in. (1 ft) soil vapor implant connected to a ¼-in. stainless-steel feeder tube to surface. Soil vapor ports will be secured to the outside of a centrally located 5/8-in. steel cable with a weight (Figure 8). Annular materials will comprise of two-ft minimum intervals of silica sand surrounding the soil vapor implants with Type I/II Portland cement with 5% bentonite intervals between the silica sand. The top of the soil boring will be completed with an 8-in. locking wells cap secured with Type I/II Portland cement as shown. MSVM wells ports will be initially developed by purging using a portable gas analyzer equipped with a pump following the completion of well installation as the soil vapor implants may be clogged with soil material and will not purge correctly. The analyzer pump should effectively pull vapor flow from the zone (indicated by the in-line flow meter) or will pull a vacuum and eventually shut down if clogged. Internal procedures are in place for guidance to attempt to unblock soil vapor ports where applicable. The initial purging of each soil vapor port will entail allowing the pump to purge the soil vapor well tubing for a minimum of five minutes per zone. Within the relatively shallow MSVM installations, this will evacuate at least three volumes of the ¼ in. tubing and soil vapor implant. The concentration of methane (CH_4), carbon dioxide (CO_2), and oxygen (O_2) indicator parameters will be monitored during the entire development operation to ensure they have stabilized, or additional development purge time may be required. During initial MSVM well development, each vapor port will be affixed with an aluminum tag engraved with the ID of that port to ensure each port can be identified in the future.
Soil Vapor Sampling	A set of soil vapor samples will be collected from each soil vapor port in the 700 Area Phase IIa soil vapor well network to determine the concentration and map the distribution of any anomalous VOCs in the subsurface. Soil vapor sampling will be performed in accordance with established WSTF guidance. At each MSVM well location, the sampling sequence will begin with the mid-trench soil vapor port and continue sequentially until the bottom-trench and sub-trench ports have been sampled. Each port will be connected to a portable gas analyzer equipped with a pump and purged prior to sampling for a minimum of five minutes which exceeds the time required to remove three volumes equivalent to the vapor implant and connecting stainless-steel tubing in the MSVM well ports. This process ensures that samples will be representative of the portion of the formation adjacent to the sample port at that depth in the well. Associated parameters on the purging monitor (CH_4, CO_2, and O_2) will also be required to equilibrate prior to sampling, otherwise additional purging will be performed until this goal is achieved.

Soil Vapor Sampling (cont.)	Samples will be collected in 1-liter stainless-steel SUMMA canisters and shipped to an accredited laboratory for analysis of VOCs by EPA Method TO-15 by full scan gas chromatography/mass spectrometry. The TO-15 analyte list comprises between 80 to 100 compounds that approximates the EPA 8260C target list for soil samples (Table 3).
Equipment Decontamination	All downhole drilling and sampling equipment that penetrates the surface soil will be decontaminated thoroughly using a steam cleaner. General decontamination guidance available in ASTM International D 5088-20 (ASTM, 2020) will be followed for this project. Decontamination procedures will be performed by 40-hour HAZWOPER trained personnel wearing appropriate personal protective equipment (PPE) under the supervision of the site supervisor or their designee. **Decontamination Area** A site-specific decontamination station will be constructed adjacent to the 700 Area Landfill to support the decontamination of all downhole equipment including the rotary hammer drill bit, steel conduit pipe, core barrels, and secondary override casing. Contamination reduction or decontamination activities will be performed over a containment device that will retain waste generated during the decontamination process. It is anticipated that all waste will be managed as solid waste. **Decontamination Methods** Decontamination will be performed on the downhole equipment to minimize the potential for any cross-contamination between soil boring locations. Any residual soil on the downhole equipment will first be removed using a wire brush at the decontamination station. Downhole equipment will be decontaminated prior to arriving at WSTF, prior to the commencement of soil boring installations, between individual soil boring locations, and prior to exiting the 700 Area Landfill area. Decontamination will involve steam cleaning the rotary hammer drill bit, steel conduit pipe, core barrels, and secondary override casing. In the event field screening instruments are used to monitor the condition of the 700 Area Landfill, dry decontamination followed by an alcohol-free moist wipe will be used for moisture sensitive equipment such as a photoionization detector.
Field Documentation Procedures	The WSTF Environmental Department field supervisor (geologist or engineer) will keep a record of daily Phase II investigation activities, a log of site personnel, safety briefings, and wastes generated in a project specific logbook. Logbooks will be bound with durable and serial numbered pages. Entries will be made in ink with no erasures. Each day's record will be reviewed and approved by another individual involved in the project. Logbook entries will include, as applicable, information that includes at a minimum: • Standard Daily Header – project name, logbook number, date, weather conditions, team members present and their affiliations (including subcontractors), sample location identification, day's task(s), daily safety meeting topics, PPE to be used, equipment in use, and any calibration information, if applicable.

Field Documentation Procedures (cont.)	• Daily activities (time and observations recorded) – site arrival and departure, visitors, the purpose of their visit, drilling information, sampling information, soil type, soil conditions, decontamination (i.e., method, equipment cleaned), waste management, and reference data sheets or maps, if applicable. • Daily summary – action items, materials used, changes or deviations made from planned protocol, plan for next day. • Signatures (field personnel and logbook reviewer). In addition to the field logbook, soil boring locations and soil samples will be recorded in soil boring logs. The logs will include the date, location, sample type, sample depth, identification number, personnel, and any circumstances, events, or decisions that could impact sample quality. MSVM well designs will be recorded in well completion diagrams that document well materials used, port depths and identification, annular materials, and personnel. Evidential records for the entire project will be maintained in hard copy or electronic form and will consist of: • Project IWP with any deviations redlined. • Site-specific internal procedural documentation or plans. • Project logbooks. • Field data records (i.e., surveyed site location). • Soil boring logs. • MSVM well completion diagrams. • Correspondence with NMED. • Final analytical data packages. • Reports. • Miscellaneous related records such as photos, maps, drawings, etc.
Investigation-Derived Waste	The RCRA Permit (NMED, 2023; Section 6.2.13 [pg86]) requires that a description of investigation-derived waste (IDW) management be included as an appendix to each IWP. IDW management is presented in this section of the AIWP in lieu of a separate appendix. IDW generated will be managed as hazardous until characterized as non-hazardous and will be stored in the immediate project area. Waste characterization will be conducted in accordance with Section 4.3.10 of the Permit (NMED, 2023, p59). All waste will be properly managed and disposed of in accordance with NASA procedures and state and federal regulations. The waste streams that will be generated during the installation of soil borings and MSVM wells include: • **Unsaturated drill cuttings.** Unsaturated drill cuttings are defined as soil cuttings or rock fragments generated from the shallow vadose zone (either used to construct the 700 Area Closure cap or located adjacent to trenches) that have not come in contact with groundwater. Unsaturated cuttings are non-hazardous solid waste. • **Drilling fluids.** Drilling fluids generated during drilling in the vadose zone are impacted with only added non-chlorinated native water from the WSTF potable water supply wells and are non-hazardous solid waste.

Investigation-Derived Waste (cont.)	• **Decontamination fluids.** Decontamination fluids such as water and soap solutions used to wash and decontaminate equipment generated during drilling above the water table are non-hazardous solid waste. • **Contact waste.** Contact waste, or debris, such as used disposable sampling equipment, PPE, plastic sheeting, and other debris generated during drilling above the water table is non-hazardous solid waste. Drill cuttings and drilling fluids generated from the shallow 700 Area Landfill vadose zone are not anticipated to contain listed hazardous waste nor meet the definition of a hazardous waste. The as-generated waste will be sampled and analytical data used to further characterize the waste. Waste characterization samples will be analyzed for volatile organic compounds by the current revision of SW-846 Method 8260, NDMA by Modified EPA Method 607M, and RCRA metals using the current revision of EPA Method 1311 (Toxicity Characteristic Leaching Procedure) and the current revision of EPA Method 6010, or equivalent. Non-hazardous drill cuttings and drilling fluids will be managed at the surface as required. For any waste that is characterized as hazardous waste (for example in the unanticipated event of a fluid leak from the drilling rig), land disposal restriction notifications, disposal facility profiles, and hazardous waste manifests will be completed as required. Hazardous waste manifested off-site will be transported for treatment and disposal at a permitted RCRA treatment, storage, and disposal facility.
Site Restoration	Any required final restoration and/or grading activities at the 700 Area Closure landfill will commence following the completion of the Phase II investigation fieldwork. As specified previously, care will be taken to follow all applicable guidance relative to Closure cap damage listed in Table 1. Any specific backfill or grading will be completed using the standard equipment utilized for previous landfill repairs to prevent the ponding of any water. The wire fencing surrounding the perimeter of the landfill will be restored to restrict access to the landfill. Stakes placed at the landfill trench footprint boundaries and for the survey grid will be removed and any disturbance backfilled and compacted. Any significant modifications or repairs to the landfill closure cap will be reported to the NMED Solid Waste Bureau.
Schedule	The schedule for the 700 Area Phase II field investigation is dependent on a baseline represented by the NMED final approval date for the 700 Area Landfill Phase II AIWP. The proposed schedule for the 700 Area Landfill Phase II investigation fieldwork and reporting is as follows: • NMED approval of 700 Area Landfill Phase II IWP – 0 days. • Perform Phase IIa investigation procurements and commence fieldwork - 60 days following initiation of field activities. • Complete Phase IIa fieldwork components in the following order - 180 days following commencement of fieldwork. o Partial restoration of Phase I standardized grid as necessary and staking of trenches and weighted soil boring locations.

Schedule (cont.)	○ Advance Phase IIa shallow soil borings above weighted trench locations and install single port soil vapor wells. ○ Advance Phase II multi-depth vertical soil borings at 32 locations (24 within the landfill area and eight peripheral), collect chemical and geotechnical soil samples, ship to analytical laboratories, and install single-port and three-port MSVM wells. ○ Perform pilot test to evaluate the feasibility of installing two angled soil borings for a conditional Phase IIb investigation. ○ Develop all single port and three-port MSVM wells. ○ Following an equilibration period of 30 days, purge and collect soil vapor samples from the 700 Area network of MSVM wells and ship to analytical laboratory. ○ Receive all soil analytical, soil vapor analytical, and survey data. • Data compilation, review, and development of draft 700 Area Landfill Phase IIa Investigation Report including internal reviews - 120 days after completion of Phase II fieldwork components and receipt of laboratory and survey data. • NASA Submits Phase IIa 700 Area Landfill Investigation Report to NMED - 360 days after initiation of field activities. • In recognition of budget constraints for FY25, the earliest this investigation can be performed is in FY26. However, this is contingent on the available budget and the status of other corrective action projects. NASA will maintain communication with NMED regarding the corrective action projects and budget, and identify any issues that may affect the scope or schedule of those projects.
References	ASTM International. ASTM Standard D5088-20, (2020). *Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites*, ASTM International, West Conshohocken, PA. Retrieved from www.astm.org City of Albuquerque, (2023, August). *Environmental Health – Landfill & Groundwater Monitoring – Closed KAFB Landfills*. Retrieved from https://www.cabq.gov/environmentalhealth/landfill-groundwater-monitoring/closed-kafb-landfills NASA Johnson Space Center White Sands Test Facility. (1978, October 19). *Application for Registration of Solid Waste Collection, Transportation and Disposal System*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (1991, November 25). *1991 NASA WSTF Solid Waste Management Draft Regulation Review*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2015, November 17). *Transmittal of Class I Permit Modification Request for the NASA White Sands Test Facility (WSTF) Hazardous Waste Permit No. NM8800019434 Attachment 16*. Las Cruces, NM.

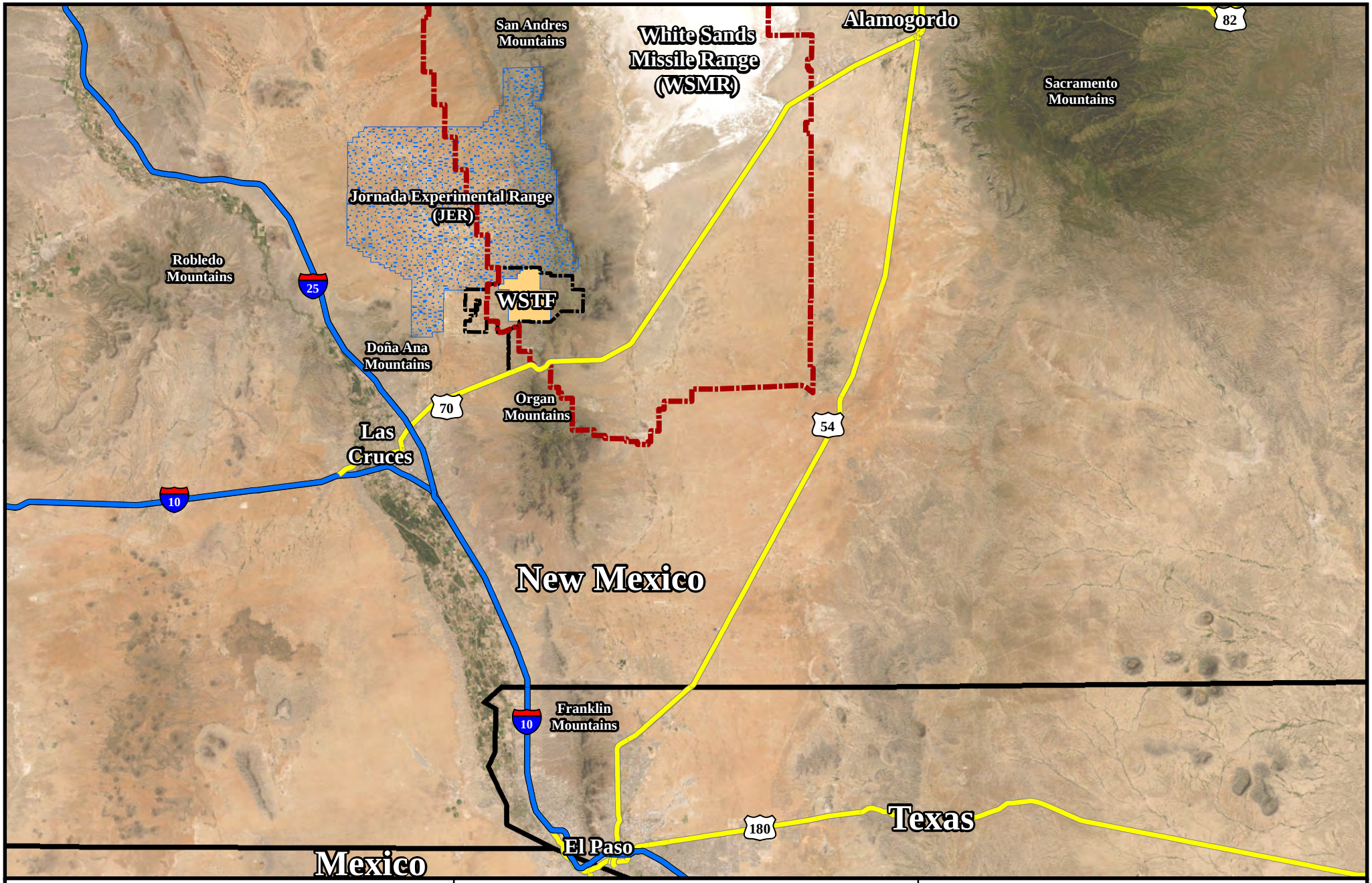
References (cont.)	NASA Johnson Space Center White Sands Test Facility. (2017, December 28). *NASA White Sands Test Facility (WSTF) SWMU 49 (700 Area Landfill) Phase I Investigation Work Plan (IWP) and Historical Information Summary (HIS)*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2019a, March 28). *Response to NMED Disapproval SWMU 49 (700 Area Landfill) Phase I Investigation Work Plan and Historical Information Summary*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2019b, August 8). *Response to NMED Approval with Modifications SWMU 49 (700 Area Landfill) Phase I Investigation Work Plan and Historical Information Summary*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2021a, October 19). *Discussion Relative to the Phase 1A and Phase 1B Soil Vapor Survey (SVS) Component of the Ongoing 700 Area Landfill Phase I Investigation*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2021b, December 21). *Revised Discussion Relative to the Phase IA and Phase IB Soil Vapor Survey (SVS) Component of the Ongoing 700 Area Landfill Phase I Investigation*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2022, April 29). *NASA White Sands Test Facility (WSTF) 700 Area Landfill Closure (SWMU 49) Phase I Investigation Report*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2023, April 27). *NASA WSTF Groundwater Monitoring Plan Update for 2023*. Las Cruces, NM. NMED Hazardous Waste Bureau. (2009, November 3). *Hazardous Waste Permit No. NM8800019434 (modified December 2019)*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2015, December 16). *Administrative Completeness and Fee Assessment Approval with Modifications Transmittal of Class 1 Permit Modification Request*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2018, November 29). *Disapproval SWMU 49, 700 Area Landfill Phase I Investigation Work Plan and Historical Information Summary.* Santa Fe, NM. NMED Hazardous Waste Bureau. (2019, June 6). *Approval with Modifications SWMU 49, 700 Area Landfill Phase I Investigation Work Plan and Historical Information Summary*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2021b, November 12). *Disapproval 700 Area Landfill (SWMU 49) Phase I Investigation Soil Vapor Survey*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2022, February 11). *Approval Revised Discussion Phase IA and Phase IB Soil Vapor Survey (SVS) 700 Area Landfill Phase I Investigation*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2023a, February 10). *Approval 700 Area Closure (SWMU 49) Investigation Report*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2023b, March 28). *RCRA Permit EPA ID # NM8800019434*. Santa Fe, NM.

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Figures

Figure 1 **WSTF Location Map**

(SEE NEXT PAGE)



1 in = 12 miles

0 6 12 24 Miles

N W E S

October 2023

- WSMR Boundary
- WSTF Boundary
- WSTF Industrial Area
- Jornada Experimental Range (JER)

WSTF Location Map

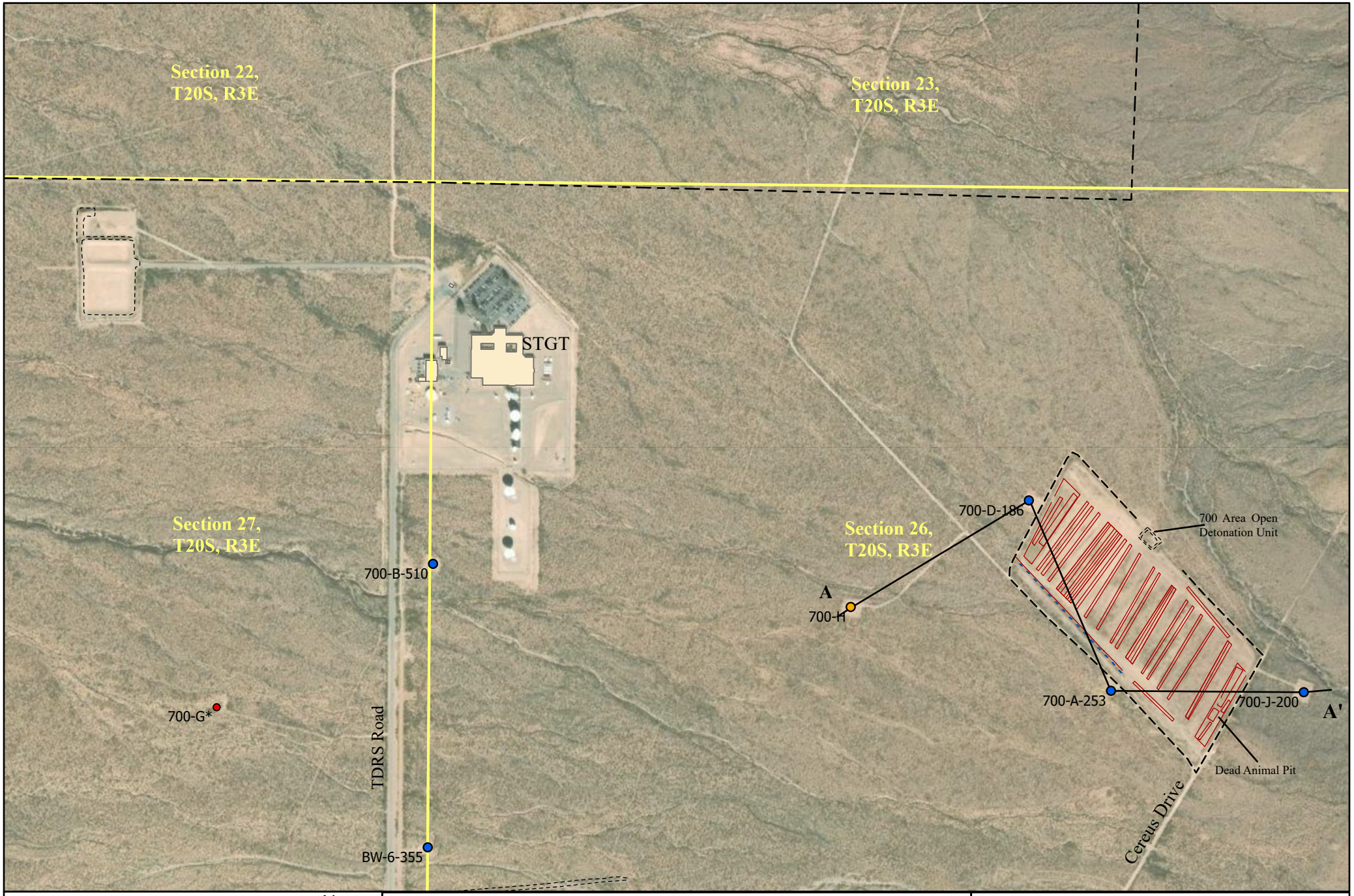
NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

Coordinate System:
NAD 1983 StatePlane New Mexico Central FIPS 3002 Feet

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Figure 2 **700 Area Landfill Location Map**

(SEE NEXT PAGE)



700 Area Landfill Area

NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

Coordinate System:
NAD 1983 HARN StatePlane New Mexico Central FIPS 3002

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Figure 3 **700 Area Landfill Detail**

(SEE NEXT PAGE)

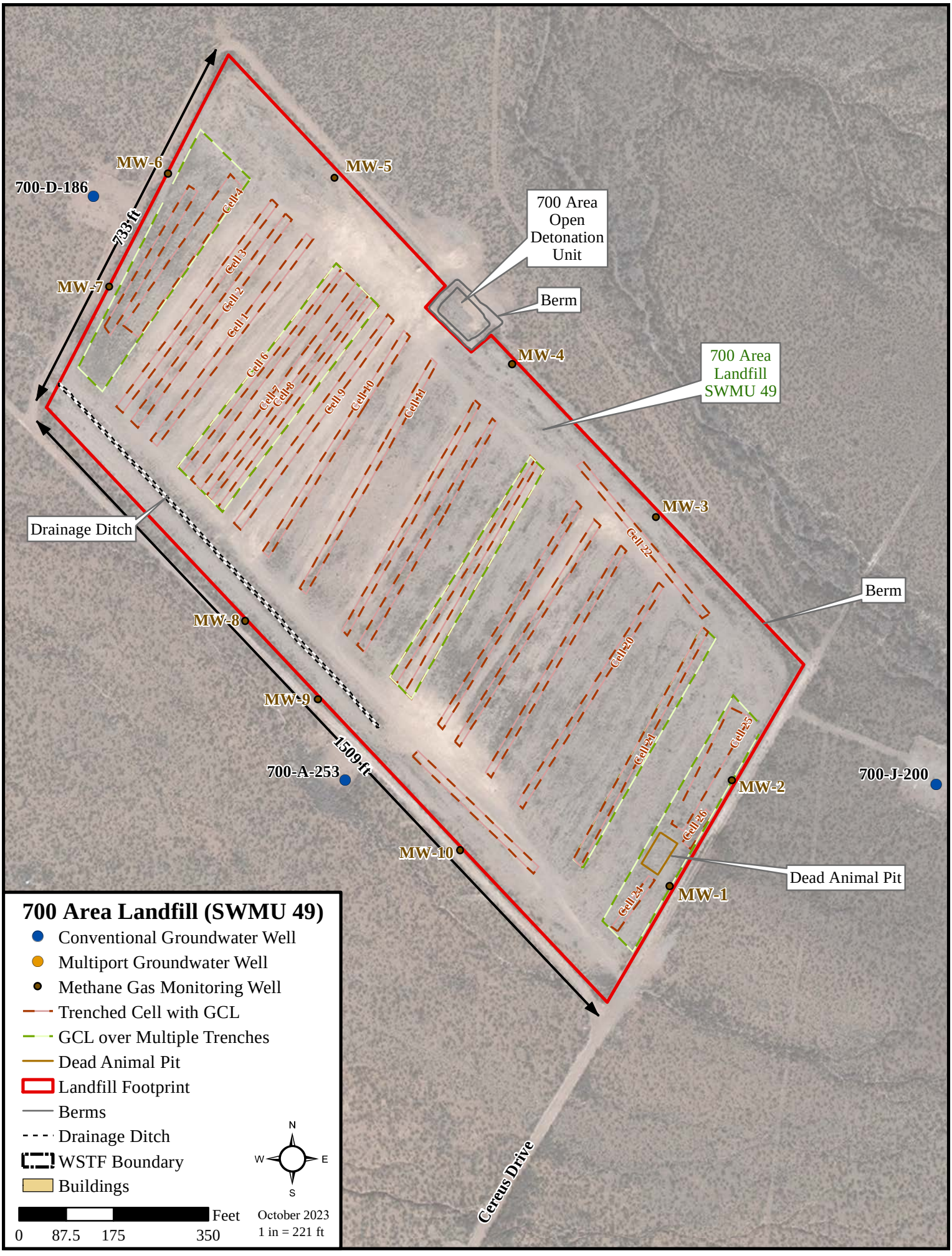

MW-6
MW-5
700-D-186
733 ft
MW-7
700 Area Open Detonation Unit
Berm
MW-4
700 Area Landfill SWMU 49
Cell 4
Cell 3
Cell 2
Cell 1
Cell 6
Cell 7
Cell 8
Cell 9
Cell 10
Cell 11
Drainage Ditch
MW-3
Cell 22
Berm
MW-8
Cell 20
MW-9
1509 ft
Cell 21
Cell 25
700-A-253
MW-2
700-J-200
MW-10
Cell 26
Dead Animal Pit
MW-1
Cell 24
Cereus Drive
700 Area Landfill (SWMU 49)
Conventional Groundwater Well
Multiport Groundwater Well
Methane Gas Monitoring Well
Trenched Cell with GCL
GCL over Multiple Trenches
Dead Animal Pit
Landfill Footprint
Berms
Drainage Ditch
WSTF Boundary
Buildings
N
W
E
S
Feet
0
87.5
175
350
October 2023
1 in = 221 ft

Figure 4 700 Area Landfill Sampling Grid Locations

(SEE NEXT PAGE)

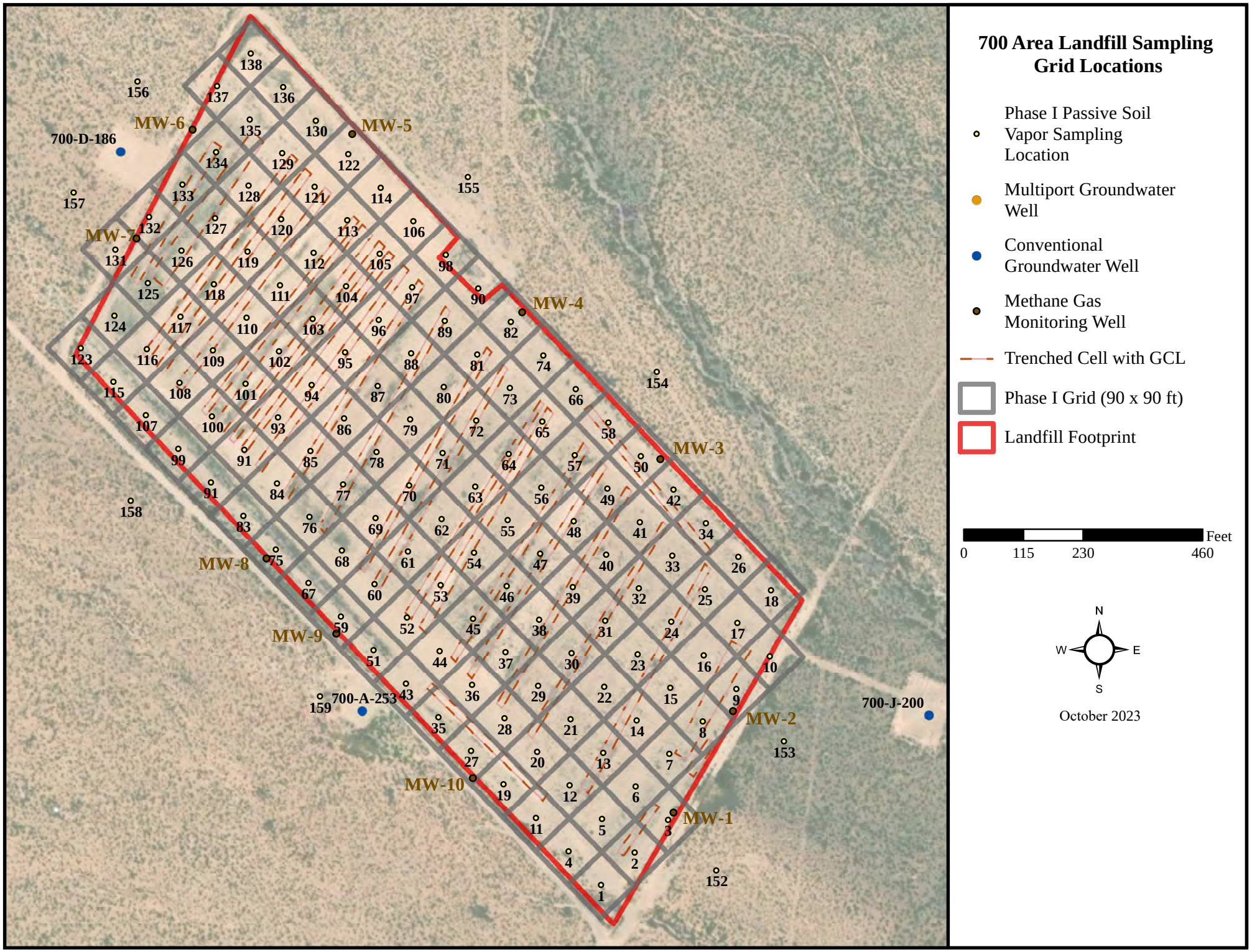

700 Area Landfill Sampling Grid Locations
Phase I Passive Soil Vapor Sampling Location
Multiport Groundwater Well
Conventional Groundwater Well
Methane Gas Monitoring Well
Trenched Cell with GCL
Phase I Grid (90 x 90 ft)
Landfill Footprint
Feet
0
115
230
460
N
W
E
S
October 2023
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
700-D-186
700-A-253
700-J-200

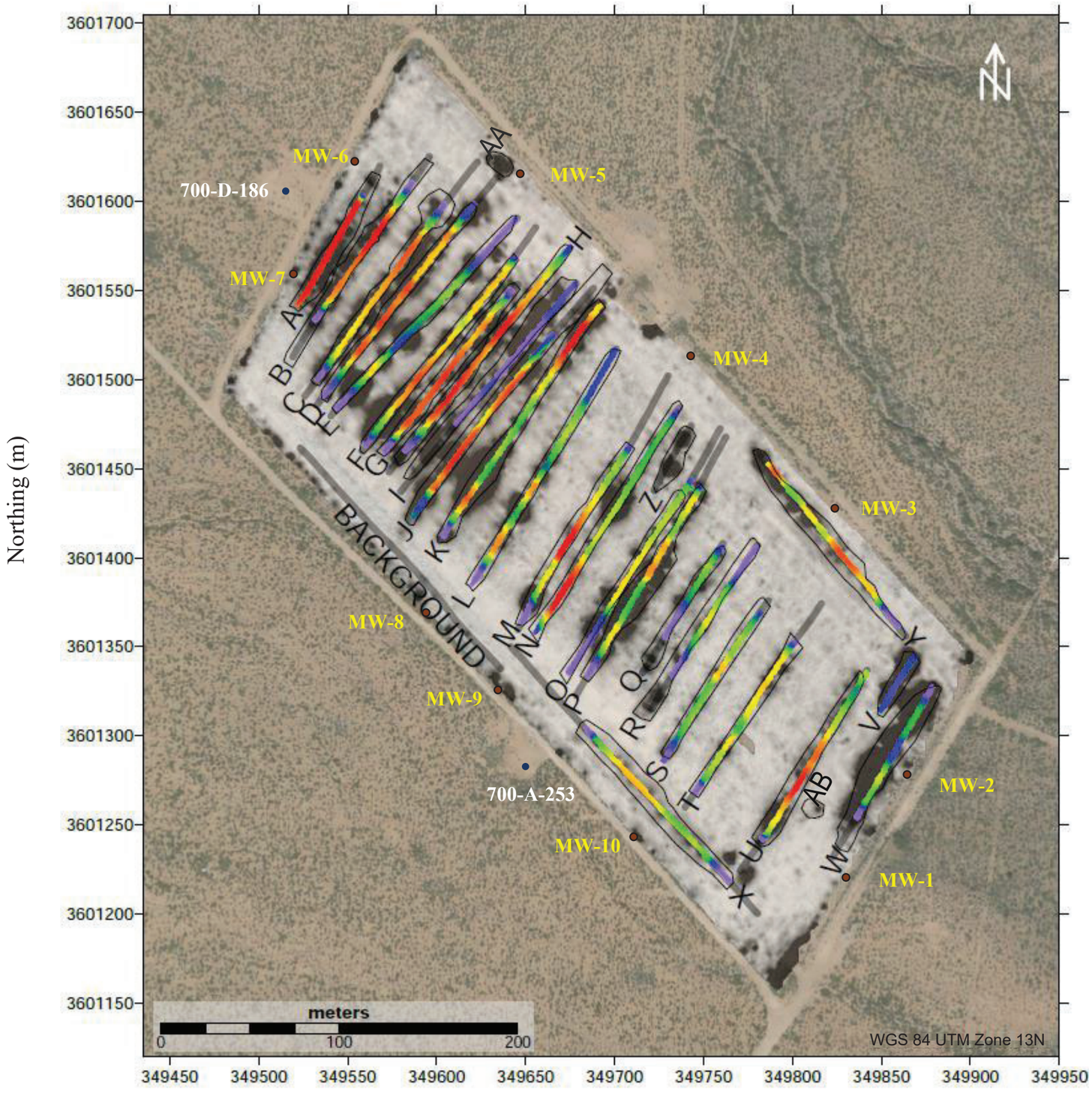
Figure 5 700 Area Landfill Seismic Active Multichannel Analyses of Surface Waves Results

(SEE NEXT PAGE)

Seismic AMASW Results
700 Area Landfill
WSTF

COLLIER GEOPHYSICS	Navarro Research & Engineering, Inc.	
	Project #: 20-167	**FIGURE A7**

Drafted by: J. Pfeiffer Checked by: J. Sheehan **August 2021**



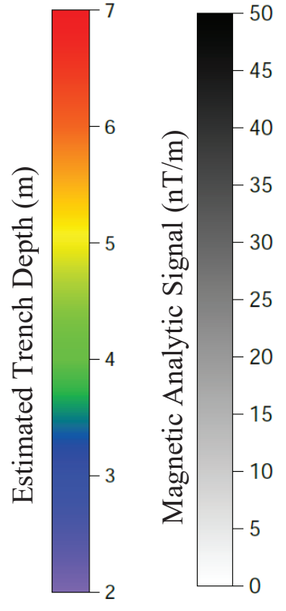
AMASW Line

A — Estimated Trench Outline - based on AMASW, FDEM, and Magnetics

Conventional Groundwater Well

Methane Gas Monitoring Well

Interpreted Trench Depth



October 2023

Figure 6 700 Area Geologic Cross-Section A-A'

(SEE NEXT PAGE)

700 AREA GEOLOGIC CROSS-SECTION A-A'

WEST
A

EAST
A'

700 AREA LANDFILL

700-H
700-D-186
700-A-253
700-J-200

QTcu
To
P

Total Depth - 695' bgs

ELEVATION (FT AMSL)
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500

LEGEND

MONITORING WELLS
- 700-J-200: Monitoring Well
- Well Screen (groundwater Sampling Zone)

GEOLOGY
- QTcu: Camp Rice Formation, Undivided
- To: Orejon Andesite
- P: Paleozoic Rocks, Undifferentiated

STRUCTURE
- Contact Between Geologic Units (dashed Where Inferred)
- D/U: Inferred Fault With Displacement

HYDROGEOLOGY
- Potentiometric Surface (2022)

SCALE

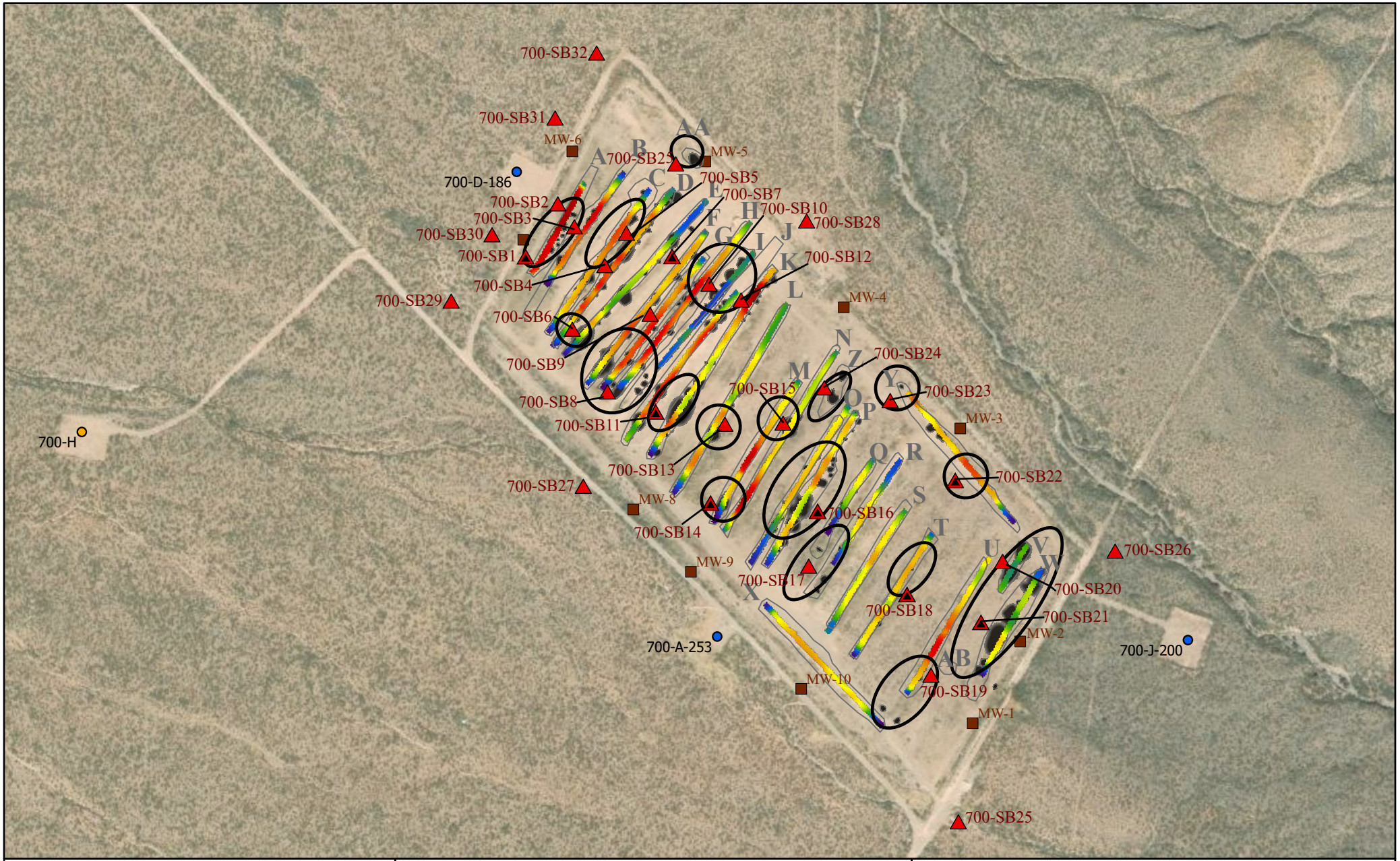
VERTICAL EXAGGERATION = x5

100'
400'

September 2023

Figure 7 **700 Area Proposed Soil Boring Locations**

(SEE NEXT PAGE)



N
W E
S

October 2023
1 in = 300 feet
0 250 500 Feet

- Multi-depth Soil Boring
- Combined Shallow and Multi-depth Soil Boring
- Methane Gas Monitoring Well
- Conventional Monitoring Well
- Multiport Monitoring Well
- Magnetic Anomalies
- Interpreted Trench Boundary

Estimated Trench Depth (ft bgs)
26
22
18
14
10
6
0

Proposed Soil Boring Locations

NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

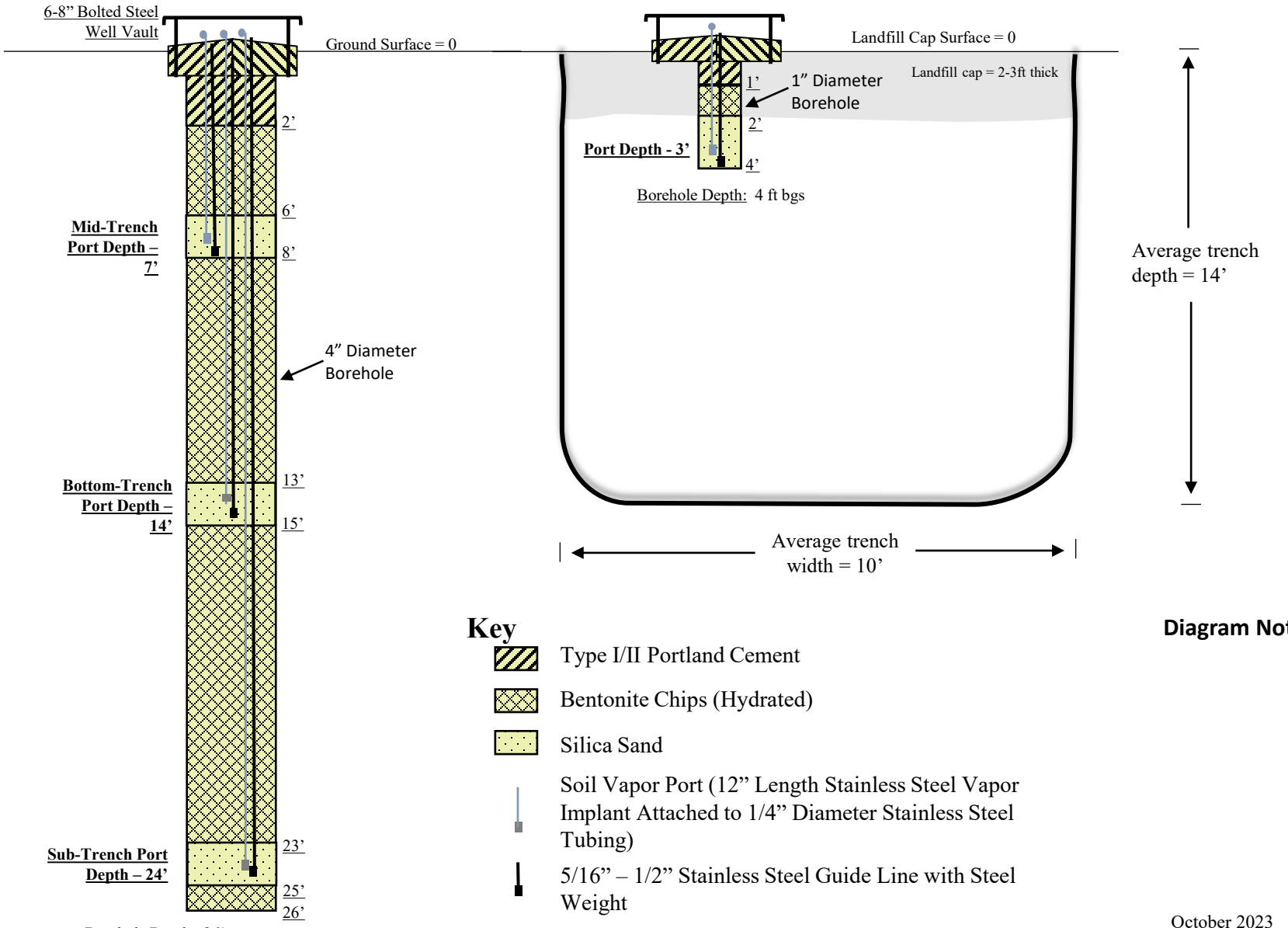
Coordinate System:
NAD 1983 HARN StatePlane New Mexico Cantral FIPS 3002

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Figure 8 General Construction Diagram for 700 Area Landfill Soil Vapor Monitoring Wells

(SEE NEXT PAGE)

General Construction Diagram for 700 Area Landfill Soil Vapor Monitoring Wells



Key

- Type I/II Portland Cement
- Bentonite Chips (Hydrated)
- Silica Sand
- Soil Vapor Port (12" Length Stainless Steel Vapor Implant Attached to 1/4" Diameter Stainless Steel Tubing)
- 5/16" – 1/2" Stainless Steel Guide Line with Steel Weight

Diagram Not to Scale

October 2023

Tables

Table 1 Potential Damage to 700 Area Closure Cap and Protection Strategies

Activity	Potential Damage to Cap	Cap Protection Strategies
All	Minimization	The importance of maximizing the closure cap integrity will be emphasized to all personnel during the project kick-off meeting. This meeting is intended to address health, safety and environmental issues, and project procedures and goals.
Mobilizing drilling equipment onto the cap and movement between soil borings. The drilling rig and associated equipment is estimated to weigh up to 30,000 pounds (total) distributed between the axles of the vehicles.	Drilling equipment tracks or tires may promote disturbance in the form of shallow rutting and potentially damage the surface of the cap.	Strategic progression to each soil boring location including route maps will be used to minimize travel distance of the rig and associated equipment. Protective matting system (DuraDeck or similar) will be used to underlay the drilling equipment to help distribute weight and mitigate rutting effects.
Support vehicle traffic from work crews (pipe truck, forklift, trucks).	Equipment tires may disturb (rut) the surface of the cap.	All support vehicles other than pipe truck and forklift will be parked off the cap unless absolutely necessary to the project. Utilize a strategic advancement plan for equipment on the cap to minimize distance traveled.
Decontamination of drilling and sampling equipment.	Contamination of cap or potential cross-contamination between individual boreholes.	The drilling rig and sampling equipment will be decontaminated upon entering WSTF and the landfill. Impermeable (6 mil) plastic sheeting will be placed under the decontamination areas and bermed. Sampling core barrels will be decontaminated on a temporary decontamination area off of the cap.
Possible fluid leakage from heavy equipment.	Contamination of cap.	Stationary motorized equipment (once located at individual boreholes) will be underlain with impermeable 6 mil (minimum thickness) plastic sheeting with berms. Drilling and downhole equipment will be decontaminated by steam cleaning prior to spudding/re-entry to another borehole.
Drilling soil borings through cap and subsequent MSVM well installation.	Punctures cap.	Drill casing will be retained within the soil borings to prevent collapse until installation of the MSVM well materials. Any annular space between the casing and borehole will be packed and sealed as required. MSVM well design in this AIWP will be reviewed by NMED to ensure that the design provides an effective seal of the cap. Soil borings selected for abandonment will be plugged appropriately in accordance with Permit requirements (NMED, 2023).
Other miscellaneous field activities occurring on cap surface.	Unforeseen damage caused during investigation.	Daily quality assurance/quality control inspections will be performed. Daily reporting and meetings to address improvements in cap protection strategy will be conducted between all personnel as necessary.

Table 2 Soil Boring/MSVM Well Designations, Sample Locations, and Selection Criteria

Soil Boring[1]	Soil Sample Location and Depths (ft bgs)	MSVM Well Ports (ft bgs)	Projected Samples	Location Relative to Trench	Selection Criteria (Trench Age, Depth, Shallow SVS, Magnetic)
700-SB-1	No Sample (Cap) 700-SB1-10[2] 700-SB1-20 700-SB1-30	700-SV1-3 700-SV1-10 700-SV1-20 700-SV1-30	3 soil chemical 4 soil vapor	Trench A (southwest end)	Consistently deep trench, 20' depth
700-SB-2	700-SB2-10 700-SB2-20 700-SB2-30	700-SV2-10 700-SV2-20 700-SV2-30	3 soil chemical 3 soil vapor	Trench A (central)	Consistently deep trench, 20' depth, small magnetic anomalies
700-SB-3	700-SB3-10 700-SB3-20 700-SB3-30[2]	700-SV3-10 700-SV3-20 700-SV3-30	3 soil chemical 3 soil vapor	Trench B (central)	Deep trench, 20' depth, trace 1-2-4 TMB, small magnetic anomalies
700-SB-4	700-SB4-9 700-SB4-18 700-SB4-28	700-SV4-9 700-SV4-18 700-SV4-28	3 soil chemical 3 soil vapor	Trench D (central)	Deep trench, 18' depth, trace F113 and 1,2,4-TMB, larger magnetic anomaly
700-SB-5	700-SB5-8 700-SB5-16[2] 700-SB5-26	700-SV5-8 700-SV5-16 700-SV5-26	3 soil chemical 3 soil vapor	Trench C (northeast half)	Deep trench, 16' depth, trace F113 and 1,2,4-TMB, magnetic anomaly
700-SB-6	700-SB-6-6 700-SB-6-12 700-SB-6-22	700-SV6-6 700-SV6-12 700-SV6-22	3 soil chemical 3 soil vapor	Trench E (southwest end)	Trench 12' depth, trace F113, 1,2,4-TMB, and Chloromethane, larger magnetic anomaly
700-SB-7	No Sample (Cap) 700-SB7-8 700-SB7-15 700-SB7-25	700-SV7-3 700-SV7-8 700-SV7-15 700-SV7-25	3 soil chemical 4 soil vapor	Trench F (northeast half)	Trench, 15' depth, F113 anomaly, trace 1,2,4-TMB
700-SB-8	700-SB8-6 700-SB8-12 700-SB8-22	700-SV8-6 700-SV8-12 700-SV8-22	3 soil chemical 3 soil vapor	Trench H (southwest end)	Trench 12' depth, trace F113, 1,2,4-TMB, 1,3,5-TMB, small magnetic anomaly
700-SB-9	700-SB9-9 700-SB9-18 700-SB-9-28	700-SV9-9 700-SV9-18 700-SV9-28	3 soil chemical 3 soil vapor	Trench G (central)	Deep trench, 18' depth, trace F113, 1,2,4-TMB
700-SB-10	700-SB10-6 700-SB10-12 700-SB10-22[2]	700-SV10-6 700-SV10-12 700-SV10-22	3 soil chemical 3 soil vapor	Trench I (northeast half)	Trench 12' depth, trace F113, 1,2,4-TMB, larger magnetic anomalies
700-SB-11	No Sample (Cap) 700-SB11-9 700-SB11-18 700-SB11-28	700-SV11-3 700-SV11-9 700-SV11-18 700-SV11-28	3 soil chemical 4 soil vapor	Trench K (southwest half)	Deep trench 18' depth, trace F113, 1,2,4-TMB, 1,3,5-TMB, PCE, larger magnetic anomaly
700-SB-12	700-SB12-10 700-SB12-20 700-SB12-30	700-SV12-10 700-SV12-20 700-SV12-30	3 soil chemical 3 soil vapor	Trench K (northeast half)	Deep trench 20' depth, trace 1,2,4-TMB, 1,3,5-TMB, small magnetic anomalies
700-SB-13	700-SB13-9 700-SB13-18 700-SB13-28	700-SV13-9 700-SV13-18 700-SV13-28	3 soil chemical 3 soil vapor	Trench L (central)	Deep trench 18' depth, trace 1,2,4-TMB, 1,3,5-TMB, larger magnetic anomaly
700-SB-14	No Sample (Cap) 700-SB14-7 700-SB14-14 700-SB14-24	700-SV14-3 700-SV14-7 700-SV14-14 700-SV14-24	3 soil chemical 4 soil vapor	Trench M (southwest half)	Trench 14' depth, 1,2,4-TMB anomaly, trace 1,3,5-TMB, larger magnetic anomaly

Soil Boring[1]	Soil Sample Location and Depths (ft bgs)	MSVM Well Ports (ft bgs)	Projected Samples	Location Relative to Trench	Selection Criteria (Trench Age, Depth, Shallow SVS, Magnetic)
700-SB-15	700-SB15-7[2] 700-SB15-14 700-SB15-24	700-SV15-7 700-SV15-14 700-S-15-24	3 soil chemical 3 soil vapor	Trench N (central)	Trench 14' depth, trace F113, larger magnetic anomaly
700-SB-16	No Sample (Cap) 700-SB16-6 700-SB16-12 700-SB16-22	700-SV16-3 700-SV16-6 700-SV16-12 700-SV16-22	3 soil chemical 4 soil vapor	Trench P (central)	Older trench with 12' depth, 1,2,4-TMB and 1,3,5-TMB anomalies, large magnetic anomalies
700-SB-17	700-SB17-5 700-SB17-10 700-SB17-20	700-SV17-5 700-SV17-10 700-SV17-20	3 soil chemical 3 soil vapor	Trench R (southwest half)	Older trench with 10' depth, trace F113, small magnetic anomalies
700-SB-18	No Sample (Cap) 700-SB18-8 700-SB18-16 700-SB18-26	700-SV18-3 700-SV18-8 700-SV18-16 700-SV18-26	3 soil chemical 4 soil vapor	Trench T (central)	Older trench with 16' depth, F113 anomaly, landfill coverage location
700-SB-19	700-SB19-9 700-SB19-18 700-SB19-28	700-SV19-9 700-SV19-18 700-SV19-28	3 soil chemical 3 soil vapor	Trench U (southwest half)	Older deep trench with 18' depth, F113 anomaly, landfill coverage location
700-SB-20	700-SB20-5 700-SB20-10[2] 700-SB20-20	700-SV20-5 700-SV20-10 700-SV20-20	3 soil chemical 3 soil vapor	Trench V (central)	Older trench with 10' depth, F113 anomaly, large magnetic anomaly, landfill coverage location
700-SB-21	No Sample (Cap) 700-SB21-7 700-SB21-14 700-SB21-24	700-SV21-3 700-SV21-7 700-SV21-14 700-SV21-24	3 soil chemical 4 soil vapor	Trench W (central)	Older trench with 14' depth, F113 anomaly, large magnetic anomaly, landfill coverage location
700-SB-22	No Sample (Cap) 700-SB22-9 700-SB22-18 700-SB-22-28[2]	700-SV22-3 700-SV22-9 700-SV22-18 700-SV22-28	3 soil chemical 4 soil vapor	Trench Y (central)	Deep trench 18' depth, F113 anomaly, landfill coverage location
700-SB-23	700-SB23-8 700-SB23-16 700-SB-23-26	700-SV23-8 700-SV23-16 700-SV23-26	3 soil chemical 3 soil vapor	Trench Y (northwest end)	Trench 16' depth, F113 anomaly, landfill coverage location
700-SB-24	700-SB24-5 700-SB24-10 700-SB24-20	700-SV24-5 700-SV24-10 700-SV24-20	3 soil chemical 3 soil vapor	Trench Z (central)	Trench 10' depth, larger magnetic anomaly, landfill coverage
700-SB-25	700-SB25-7 700-SB25-14 700-SB25-24[2]	700-SV25-7 700-SV25-14 700-SV25-24	3 soil chemical 3 soil vapor	Peripheral (upgradient)	Assumes average trench depth of 14 ft, upgradient background
700-SB-26	700-SB26-7 700-SB26-14 700-SB26-24	700-SV26-7 700-SV26-14 700-SV26-24	3 soil chemical 3 soil vapor	Peripheral (upgradient)	Assumes average trench depth of 14 ft, upgradient background
700-SB-27	700-SB27-7 700-SB27-14 700-SB27-24	700-SV27-7 700-SV27-14 700-SV27-24	3 soil chemical 3 soil vapor	Peripheral (southwest side)	Assumes average trench depth of 14 ft, southwest side background
700-SB-28	700-SB28-7[2] 700-SB28-14 700-SB28-24	700-SV28-7 700-SV28-14 700-SV28-24	3 soil chemical 3 soil vapor	Peripheral (northeast side)	Assumes average trench depth of 14 ft, northeast side background
700-SB-29	700-SB29-7 700-SB29-14 700-SB29-24	700-SV29-7 700-SV29-14 700-SV29-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background

Soil Boring[1]	Soil Sample Location and Depths (ft bgs)	MSVM Well Ports (ft bgs)	Projected Samples	Location Relative to Trench	Selection Criteria (Trench Age, Depth, Shallow SVS, Magnetic)
700-SB-30	700-SB30-7[2] 700-SB30-14 700-SB30-24	700-SV30-7 700-SV30-14 700-SV30-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background
700-SB-31	700-SB31-7 700-SB31-14 700-SB31-24	700-SV31-7 700-SV31-14 700-SV31-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background
700-SB-32	700-SB32-7 700-SB32-14 700-SB32-24	700-SV32-7 700-SV32-14 700-SV32-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background
Totals			**96 soil chemical 104 soil vapor**		

Notes:

[1] Refer to Figure 7 for soil boring locations.

[2] Geotechnical soil sample location (collected at a rate of 10%).

Field duplicates shall be collected at a rate of 10%.

Equipment blanks shall be collected from all sampling apparatus at a frequency of 10% for chemical analysis.

Equipment blanks shall be collected at a frequency of one per day if disposable sampling equipment is used.

Field blanks shall be collected at a frequency of one per day for each media.

Reagent blanks shall be used if chemical analytical procedures requiring reagents are employed.

Table 3 List of COPCs with Chemical Analytical Method for Soil Samples

Constituent	Sample Type	Analytical Method
Cyanide	CYANIDE	SW-846 Method 9012A
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)[1]	Dxns/Frns	SW-846 Method 8290
Hydrazine	HYDRAZINE	SW-846 Method 8315A M
Aluminum	METALS	SW-846 Method 6010C
Antimony	METALS	SW-846 Method 6010C
Arsenic	METALS	SW-846 Method 6010C
Barium	METALS	SW-846 Method 6010C
Beryllium	METALS	SW-846 Method 6010C
Boron	METALS	SW-846 Method 6010C
Cadmium	METALS	SW-846 Method 6010C
Calcium	METALS	SW-846 Method 6010C
Chloride	ANION	EPA Method 300.0
Fluoride	ANION	EPA Method 300.0
Phosphorus	ANION	EPA Method 300.0
Sulfate	ANION	EPA Method 300.0
Chromium (Total)	METALS	SW-846 Method 6010C
Chromium (VI)	METALS	SW-846 Method 7199
Cobalt	METALS	SW-846 Method 6010C
Copper	METALS	SW-846 Method 6010C
Lead	METALS	SW-846 Method 6010C
Mercury	METALS	SW-846 Method 7471B
Molybdenum	METALS	SW-846 Method 6010C
Nickel	METALS	SW-846 Method 6010C
Selenium	METALS	SW-846 Method 6010C
Silver	METALS	SW-846 Method 6010C
Strontium	METALS	SW-846 Method 6010C
Thallium	METALS	SW-846 Method 6010C
Tin	METALS	SW-846 Method 6010C
Vanadium	METALS	SW-846 Method 6010C
Zinc	METALS	SW-846 Method 6010C
N-Nitrodimethylamine	NDMA	EPA Method 607M
N-Nitrosodimethylamine	NDMA	EPA Method 607M
Nitrate	NITROGEN	EPA Method 300.0
Nitrite	NITROGEN	EPA Method 300.0
Perchlorate	PERCHLORATE	EPA Method 331.0M

Constituent	Sample Type	Analytical Method
Bis(2-ethylhexyl) Phthalate	SVOA	SW-846 Method 8270D
Di-n-butyl Phthalate	SVOA	SW-846 Method 8270D
Naphthalene	SVOA	SW-846 Method 8270D
1,1,1-Trichloroethane	VOA	SW-846 Method 8260C
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC 113)	VOA	SW-846 Method 8260C
1,1-Dichloroethane	VOA	SW-846 Method 8260C
1,1-Dichloroethene	VOA	SW-846 Method 8260C
1,2-Dichloroethane	VOA	SW-846 Method 8260C
2-Butanone (MEK)	VOA	SW-846 Method 8260C
Acetone	VOA	SW-846 Method 8260C
Acrilonitrile	VOA	SW-846 Method 8260C
Bromodichloromethane	VOA	SW-846 Method 8260C
Bromoform	VOA	SW-846 Method 8260C
Bromomethane	VOA	SW-846 Method 8260C
Chlorobenzene	VOA	SW-846 Method 8260C
Chloroform	VOA	SW-846 Method 8260C
Chloromethane	VOA	SW-846 Method 8260C
Dibromochloromethane	VOA	SW-846 Method 8260C
Dichlorodifluoromethane (CFC 12)	VOA	SW-846 Method 8260C
Methyl tert-Butyl Ether	VOA	SW-846 Method 8260C
Methylene Chloride	VOA	SW-846 Method 8260C
m-Xylene & p-Xylene	VOA	SW-846 Method 8260C
Styrene	VOA	SW-846 Method 8260C
Tetrachloroethene (PCE)	VOA	SW-846 Method 8260C
Toluene	VOA	SW-846 Method 8260C
trans-1,2-Dichloroethene	VOA	SW-846 Method 8260C
Trichloroethene (TCE)	VOA	SW-846 Method 8260C
Trichlorofluoromethane (CFC 11)	VOA	SW-846 Method 8260C
Vinyl Chloride	VOA	SW-846 Method 8260C
Explosive Residues[2]	Nitroaromatics	EPA Method 8330b
Polyfluoroalkyl and Perfluoroalkyl Substances[3]	PFAS	EPA Method 1633
Total Petroleum Hydrocarbons[4]	TPH	SW-846 Method 8015C or best method available
Polychlorinated Biphenyls	PCB	SW-846 Method 8082A

Notes:
[1] – Dioxins and furans will be evaluated in accordance with the RA Guidance (NMED, 2022) Section 2-1. The 17 dioxin and furan congeners listed in Table 2.1 of the RA Guidance will be analyzed by the listed method and

evaluated by application of toxicity equivalency factors to determine the toxicity equivalent quotient that will be compared with the established screening levels for 2,3,7,8-TCDD.

[2] – Explosive constituents analyzed using EPA Method 8330b includes 17 constituents. NASA will evaluate all constituent concentrations using NMED SSLs or EPA RSLs as required by the RA Guidance.

[3] - Polyfluoroalkyl and Perfluoroalkyl Compounds (PFAS) will be evaluated in accordance with the RA Guidance (NMED, 2022) Section 5.4. The 24 PFAS constituents listed in Table 5-2 of the RA Guidance will be analyzed by the listed method and evaluated using established NMED or EPA screening levels.

[4] – Total Petroleum Hydrocarbons (TPH) analyses will include analyses of gasoline range organics, diesel range organics, and oil range organics by the listed method and the results will be evaluated using established NMED or EPA screening levels.

Comments for Approval with Modifications of 700 Area Landfill Closure (SWMU 49) Phase II AIWP

NMED Comment Number	NMED Comments	NASA Revisions/Responses/Discussion
1. Phase IIb Soil Borings, Pages 9 and 10	**NMED Comment:** The SWMU 49 historical information summary indicated that drums, containers, and liquid containing trichlorofluoromethane, 1,1,2-trichloro-1,2,2-trifluoroethane, and trichloroethylene were likely disposed of at the landfill prior to the inception of the RCRA program. Detections of these primary White Sands Test Facility (WSTF) volatile organic compounds have been detected in groundwater samples collected at SWMU 49 adjacent monitoring wells 700-A-253 (cross-gradient) and 700-D-186 (down- gradient) at low levels suggesting a release from the landfill has reached groundwater. Therefore, should the angle boring pilot test planned for investigation Phase IIa fail, and if contamination is present beyond the extent of the proposed boring termination depths, vertical borings must be advanced, and samples collected, at least five feet below the deepest detected contamination to meet the March 2023 *WSTF RCRA Hazardous Waste Permit* (Permit), Section 4.2.3.1, Drilling, minimum requirements for site characterization. Necessary sampling for vertical delineation of subsurface contamination encountered may be collected at locations that will maintain the existing integrity of the landfill at locations most likely to yield the most representative site characterization data. Revise the Work Plan to address this comment and provide any necessary revised replacement pages.	NASA revised Phase IIb, Soil Borings to satisfy the Permit requirement for vertical delineation of identified site contamination should the pilot testing of the feasibility of installing angled borings prove unsuccessful. The revision discusses installation of vertical borings with the objective of collecting soil samples from a minimum depth of 5 feet below contamination identified by the Phase IIa investigation.
2. Table 3, List of COPCs [Contaminants of Potential Concern] with	**NMED Comment:** The following comments must be addressed: a. SWMU 49 Historical Information Summary Section 7.8.2, Spills Reports, includes information	a. NASA revised Table 3 to add both total petroleum hydrocarbons analyses by SW-846 Method 8015C or best method available to provide results for gasoline range, diesel range, and oil range organics in soil samples.

NMED Comment Number	NMED Comments	NASA Revisions/Responses/Discussion
Chemical Analytical Method for Soil Samples, Pages 32 through 34	on multiple occurrences of the disposal of petroleum contaminated soil, spill absorbent, and other petroleum containing materials at the landfill. To address this the sample analysis schedule must be revised to include total petroleum hydrocarbons as COPCs and soil samples must be analyzed for gasoline range organics, diesel range organics, and oil range organics. The soil sample chemical analysis schedule must be revised accordingly, and a revised replacement table provided. b. SWMU 49 Historical Information Summary Section 7.9, Polychlorinated Biphenyls [PCB], discussion indicates that prior to 1980 PCB containing materials such as florescent light ballasts, electrical equipment, and other PCB laden materials may have been disposed at the 700 Area landfill. Based on this information, Table 3 must be revised to include PCBs as COPCs, and the sampling schedule revised to include soil sample chemical analysis for PCBs, and a replacement table provided. c. If per-and polyfluoroalkyl substances (PFAS) are detected in proposed soil samples, groundwater samples at 700 Area Landfill monitoring wells must be collected and analyzed for PFAS. Any necessary additional sampling must be addressed in the Phase II investigation report recommendations. No revisions to the Work Plan are required in response to this comment.	b. NASA also revised Table 3 to include PCB constituents as COPCs for analysis by SW-846 Method 8082A. c. NASA revised Table 3 to correct the analytical method for PFAS as EPA Method 1633, as the EPA finalized Method 1633 in January 2024. NASA understands that if PFAS are detected in proposed soil samples, groundwater samples at 700 Area Landfill monitoring wells must be collected and analyzed for PFAS. Any necessary additional sampling will be addressed in the Phase II investigation report recommendations. No revisions to the Work Plan were completed in response to this comment.

700 Area Landfill Closure (SWMU 49) Phase II Abbreviated Investigation Work Plan

Introduction	This abbreviated investigation work plan (AIWP) describes the approach for a Phase II investigation of the 700 Area Landfill at the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF; Figure 1). The Phase II AIWP is provided in accordance with the requirements of *700 Area Landfill Closure (SWMU 49) Phase I* (Phase I) *Investigation Report* (IR) submitted to the New Mexico Environment Department (NMED) on April 29, 2022 (NASA, 2022) and approved on February 10, 2023 (NMED, 2023a). The WSTF 700 Area Landfill is identified as solid waste management unit (SWMU) 49 in the Resource Conservation and Recovery Act (RCRA) Permit (Permit; NMED, 2023b). The landfill began operation between 1963 and 1965; the last waste was received on October 27, 1997. The specific wastes and their quantities disposed of in the landfill are not well documented, although evidence of the nature of the waste is available in spill reports and employee interviews for the deposition of hazardous substances (historical information summary [HIS]; NASA, 2017). The landfill was designed to contain solid waste for disposal within excavated cells or trenches and has previously been described as a "modified landfill" (NASA, 1978), a sanitary landfill, and a "Class B landfill," which was "a sanitary landfill serving a population of less than 3,000" (NASA, 1991). The 700 Area Landfill is located in Section 26, Township 20 South, Range 3 East within the remote northeast part of WSTF (Figure 2) and is a 24-acre trapezoid-shaped piece of land with the long axis-oriented northwest-southeast. Access to the 700 Area is provided by gravel roads (Road P and Cereus Drive) from Apollo Boulevard, the main paved access road through WSTF. The Second Tracking and Data Relay Satellite Ground Terminal located approximately a half-mile to the west northwest of the landfill represents the most proximal facility. Design and operational details for the landfill are provided in the HIS (NASA, 2017). The only structures present in the immediate vicinity of the 700 Area Landfill include conventional and multiport groundwater monitoring wells located upgradient and downgradient of the landfill and methane gas monitoring wells inside the landfill perimeter (Figure 3). A total of 26 original cells were documented at the landfill based on historical photographs, personnel interviews, and surface topographic features. Trenches were initially excavated at the southeast side of the landfill close to the entrance on the southeast side and moved progressively northwest. The Closure cap cover is generally 2 to 3 feet (ft) in total thickness and includes a geosynthetic clay liner (GCL) located above the trenches inserted between 2 inches (in.) of select fill (screened to one quarter inch and less in diameter) above and below to prevent any large rocks from damaging its integrity. The base of the cap consists of a minimum 10-in. layer of compacted local fill that is covered by the select fill and GCL. The select fill is overlain by a minimum of 10-in. of uncompacted screened local material (topsoil) to complete the cap (NASA, 2017). The Phase I IR (NASA, 2022) includes a summary of the 700 Area Landfill

Introduction (cont.)	background including operational history, potential wastes, previous monitoring results, a preliminary site conceptual exposure model, exposure pathways, and potential receptors.
Regulatory Background	NASA is currently implementing Post-Closure Care (PCC) requirements at the 700 Area Landfill in accordance with the PCC plan submitted to and approved by the NMED Solid Waste Bureau (SWB) on August 22, 1997. At the same time and specific to subsequent investigation of the landfill, the WSTF RCRA Permit (NMED, 2023, p81) requires the development and submission of an investigation work plan (IWP) that addresses the projected work to be performed. Initially, the due date for submittal of the IWP for the 700 Area Landfill was December 30, 2015 (NMED, 2009). On November 17, 2015, NASA submitted a *Class 1 Permit Modification Request* (NASA, 2015) to the NMED HWB requesting a new due date for submittal of the IWP and HIS of December 29, 2017. NMED approved the Permit Modification Request on December 16, 2015 (NMED, 2015). NASA submitted the *NASA WSTF SWMU 49 (700 Area Landfill) Phase I IWP and HIS* on December 28, 2017 (NASA, 2017), which was disapproved by NMED on November 29, 2018 (NMED, 2018). NASA submitted the *Response to NMED Disapproval SWMU 49 (700 Area Landfill) Phase I IWP and HIS* on March 28, 2019 (NASA, 2019a) and received NMED's *Approval with Modifications SWMU 49 (700 Area Landfill) Phase I IWP and HIS* on June 6, 2019 (NMED, 2019). NASA responded to the Approval with Modifications on August 8, 2019 (NASA, 2019b). On October 19, 2021, NASA submitted a *Discussion Relative to the Phase IA and Phase IB Soil Vapor Survey (SVS) Component of the Ongoing 700 Area Landfill Phase I Investigation* (NASA, 2021a). NMED responded with the *Disapproval 700 Area Landfill (SWMU 49) Phase I Investigation Soil Vapor Survey* on November 12, 2021 (NMED, 2021). NASA submitted the *Revised Discussion Relative to the Phase IA and Phase IB SVS Component of the Ongoing 700 Area Landfill Phase I Investigation* on December 21, 2021 (NASA, 2021b), which was approved by NMED on February 11, 2022 (NMED, 2022). NASA conducted the Phase I field investigation between September 2019 and March 2022 and incorporated shallow soil vapor survey (SVS) and surficial geophysical survey techniques to provide improved conceptualization of the 700 Area Landfill. The *700 Area Closure (SWMU 49) Phase I Investigation Report (IR)* was submitted to NMED on April 29, 2022 (NASA, 2022) and approved on February 10, 2023 (NMED, 2023a).
Phase I Investigation	The 700 Area Closure Phase I investigation (NASA, 2022) provided additional information on the 26 individual trenches originally identified in the HIS (NASA, 2017). The SVS provided an improved conceptualization of the 700 Area Landfill by providing the distribution of volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPH) in soil vapor of the shallow vadose zone. The geophysical surveys collectively provided information relative to the dimensions of each of the waste disposal trenches, the location of metallic waste within the

Phase I Investigation (cont.)	trenches, and subsurface geology with respect to the alluvial-bedrock interface at a depth. The Phase I investigation extended across the 700 Area Landfill and adjacent surrounding areas. The primary target area was traversed by a standardized field survey grid (Figure 4) constructed using 90-foot (ft) x 90-ft grid cells as the base grid for the shallow SVS survey and suite of four geophysical surveys comprising: electromagnetic induction (EMI), vertical magnetic gradiometry (VMG), active multichannel analyses of surface waves (AMASW; used to replace ground penetrating radar); and an enhanced passive seismic survey (PSS). Individual geophysical survey line spacings using the standardized grid varied, and the final traverse lines for each survey were developed at the recommendation of the geophysical subcontractors. Phase I was focused on the upper 20 to 25 ft of the vadose zone that incorporated the individual landfill trenches. The qualitative shallow SVS was used to map the distribution of soil vapor VOCs and TPH in the shallow subsurface across the 700 Area Landfill and adjacent areas in the low nanogram (ng; one billionth of a gram) range. Passive sampling modules were set at the nodes of the 90-ft x 90-ft grid cells and were suspended in shallow soil borings for 15 days at depths of 25 to 30 in. below the depth of the low conductivity GCL. For comparative purposes, modules were also suspended inside the casing of 10 screened methane monitoring wells and three groundwater monitoring wells (Figure 3). A sparse distribution of low concentrations for contaminants of potential concern (COPC) near the limit of quantitation for the majority the Environmental Protection Agency (EPA) 8260C compounds restricted the ability to achieve the original objectives of the survey. Summaries of the shallow SVS results for COPCs were presented as isoconcentration maps for six analytes selected based on either frequency of detection and/or significance relative to the known list of COPCs present at the 700 Area Landfill (NASA, 2019a). These comprised: 1,1,2-trichlorotrifluoroethane (Freon®[1] 113); 1,2,4-trimethylbenzene; 1,3,5-trimethylbenzene; chloromethane; tetrachloroethene (PCE); and trichloroethane (TCE). Qualitative passive shallow soil vapor concentration maps are provided in the Phase I IR (NASA, 2022). The qualitative shallow SVS distributions for the six analytes did not identify a significant number of elevated concentrations across the footprint of the landfill trenches. The highest concentrations were typically associated the SVS modules suspended within the inside of monitoring well casings that were directly exposed to vapor above contaminated groundwater. Freon 113 and TCE concentrations in soil vapor were inferred to be related to a groundwater volatilization origin. The EMI survey was performed to establish spatial distribution of soil conditions within the landfill; the AMASW survey to delineate the dimensions of landfill trenches; and the VMG survey to locate and map the distribution of metallic objects. Individual survey grids were developed by the geophysical subcontractor during the planning phase for each field survey. The fourth geophysical survey

[1] Freon is a registered trademark of The Chemours Company FC, LLC.

Phase I Investigation (cont.)	comprised a PSS that was used to improve characterization of the deeper vadose zone including the bedrock surface below the landfill. The EMI, VMG, and AMASW geophysical surveys confirmed the presence and dimensions of all but one of the previously documented 26 trenches. Correlation with geographic information system map data of the landfill trenches, provided in the original HIS (NASA, 2017) was strong, which yielded a high degree of confidence in the results obtained. Updated lateral trench extents and depths were well represented by the AMASW survey data that was coupled with the magnetic data from the EMI and VMG surveys for comprehensive representation of the data (Figure 5). Confirmed landfill trenches were labeled A through Y with three additional depressions identified as Z, AA, and AB. Trenches were generally located subparallel to each other in a northeast-southwest direction and had typical dimensions of approximately 12 to 22 ft (depth) x 20 ft (width) x 300 to 600 ft (length). Two trenches were oriented northwest-southeast (X and Y), and two trenches were significantly smaller in length (V and Z at approximately 50 ft). In addition to the shallow vadose zone investigation, the alluvial-bedrock interface at depths between 110 ft and 180 ft below ground surface (bgs) was evaluated using the enhanced PSS and integrated with known depths from monitoring well boreholes. The strike of previously inferred faults below the landfill footprint based on borehole data generally aligns with the change in depth to bedrock observed in the interpreted PSS results.
Purpose	The purpose of the Phase II investigation is to perform a subsurface investigation to below the depth of the landfill trenches and adjacent shallow vadose zone of the 700 Area landfill through the installation of soil borings, soil chemical and geotechnical sampling and analysis, MSVM well installation, and soil vapor chemical sampling and analysis. Groundwater chemical sampling and analysis will be evaluated using the existing monitoring well network. Phase II will provide quantitative analytical results relative to the distribution of VOCs, semi-volatile organic compounds, and other analytes historically associated with landfill activities in the subsurface (NASA, 2017). The investigation will allow evaluation of the concentrations of specific COPCs that may be present in the 700 Area Landfill. Quantitative soil, groundwater, and soil vapor analytical data will also support determination of the nature and extent of any contamination identified and the potential pathways of releases to soil or groundwater. Once quantified analytical data have been received and validated, these data will be evaluated in accordance with procedures detailed in the Risk Assessment (RA) Guidance to support the characterization of site risk to human and ecological receptors and to the environment. Characterization of the risk will support conclusions presented in the IR and decisions regarding follow-on activities. Corrective action activities for the 700 Area landfill will be determined following submittal and NMED review of the Phase II IR. In the interim, NASA will continue with ongoing PCC activities until a final resolution for the landfill is determined based on evaluation of the collective results from the Phase I and

Purpose (cont.)	Phase II investigations and determination of site risk in accordance with the site RA Guidance. Comparable investigation approaches (geophysical surveys, shallow soil vapor surveys, soil sample geochemical and geotechnical analysis, groundwater sampling and analysis, soil vapor sampling and analysis) have been used to evaluate other landfills in New Mexico (e.g., City of Albuquerque, 2023). The final resolution will determine the path forward with respect to future disposition of the landfill. Projected strategies may potentially include: • The excavation and removal (with soil backfill) of any hazardous material identified and transport off-site to approved disposal facilities; • Application for landfill closure per NMED approval with no further action (NFA) status; or • Long Term Monitoring (LTM) under NMED guidance with or without Closure cap modification. The network of groundwater and MSVM wells projected to be in place following the Phase II investigation will allow detailed monitoring of concentrations in groundwater and soil vapor with respect to NMED regulatory criteria.
Geology and Hydrology	The 700 Area Landfill is located in soils composed of coalescent alluvial fans locally dissected by small drainages at surface in an area between 4,800 to 5,000 ft above mean sea level in elevation. The relatively flat topography is typical the western pediment of the San Andres Mountains (SAM). The surface elevation decreases from east to west moving down topographic gradient from the SAM into the southern Jornada del Muerto Basin. The shallow dissecting drainages up to a few feet in depth flow during periods of heavy rainfall and primarily trend east to west in accordance with the local surface gradient (Figure 2). The surface geology consists of Quaternary piedmont slope facies of the Camp Rice Formation, part of the widespread upper Santa Fe Group alluvium (Seager, 1981) derived from the adjacent SAM. The piedmont slope alluvial deposits originated from Bear Canyon, a major east-west-trending transverse canyon in the southern SAM located 1 mile (mi) to the east southeast of the landfill. Alluvium comprises of coarse and variably sized gravel clasts within a sand, silt, and clay matrix. Alluvium is primarily unconsolidated, poorly sorted, and locally contains discontinuous cemented caliche horizons up to a few inches in thickness. The closest bedrock outcrops are located to the east southeast in the Bear Canyon area and comprise Pennsylvanian to Permian age limestone, sandstone, siltstone, and shale. Subsurface bedrock lithologies at a depth in the vicinity of the 700 Area Landfill comprise Permian Hueco Limestone and Tertiary Orejon Andesite. Two styles of geologic deformation are present (Seager, 1981). The older and less prevalent deformation consists of west to northwest-trending folding and faulting associated with the Late Cretaceous to Early Tertiary Laramide Orogeny. This compressional deformation is present to the east southeast in Bear Canyon in the Bear Peak Fold and Thrust Zone. Thrust faults of the Bear Peak Fold and Thrust zone are interpreted to extend northwestward along strike in the subsurface and pass north of the northern boundary of the landfill. The second more recent deformational style consists of extensional northwest-trending Late Tertiary Basin

Geology and Hydrology (cont.)	and Range normal faulting. Basin and Range normal faulting that commenced between 26 and 32 million years ago continues to the present. Line of cross-section A-A' is identified in Figure 2 and provided in Figure 6. The local bedrock forms an eroded surface based on existing borehole lithological and geophysical data that decreases in elevation and increases in depth below ground surface from east to west across the landfill from 110 ft (well 700-J-200) to 180 ft (well 700-D-186) in the direction of dip of the pediment slope. Subsurface normal faults in the vicinity of the landfill have been inferred from seismic reflection data, PSS data, and borehole lithologic and geophysical logs (NASA, 2022). Two inferred northwest-striking normal faults are located in bedrock in the vicinity of the landfill with displacements of approximately 50 ft that downfault a small block of Orejon Andesite into Hueco Limestone at depth. Limestone is located on the northeast and southwest sides of the fault block (intercepted by wells 700-J-200 and 700-D-186, respectively). Adjacent and to the west of the landfill, a third normal fault (potentially the extension of the Hardscrabble Hill Fault) significantly drops the Paleozoic limestone to depth below the base of well 700-H installed in andesite by at least 530 ft as indicated by the thickness of andesite intercepted. The subsurface normal faults may be related to an early period of extensional basin-range faulting, with beveling of the surface before deposition of the alluvium. The local aquifer is hosted within the Hueco Limestone and Orejon Andesite bedrock, typically at a depth of 30 ft below the bedrock surface. There is little to no primary porosity in the bedrock and groundwater flow is within secondary bedding solution channels and fractures within the limestone, and secondary fractures within the andesite. Monitoring wells in the vicinity of the 700 Area Landfill (700-J-200, 700-A-253, 700-D-186, 700-H, and 700-B-510; Figure 6) are screened below the static potentiometric surface in order to maximize groundwater flow from fractured zones. The wells are conventional single screen wells and are located in the uppermost aquifer with the exception of 700-H, which consists of three Westbay®[2] sampling ports designed for vertical characterization along a deeper aquifer profile. The details of these well construction designs are discussed in the site-wide Groundwater Monitoring Plan (NASA, 2023). Groundwater flow is from east to west based on groundwater depth measurements with relatively steep groundwater gradient of 0.1 ft/ft and a velocity of 0.3 to 1.6 ft per day (NASA, 2022). The volume of flow in bedrock is restricted based on low hydraulic conductivities within the aquifer determined from slug testing at monitoring wells 700-H and 700-B-510, and a dry borehole installed at the 700-G location (Figure 2).
Survey Grid and Field Staking	The original Phase I survey grid provided in Figure 4 (NASA, 2022) will be re-staked in order to target specific locations identified for the Phase II investigation. Additional stakes will be added in the field to mark the footprint of trench boundaries and the locations of the proposed Phase II soil borings to support the logistics associated with the movement of heavy equipment.

[2] Westbay is a registered trademark of Nova Metrix Ground Monitoring (CANADA) LTD.

Closure Cap Preparation and Protection	The Closure cap surface is sparsely to moderately vegetated with desert shrubs and grasses, some of which may impede easy progression of equipment along planned survey lines. To ensure adequate access for drilling equipment, some vegetation may be mowed or mechanically removed as performed in the past for the Phase I investigation (NASA, 2022). Phase II subsurface soil boring locations require the installation of one to four-inch diameter soil borings that will be cored through the landfill Closure cap to facilitate subsurface soil sampling and soil vapor well installations. The locations selected for the installation of soil borings will be assessed individually to determine the required surface preparation to allow for access of drilling equipment while ensuring the cap is protected. Table 1 summarizes the potential sources of damage to the cap and the planned protection strategies. The wire fencing surrounding the perimeter of the landfill will be removed prior to the inception of drilling to afford direct access to each soil boring location from a peripheral dirt road outside the landfill boundary (Figure 4). Equipment movement planning will include access route maps for each soil boring with careful avoidance of the trench footprints. Access to the interior landfill will utilize only the native soil formation bridges between trench footprints. Any rutting from movement of the drilling equipment that could potentially damage the cap will be minimized through the use of plastic ground protection mats (DuraDeck®[3] or equivalent).
Drilling Approach	Sonic drilling is proposed for the installation of shallow (3 ft) and multi-depth (up to 30 ft) vertical soil borings, the collection of chemical and geotechnical soil samples, and the completion of MSVM wells through unconsolidated alluvium without the use of drilling fluids. Available space between the landfill trench footprints is limited, and extreme care will be taken during mobilization of the sonic rig. Soil borings will be positioned as close as is feasible to the locations adjacent to the trenches with consideration of the size of the drilling equipment. The core barrel diameter used for the multi-depth soil borings will have a diameter of approximately four inches to allow for a sufficient volume of soil to facilitate sampling, reduced potential temperatures within the soil sample, and to allow sufficient annular space for the installation of MSVM wells. Sonic drilling involves advancement of a core barrel using vibration, rotation, and a downward force to install soil borings and collect soil samples from the undisturbed alluvial formation. The sonic drilling rig has a hydraulically powered oscillator, which generates adjustable high-frequency vibrational forces. The sonic head is attached directly to the drill pipe or outer casing, sending vibrations down through the drill pipe to the bit. Once the core barrel has been advanced, a secondary override casing will be advanced down to the same depth as the inner core barrel to keep the borehole from collapsing. Once the core barrel is removed, the soil core will be extruded from the core barrel by gravity-aided vibration, into chemically resistant containers (e.g., polyethylene sleeves), minimizing the disturbance of the soil core and ensuring the collection of the most representative soil samples. To minimize the effects that heating of the core barrel may have on

[3] DuraDeck is a registered trademark of Signature Systems Group, LLC.

Drilling Approach (cont.)	soil sample quality, a lower vibration frequency will be used where feasible, short runs of one to two ft will be driven where soil samples are to be collected, and four-in core barrels will be deployed.
Soil Borings	The Phase II investigation is subdivided into two components; Phase IIa (weighted shallow soil borings within trench footprints and multi-depth vertical borings adjacent to trenches defined on the basis of Phase I results [NASA, 2022]); and Phase IIb (conditional angled soil borings defined on the basis of Phase IIa results). PHASE IIa SOIL BORINGS (8 + 32) Based on the results presented in the Phase I investigation (NASA, 2022) total of eight shallow soil borings inside trench footprints and 32 multi-depth soil boring locations comprising 24 within the 700 Area Landfill boundary and eight peripheral and outside the landfill are proposed for the Phase IIa investigation (Figure 7, Table 2). The eight shallow soil borings proposed within trenches are paired with eight of the 24 soil borings within the landfill boundary. In order to weight the locations of the Phase IIa soil borings in the vicinity of the landfill trench footprints, specific areas of interest were established on the basis of: • Trench age (preference given to older trenches active between the mid-1960s and late-1980s prior to the implementation of stringent waste management practices [NASA, 2017]). • Shallow soil vapor survey data concentration maps (preference given to relatively higher concentrations for six primary COPCs [NASA, 2022]). • Trench depth (preference given to deeper trenches as depicted by AMASW data [NASA, 2022]). • Trench magnetic anomalies as identified by EMI and VMG data (NASA, 2022). Following selection, specific areas of interest were further evaluated to identify eight primary locations likely to present the greatest opportunity for subsurface contamination. Soil boring locations were biased to coincide with these primary locations (Table 2) that incorporate the paired shallow soil borings within the trench footprint and a vertical soil boring adjacent the trench. Additional soil borings were used to address the other specific areas of interest and provide coverage across the landfill for the purpose of generating soil and soil vapor concentration maps. Shallow Soil Borings Above Primary Weighted Locations (8) Eight shallow soil borings will be installed at a depth of 3 ft bgs at the primary weighted locations within the footprint of specific trenches to quantitatively evaluate shallow soil vapor conditions above the trench contents (Figure 8, Table 2). No soil samples will be collected because the lithology comprises imported Closure cap materials above the trenches. Single-port soil vapor wells will subsequently be installed at each location with a sample port depth that is

Soil Borings (cont.)	coincident to the soil sampling location. The 3 ft target depth within the closure cap is located below the GCL at approximately 2 ft bgs (NASA, 2022). Multi-depth Soil Borings Adjacent to Weighted Locations (24) A total of 24 multi-depth vertical soil borings will be installed inside the 700 Area Landfill boundary to depths up to 30 ft bgs. Vertical soil borings will be installed adjacent to the footprint of individual trenches based on the specific areas of interest to a depth of 2 ft below the bottom of the adjacent trench to facilitate the collection of soil samples. Three soil sample depths are proposed at each vertical soil boring related to the trench depth determined from the Phase I investigation (Figure 5): mid-trench; bottom-trench; and sub-trench. The proposed soil boring locations and sample depths are provided in Figure 8 and Table 2. Multi-depth Peripheral Soil Borings Outside Landfill Boundary (8) Eight peripheral vertical soil borings will be installed upgradient (2 locations), on the sides (2 locations), and downgradient (4 locations) outside the 700 Area Landfill boundary (Figure 7, Table 2). These soil boring locations will be used to complement the multi-depth soil borings inside the landfill boundary and provide a supplemental analytical dataset for soil and soil vapor samples outside the landfill for statistical comparison. Three soil sample depths are proposed following the same strategy as soil borings installed within the landfill footprint (mid-trench, bottom-trench, and sub-trench). The depth peripheral soil borings are based on the average trench depth of 14 ft. Three-port MSVM wells will be installed at each location with sample port depths that correspond to the soil sampling locations. PHASE IIb SOIL BORINGS Phase IIb soil borings are planned conditionally based on the quantitative sampling results from the Phase IIa soil and soil vapor samples. NASA proposes the Phase IIb investigation be planned as a follow up field effort following submittal and NMED review of a Phase IIa investigation report. Angled Soil Borings Below Phase IIa Anomalies A preliminary pilot test will be performed in the vicinity of the 700 Area Landfill on completion of the Phase IIa drilling and soil vapor well installation activities. The pilot test will comprise the installation of two angled soil borings outside and adjacent to the landfill area. Results of the angled borehole pilot test will be included in the Phase IIa investigation report. If the installation of the two angled soil borings is unsuccessful and not deemed to be feasible, this will preclude the installation of any Phase IIb angled soil borings, and vertical borings will be installed. ~~Results of the angled borehole pilot test will be included in the Phase IIa investigation report.~~ Should results of the pilot test indicate angled borings are feasible the following activities will be completed. Based primarily on the quantitative soil and soil vapor results from the eight shallow and 24 multi-depth soil boring locations inside the 700 Area Landfill boundary, a set of angled soil borings will be ~~conditionally~~ installed adjacent to anomalous locations ~~contingent on the~~

Soil Borings (cont.)	~~feasibility of installation~~. Angled soil borings are planned with the objective of collecting a soil sample from directly below the trench locations considered to be anomalous. Angled sonic drilling presents a~~s~~n opportunity to potentially collect soil samples at between 40 and 60 ft directly below the base of the target trench locations. Based on subcontractor capabilities, angled soil borings are planned at an angle between 15 to 25 degrees from the vertical in conjunction with a step-off from the target of between 15 to 20 ft outside the adjacent trench wall. The exact location of the soil boring in the field may be influenced by rig access and Closure protection practices. Due to the coarse nature of native alluvial gravels, probable inaccuracy in the exact trench depths defined geophysical surveys, and the potential for the angled drill stem to deflect in its path during installation (large cobbles), extreme care will be taken during any attempted angled soil boring installations. Because angled soil borings have not been previously attempted in the alluvial gravels at WSTF, the feasibility of completing a soil vapor port within this type of soil boring is to be determined during the pilot test. Should installation of angled borings be infeasible, vertical borings will be installed to collect soil samples adjacent to the anomalous trench locations identified by the Phase IIa investigation. Vertical borings will be advanced, and samples collected, at least 5 ft below the deepest detected contamination to meet the Permit, Section 4.2.3.1, Drilling, minimum requirements for site characterization. Sampling for vertical delineation of subsurface contamination encountered will be collected at locations that will maintain the existing integrity of the landfill at locations most likely to yield the most representative site characterization data. The locations and depths of the Phase IIb borings will be determined based on a full evaluation of soil chemical data generated by the Phase IIa investigation.
Soil and Soil Vapor Quality Assurance/Quality Control Procedures	Soil and soil vapor samples will be collected in accordance with Permit Section 4.2.6 (NMED, 2023b) and shall be representative of the media and site conditions being investigated. Quality Assurance/Quality Control (QA/QC) samples will be collected to monitor the validity of the collection procedures and shall follow the following sampling protocols: • field duplicates shall be collected at a rate of 10%; • equipment blanks shall be collected from all sampling apparatus at a frequency of 10% for chemical analysis; • equipment blanks shall be collected at a frequency of one per day if disposable sampling equipment is used; • field blanks shall be collected at a frequency of one per day for each media; and • reagent blanks shall be used if chemical analytical procedures requiring reagents are employed. Soil samples and soil vapor samples will be shipped to accredited independent off-site laboratories for chemical analyses of the complete list of COPCs identified in this AIWP. Following receipt of all chemical analytical data,

	qualified NASA personnel will review and manage these data in accordance with established WSTF procedures. Data validation will be performed by experienced data management personnel upon receipt to ensure data met project objectives. Data will be reviewed for QA/QC compliance to ensure representativeness and comparability and to determine if systematic bias exists. Laboratory reports will be thoroughly evaluated to assess data quality exceptions and apply quality flags, note these exceptions, and evaluate the impact to the quality of the project data. Specific information related to soil and soil vapor chemical analyses will be provided with the field investigation results within the IR, and QA reports will be provided for all data sets as appendices.
Soil Sampling **Soil Sampling (cont.)**	Table 2 includes a summary of the proposed soil boring nomenclature, reference to the individual soil boring sample locations shown in Figure 7, sample depths, the criteria for soil boring selection, and the estimated total number of projected soil samples (96). Duplicate soil samples will be collected at a rate of 10% of the total locations. No soil samples will be collected for the shallow 3 ft soil borings above the footprint of the trenches that consist of imported Closure cap construction materials. Three chemical soil samples will be collected from each of the 32 proposed vertical soil borings using 4-in. diameter sonic core barrels. Soil samples will extend over one-ft intervals at locations dependent on the total trench depth mapped during the Phase I investigation. For example, using an average trench depth of 14 ft, the following three soil samples will be collected. • Mid-trench representing the central trench at 7 ft bgs. • Bottom-trench representing the location coincident with the bottom of the trench at 14 ft bgs. • Sub-trench representing the location 10 ft below the base of the trench at 24 ft bgs. Soil samples will be collected for analysis for the comprehensive suite of COPCs listed with the analytical methods in Table 3 compiled based on the historic 700 Area Landfill activities (NASA, 2017; NASA, 2022). Results from the soil sample analysis will be included in each respective MSVM well completion reports. Geotechnical soil samples will be collected at a rate of approximately 10% of the chemical soil samples identified in Table 2 to provide native soil geotechnical conditions at the 700 Area Landfill. These samples will be used to supplement the sitewide database of geotechnical samples and provide parameters that may be required to support future engineering planning and the determination of the final disposition of the landfill.
MSVM Well Installation and Initial Development	Following the advancement of the soil borings and collection of soil samples to the projected total depths, either a one port (shallow soil borings) or three port (multi-depth soil borings) soil vapor well will be installed inside the over-ride casing at each location (Figure 7, Table 2). Soil vapor sample port depths will be

MSVM Well Installation and Initial Development (cont.)	coincident with the soil sample locations within each soil boring to afford a comparative evaluation between the soil and soil vapor analytical data. The generalized construction design for single-port soil vapor wells and three-port MSVM wells and location relative to landfill trenches is provided in Figure 8. Soil vapor sample ports are designed with the objective of providing the vertical delineation of soil vapor concentrations in native alluvial formation adjacent to each soil sample location. MSVM port locations correspond to shallow supra-trench (3-ft bgs), mid-trench, bottom-trench, and sub-trench locations as listed in Table 2. Soil vapor port positions may be modified slightly during the design phase if a location of specific interest is justified during lithological logging of the borehole (for example visible discoloration of the native soils). Individual soil vapor ports will consist of a 12-in. (1 ft) soil vapor implant connected to a ¼-in. stainless-steel feeder tube to surface. Soil vapor ports will be secured to the outside of a centrally located 5/8-in. steel cable with a weight (Figure 8). Annular materials will comprise of two-ft minimum intervals of silica sand surrounding the soil vapor implants with Type I/II Portland cement with 5% bentonite intervals between the silica sand. The top of the soil boring will be completed with an 8-in. locking wells cap secured with Type I/II Portland cement as shown. MSVM wells ports will be initially developed by purging using a portable gas analyzer equipped with a pump following the completion of well installation as the soil vapor implants may be clogged with soil material and will not purge correctly. The analyzer pump should effectively pull vapor flow from the zone (indicated by the in-line flow meter) or will pull a vacuum and eventually shut down if clogged. Internal procedures are in place for guidance to attempt to unblock soil vapor ports where applicable. The initial purging of each soil vapor port will entail allowing the pump to purge the soil vapor well tubing for a minimum of five minutes per zone. Within the relatively shallow MSVM installations, this will evacuate at least three volumes of the ¼ in. tubing and soil vapor implant. The concentration of methane (CH_4), carbon dioxide (CO_2), and oxygen (O_2) indicator parameters will be monitored during the entire development operation to ensure they have stabilized, or additional development purge time may be required. During initial MSVM well development, each vapor port will be affixed with an aluminum tag engraved with the ID of that port to ensure each port can be identified in the future.
Soil Vapor Sampling	A set of soil vapor samples will be collected from each soil vapor port in the 700 Area Phase IIa soil vapor well network to determine the concentration and map the distribution of any anomalous VOCs in the subsurface. Soil vapor sampling will be performed in accordance with established WSTF guidance. At each MSVM well location, the sampling sequence will begin with the mid-trench soil vapor port and continue sequentially until the bottom-trench and sub-trench ports have been sampled. Each port will be connected to a portable gas analyzer equipped with a pump and purged prior to sampling for a minimum of five minutes which exceeds the time required to remove three volumes equivalent to the vapor implant and connecting stainless-steel tubing in the MSVM well ports. This process ensures that samples will be representative of the portion of the formation adjacent to the sample port at that depth in the well. Associated parameters on the purging monitor (CH_4, CO_2, and O_2) will also be required to

	equilibrate prior to sampling, otherwise additional purging will be performed until this goal is achieved. Samples will be collected in 1-liter stainless-steel SUMMA canisters and shipped to an accredited laboratory for analysis of VOCs by EPA Method TO-15 by full scan gas chromatography/mass spectrometry. The TO-15 analyte list comprises between 80 to 100 compounds that approximates the EPA 8260C target list for soil samples (Table 3).
Equipment Decontamination	All downhole drilling and sampling equipment that penetrates the surface soil will be decontaminated thoroughly using a steam cleaner. General decontamination guidance available in ASTM International D 5088-20 (ASTM, 2020) will be followed for this project. Decontamination procedures will be performed by 40-hour HAZWOPER trained personnel wearing appropriate personal protective equipment (PPE) under the supervision of the site supervisor or their designee. **Decontamination Area** A site-specific decontamination station will be constructed adjacent to the 700 Area Landfill to support the decontamination of all downhole equipment including the rotary hammer drill bit, steel conduit pipe, core barrels, and secondary override casing. Contamination reduction or decontamination activities will be performed over a containment device that will retain waste generated during the decontamination process. It is anticipated that all waste will be managed as solid waste. **Decontamination Methods** Decontamination will be performed on the downhole equipment to minimize the potential for any cross-contamination between soil boring locations. Any residual soil on the downhole equipment will first be removed using a wire brush at the decontamination station. Downhole equipment will be decontaminated prior to arriving at WSTF, prior to the commencement of soil boring installations, between individual soil boring locations, and prior to exiting the 700 Area Landfill area. Decontamination will involve steam cleaning the rotary hammer drill bit, steel conduit pipe, core barrels, and secondary override casing. In the event field screening instruments are used to monitor the condition of the 700 Area Landfill, dry decontamination followed by an alcohol-free moist wipe will be used for moisture sensitive equipment such as a photoionization detector.
Field Documentation Procedures	The WSTF Environmental Department field supervisor (geologist or engineer) will keep a record of daily Phase II investigation activities, a log of site personnel, safety briefings, and wastes generated in a project specific logbook. Logbooks will be bound with durable and serial numbered pages. Entries will be made in ink with no erasures. Each day's record will be reviewed and approved by another individual involved in the project. Logbook entries will include, as applicable, information that includes at a minimum: • Standard Daily Header – project name, logbook number, date, weather conditions, team members present and their affiliations (including subcontractors), sample location identification, day's task(s), daily safety

Field Documentation Procedures (cont.)	meeting topics, PPE to be used, equipment in use, and any calibration information, if applicable. • Daily activities (time and observations recorded) – site arrival and departure, visitors, the purpose of their visit, drilling information, sampling information, soil type, soil conditions, decontamination (i.e., method, equipment cleaned), waste management, and reference data sheets or maps, if applicable. • Daily summary – action items, materials used, changes or deviations made from planned protocol, plan for next day. • Signatures (field personnel and logbook reviewer). In addition to the field logbook, soil boring locations and soil samples will be recorded in soil boring logs. The logs will include the date, location, sample type, sample depth, identification number, personnel, and any circumstances, events, or decisions that could impact sample quality. MSVM well designs will be recorded in well completion diagrams that document well materials used, port depths and identification, annular materials, and personnel. Evidential records for the entire project will be maintained in hard copy or electronic form and will consist of: • Project IWP with any deviations redlined. • Site-specific internal procedural documentation or plans. • Project logbooks. • Field data records (i.e., surveyed site location). • Soil boring logs. • MSVM well completion diagrams. • Correspondence with NMED. • Final analytical data packages. • Reports. • Miscellaneous related records such as photos, maps, drawings, etc.
Investigation-Derived Waste	The RCRA Permit (NMED, 2023; Section 6.2.13 [pg86]) requires that a description of investigation-derived waste (IDW) management be included as an appendix to each IWP. IDW management is presented in this section of the AIWP in lieu of a separate appendix. IDW generated will be managed as hazardous until characterized as non-hazardous and will be stored in the immediate project area. Waste characterization will be conducted in accordance with Section 4.3.10 of the Permit (NMED, 2023, p59). All waste will be properly managed and disposed of in accordance with NASA procedures and state and federal regulations. The waste streams that will be generated during the installation of soil borings and MSVM wells include: • **Unsaturated drill cuttings.** Unsaturated drill cuttings are defined as soil cuttings or rock fragments generated from the shallow vadose zone (either used to construct the 700 Area Closure cap or located adjacent to trenches) that have not come in contact with groundwater. Unsaturated cuttings are non-hazardous solid waste.

Investigation-Derived Waste (cont.)	• **Drilling fluids.** Drilling fluids generated during drilling in the vadose zone are impacted with only added non-chlorinated native water from the WSTF potable water supply wells and are non-hazardous solid waste. • **Decontamination fluids.** Decontamination fluids such as water and soap solutions used to wash and decontaminate equipment generated during drilling above the water table are non-hazardous solid waste. • **Contact waste.** Contact waste, or debris, such as used disposable sampling equipment, PPE, plastic sheeting, and other debris generated during drilling above the water table is non-hazardous solid waste. Drill cuttings and drilling fluids generated from the shallow 700 Area Landfill vadose zone are not anticipated to contain listed hazardous waste nor meet the definition of a hazardous waste. The as-generated waste will be sampled and analytical data used to further characterize the waste. Waste characterization samples will be analyzed for volatile organic compounds by the current revision of SW-846 Method 8260, NDMA by Modified EPA Method 607M, and RCRA metals using the current revision of EPA Method 1311 (Toxicity Characteristic Leaching Procedure) and the current revision of EPA Method 6010, or equivalent. Non-hazardous drill cuttings and drilling fluids will be managed at the surface as required. For any waste that is characterized as hazardous waste (for example in the unanticipated event of a fluid leak from the drilling rig), land disposal restriction notifications, disposal facility profiles, and hazardous waste manifests will be completed as required. Hazardous waste manifested off-site will be transported for treatment and disposal at a permitted RCRA treatment, storage, and disposal facility.
Site Restoration	Any required final restoration and/or grading activities at the 700 Area Closure landfill will commence following the completion of the Phase II investigation fieldwork. As specified previously, care will be taken to follow all applicable guidance relative to Closure cap damage listed in Table 1. Any specific backfill or grading will be completed using the standard equipment utilized for previous landfill repairs to prevent the ponding of any water. The wire fencing surrounding the perimeter of the landfill will be restored to restrict access to the landfill. Stakes placed at the landfill trench footprint boundaries and for the survey grid will be removed and any disturbance backfilled and compacted. Any significant modifications or repairs to the landfill closure cap will be reported to the NMED Solid Waste Bureau.
Schedule	The schedule for the 700 Area Phase II field investigation is dependent on a baseline represented by the NMED final approval date for the 700 Area Landfill Phase II AIWP. The proposed schedule for the 700 Area Landfill Phase II investigation fieldwork and reporting is as follows: • NMED approval of 700 Area Landfill Phase II IWP – 0 days. • Perform Phase IIa investigation procurements and commence fieldwork - 60 days following ~~NMED approval~~initiation of field activities. • Complete Phase IIa fieldwork components in the following order - 180 days following commencement of fieldwork.

Schedule (cont.)	○ Partial restoration of Phase I standardized grid as necessary and staking of trenches and weighted soil boring locations. ○ Advance Phase IIa shallow soil borings above weighted trench locations and install single port soil vapor wells. ○ Advance Phase II multi-depth vertical soil borings at 32 locations (24 within the landfill area and eight peripheral), collect chemical and geotechnical soil samples, ship to analytical laboratories, and install single-port and three-port MSVM wells. ○ Perform pilot test to evaluate the feasibility of installing two angled soil borings for a conditional Phase IIb investigation. ○ Develop all single port and three-port MSVM wells. ○ Following an equilibration period of ~~one month~~30 days, purge and collect soil vapor samples from the 700 Area network of MSVM wells and ship to analytical laboratory. ○ Receive all soil analytical, soil vapor analytical, and survey data. • Data compilation, review, and development of draft 700 Area Landfill Phase IIa Investigation Report including internal reviews - 120 days after completion of Phase II fieldwork components and receipt of laboratory and survey data. • NASA Submits Phase IIa 700 Area Landfill Investigation Report to NMED - 360 days after ~~approval of the 700 Area Landfill Phase II AIWP~~initiation of field activities. • In recognition of budget constraints for FY25, the earliest this investigation can be performed is in FY26. However, this is contingent on the available budget and the status of other corrective action projects. NASA will maintain communication with NMED regarding the corrective action projects and budget and identify any issues that may affect the scope or schedule of those projects.
References	ASTM International. ASTM Standard D5088-20, (2020). *Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites*, ASTM International, West Conshohocken, PA. Retrieved from www.astm.org City of Albuquerque, (2023, August). *Environmental Health – Landfill & Groundwater Monitoring – Closed KAFB Landfills*. Retrieved from https://www.cabq.gov/environmentalhealth/landfill-groundwater-monitoring/closed-kafb-landfills NASA Johnson Space Center White Sands Test Facility. (1978, October 19). *Application for Registration of Solid Waste Collection, Transportation and Disposal System*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (1991, November 25). *1991 NASA WSTF Solid Waste Management Draft Regulation Review*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2015, November 17). *Transmittal of Class I Permit Modification Request for the NASA White Sands*

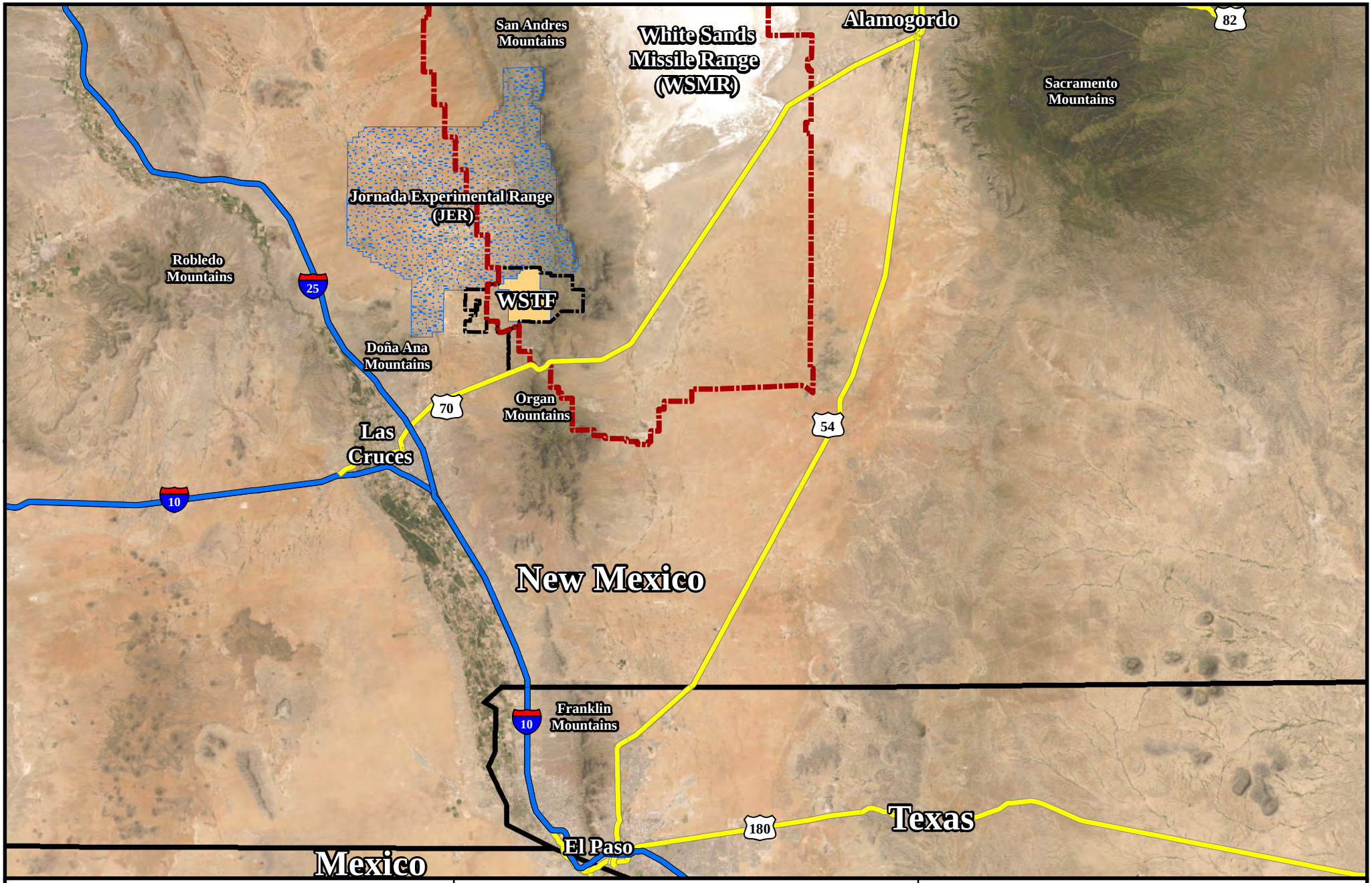
References (cont.)	*Test Facility (WSTF) Hazardous Waste Permit No. NM8800019434 Attachment 16*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2017, December 28). *NASA White Sands Test Facility (WSTF) SWMU 49 (700 Area Landfill) Phase I Investigation Work Plan (IWP) and Historical Information Summary (HIS)*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2019a, March 28). *Response to NMED Disapproval SWMU 49 (700 Area Landfill) Phase I Investigation Work Plan and Historical Information Summary*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2019b, August 8). *Response to NMED Approval with Modifications SWMU 49 (700 Area Landfill) Phase I Investigation Work Plan and Historical Information Summary*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2021a, October 19). *Discussion Relative to the Phase 1A and Phase 1B Soil Vapor Survey (SVS) Component of the Ongoing 700 Area Landfill Phase I Investigation*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2021b, December 21). *Revised Discussion Relative to the Phase IA and Phase IB Soil Vapor Survey (SVS) Component of the Ongoing 700 Area Landfill Phase I Investigation*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2022, April 29). *NASA White Sands Test Facility (WSTF) 700 Area Landfill Closure (SWMU 49) Phase I Investigation Report*. Las Cruces, NM. NASA Johnson Space Center White Sands Test Facility. (2023, April 27). *NASA WSTF Groundwater Monitoring Plan Update for 2023*. Las Cruces, NM. NMED Hazardous Waste Bureau. (2009, November 3). *Hazardous Waste Permit No. NM8800019434 (modified December 2019)*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2015, December 16). *Administrative Completeness and Fee Assessment Approval with Modifications Transmittal of Class 1 Permit Modification Request*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2018, November 29). *Disapproval SWMU 49, 700 Area Landfill Phase I Investigation Work Plan and Historical Information Summary.* Santa Fe, NM. NMED Hazardous Waste Bureau. (2019, June 6). *Approval with Modifications SWMU 49, 700 Area Landfill Phase I Investigation Work Plan and Historical Information Summary*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2021b, November 12). *Disapproval 700 Area Landfill (SWMU 49) Phase I Investigation Soil Vapor Survey*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2022, February 11). *Approval Revised Discussion Phase IA and Phase IB Soil Vapor Survey (SVS) 700 Area Landfill Phase I Investigation*. Santa Fe, NM. NMED Hazardous Waste Bureau. (2023a, February 10). *Approval 700 Area Closure (SWMU 49) Investigation Report*. Santa Fe, NM.

	NMED Hazardous Waste Bureau. (2023b, March 28). *RCRA Permit EPA ID # NM8800019434*. Santa Fe, NM. Seager, W. R. (1981, May). *Geology of Organ Mountains and Southern San Andres Mountains, New Mexico*. New Mexico Bureau of Mines & Mineral Resources, Memoir 36. Socorro, NM.

Figures

Figure 1 **WSTF Location Map**

(SEE NEXT PAGE)



1 in = 12 miles

0 6 12 24 Miles

N W E S

October 2023

- WSMR Boundary
- WSTF Boundary
- WSTF Industrial Area
- Jornada Experimental Range (JER)

WSTF Location Map

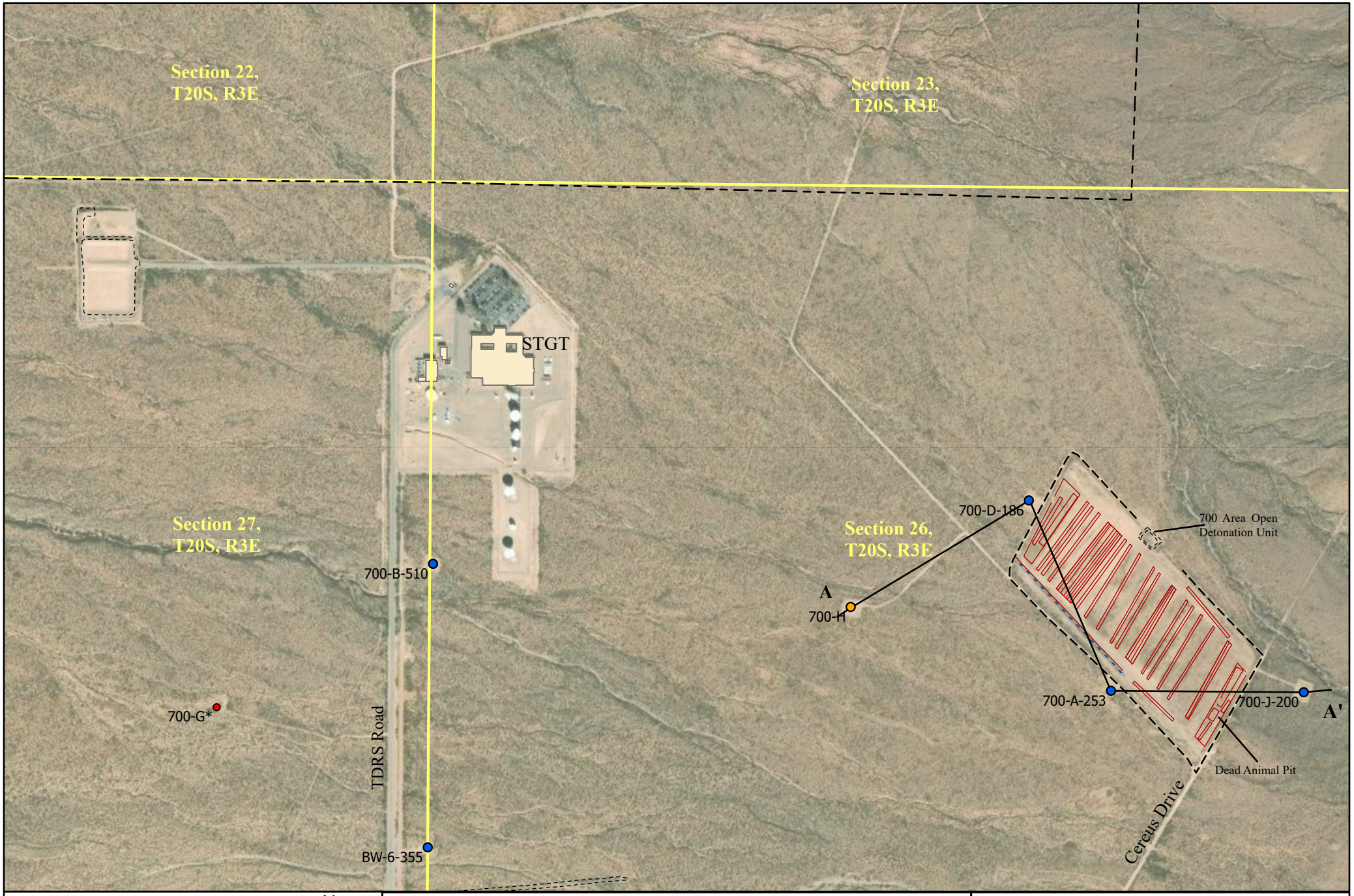
NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

Coordinate System:
NAD 1983 StatePlane New Mexico Central FIPS 3002 Feet

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Figure 2 **700 Area Landfill Location Map**

(SEE NEXT PAGE)



700 Area Landfill Area

NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

Coordinate System:
NAD 1983 HARN StatePlane New Mexico Central FIPS 3002

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Figure 3 **700 Area Landfill Detail**

(SEE NEXT PAGE)

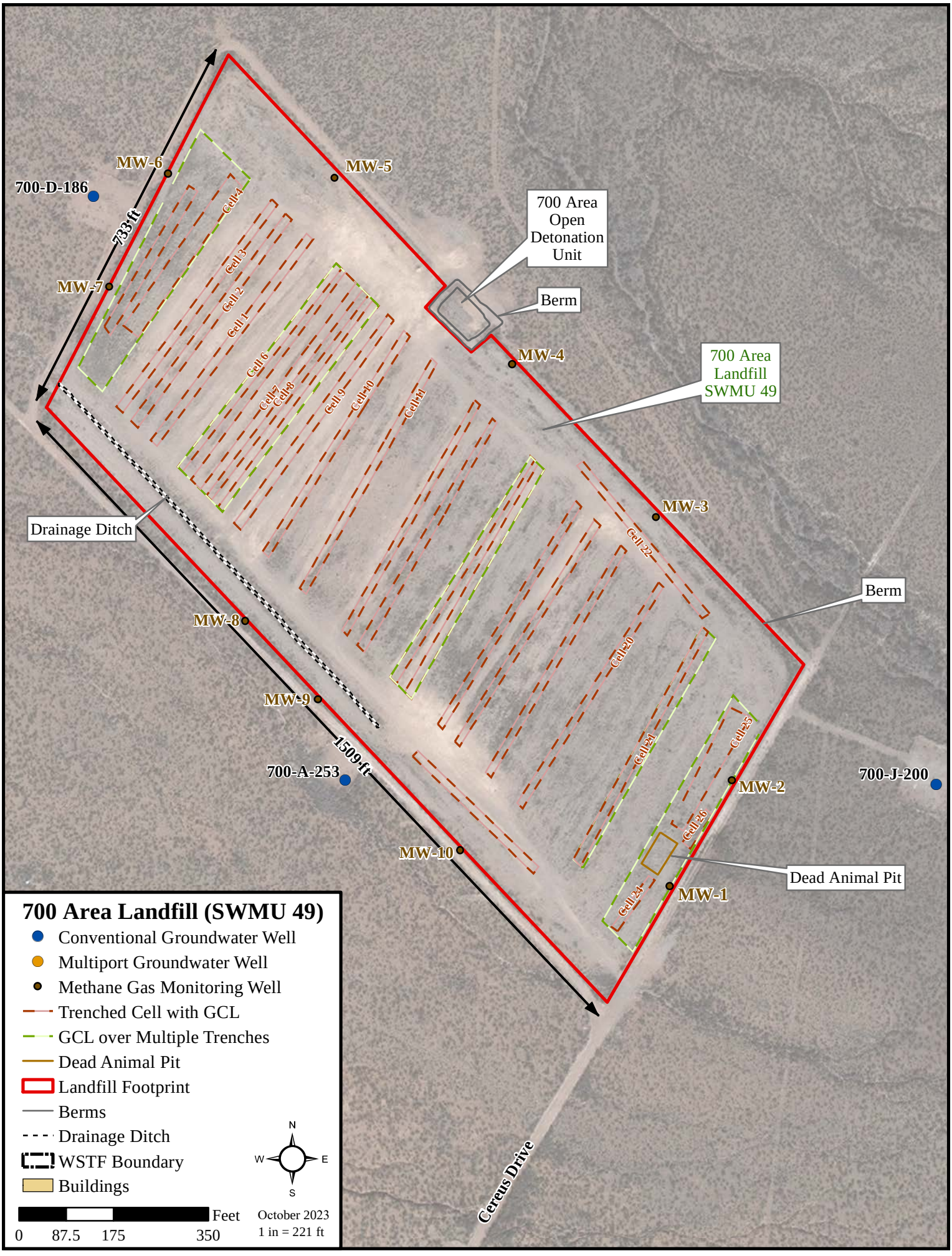

MW-6
MW-5
700-D-186
733 ft
MW-7
700 Area Open Detonation Unit
Berm
MW-4
700 Area Landfill SWMU 49
Cell 4
Cell 3
Cell 2
Cell 1
Cell 6
Cell 7
Cell 8
Cell 9
Cell 10
Cell 11
Drainage Ditch
MW-3
Cell 22
Berm
MW-8
Cell 20
MW-9
1509 ft
Cell 21
Cell 25
700-A-253
MW-2
700-J-200
MW-10
Cell 26
Dead Animal Pit
MW-1
Cell 24
Cereus Drive
700 Area Landfill (SWMU 49)
Conventional Groundwater Well
Multiport Groundwater Well
Methane Gas Monitoring Well
Trenched Cell with GCL
GCL over Multiple Trenches
Dead Animal Pit
Landfill Footprint
Berms
Drainage Ditch
WSTF Boundary
Buildings
N
W
E
S
Feet
0
87.5
175
350
October 2023
1 in = 221 ft

Figure 4 700 Area Landfill Sampling Grid Locations

(SEE NEXT PAGE)

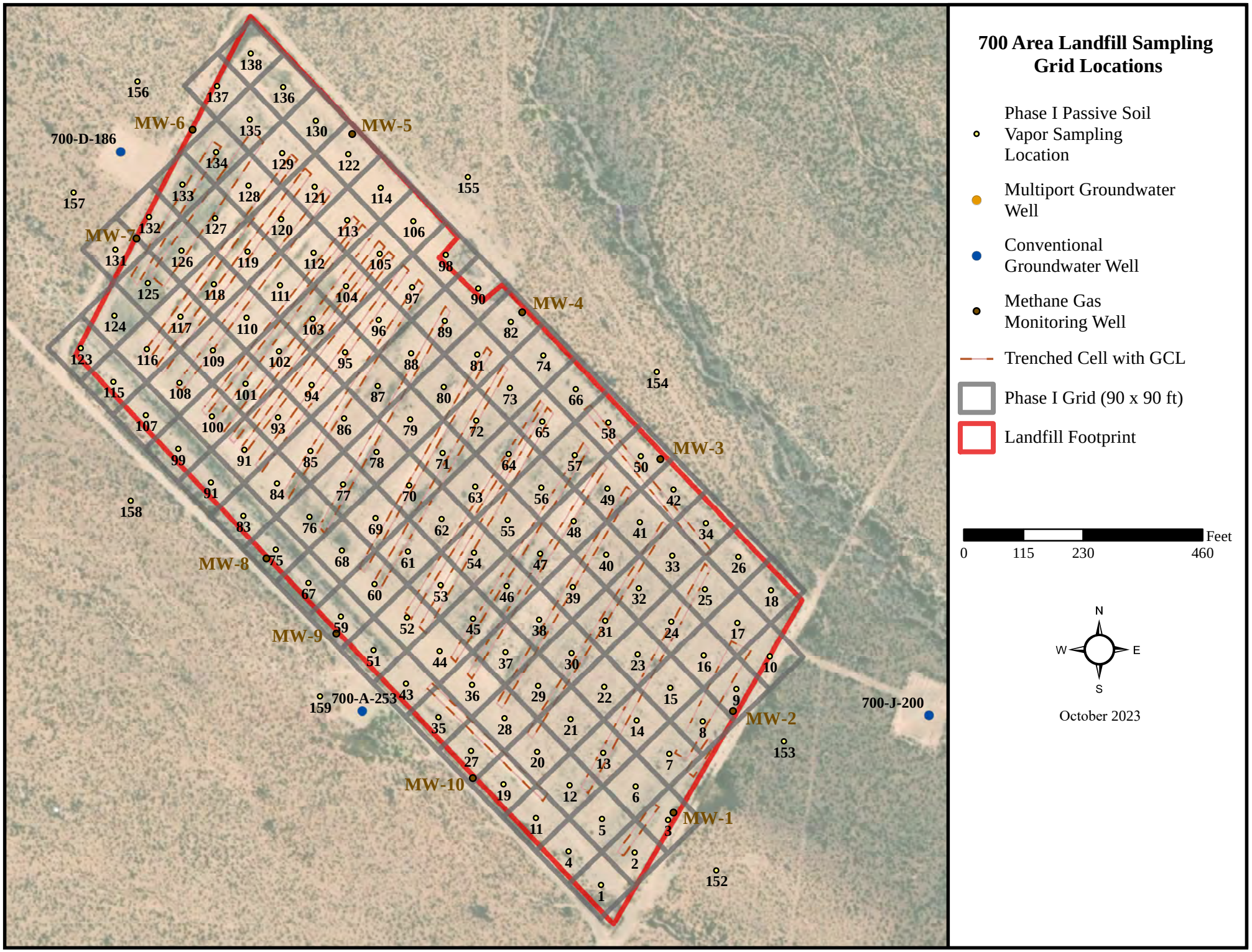

700 Area Landfill Sampling Grid Locations
Phase I Passive Soil Vapor Sampling Location
Multiport Groundwater Well
Conventional Groundwater Well
Methane Gas Monitoring Well
Trenched Cell with GCL
Phase I Grid (90 x 90 ft)
Landfill Footprint
Feet
0
115
230
460
N
W
E
S
October 2023
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
700-D-186
700-A-253
700-J-200

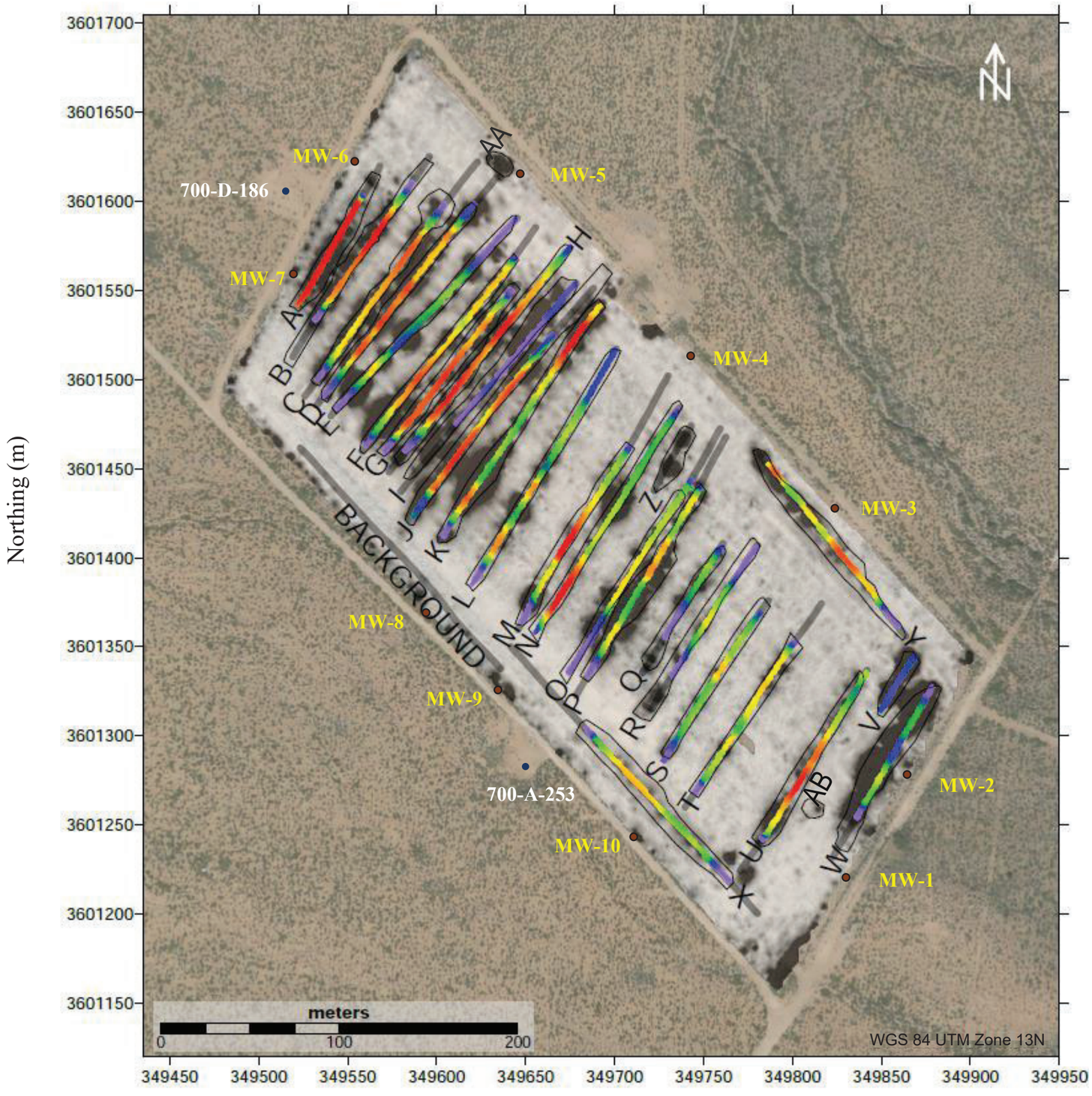
Figure 5 700 Area Landfill Seismic Active Multichannel Analyses of Surface Waves Results

(SEE NEXT PAGE)

Seismic AMASW Results
700 Area Landfill
WSTF

COLLIER GEOPHYSICS	Navarro Research & Engineering, Inc.	
	Project #: 20-167	**FIGURE A7**

Drafted by: J. Pfeiffer Checked by: J. Sheehan **August 2021**



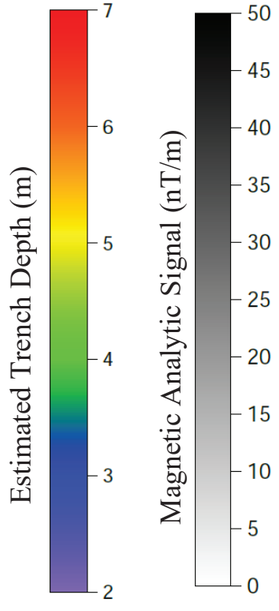
AMASW Line

A — Estimated Trench Outline - based on AMASW, FDEM, and Magnetics

Conventional Groundwater Well

Methane Gas Monitoring Well

Interpreted Trench Depth



Easting (m)
WGS 84 UTM Zone 13N

October 2023

Figure 6 700 Area Geologic Cross-Section A-A'

(SEE NEXT PAGE)

700 AREA GEOLOGIC CROSS-SECTION A-A'

WEST
A

EAST
A'

700 AREA LANDFILL

700-H
700-D-186
700-A-253
700-J-200

QTcu
To
P

Total Depth - 695' bgs

ELEVATION (FT AMSL)
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500

LEGEND

MONITORING WELLS
- 700-J-200: Monitoring Well
- Well Screen (groundwater Sampling Zone)

GEOLOGY
- QTcu: Camp Rice Formation, Undivided
- To: Orejon Andesite
- P: Paleozoic Rocks, Undifferentiated

STRUCTURE
- Contact Between Geologic Units (dashed Where Inferred)
- D/U: Inferred Fault With Displacement

HYDROGEOLOGY
- Potentiometric Surface (2022)

SCALE

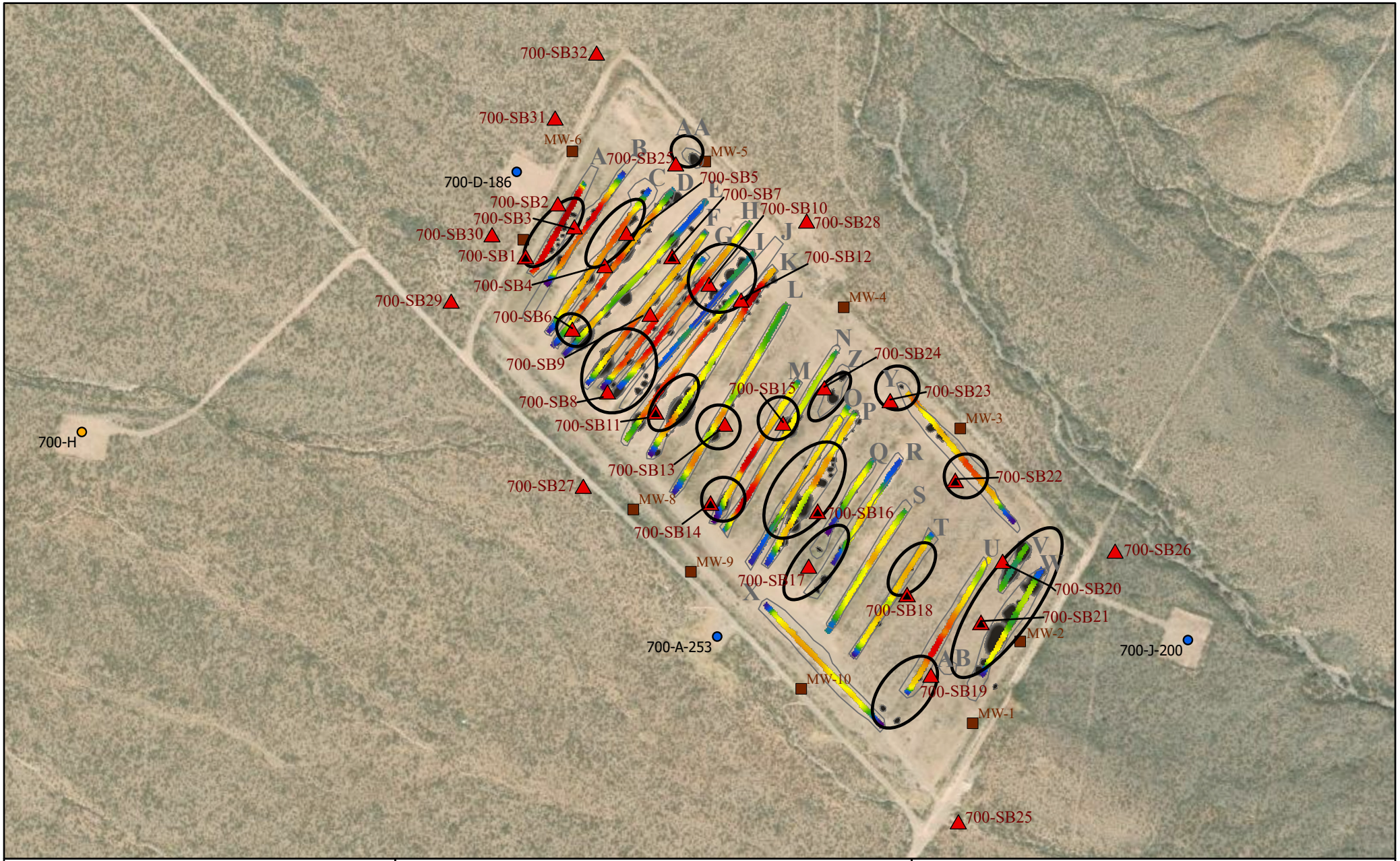
VERTICAL EXAGGERATION = x5

100'
400'

September 2023

Figure 7 **700 Area Proposed Soil Boring Locations**

(SEE NEXT PAGE)



N
W E
S

October 2023
1 in = 300 feet
0 250 500 Feet

- Multi-depth Soil Boring
- Combined Shallow and Multi-depth Soil Boring
- Methane Gas Monitoring Well
- Conventional Monitoring Well
- Multiport Monitoring Well
- Magnetic Anomalies
- Interpreted Trench Boundary

Estimated Trench Depth (ft bgs)
26
22
18
14
10
6
0

Proposed Soil Boring Locations

NASA Johnson Space Center
White Sands Test Facility
Las Cruces, New Mexico

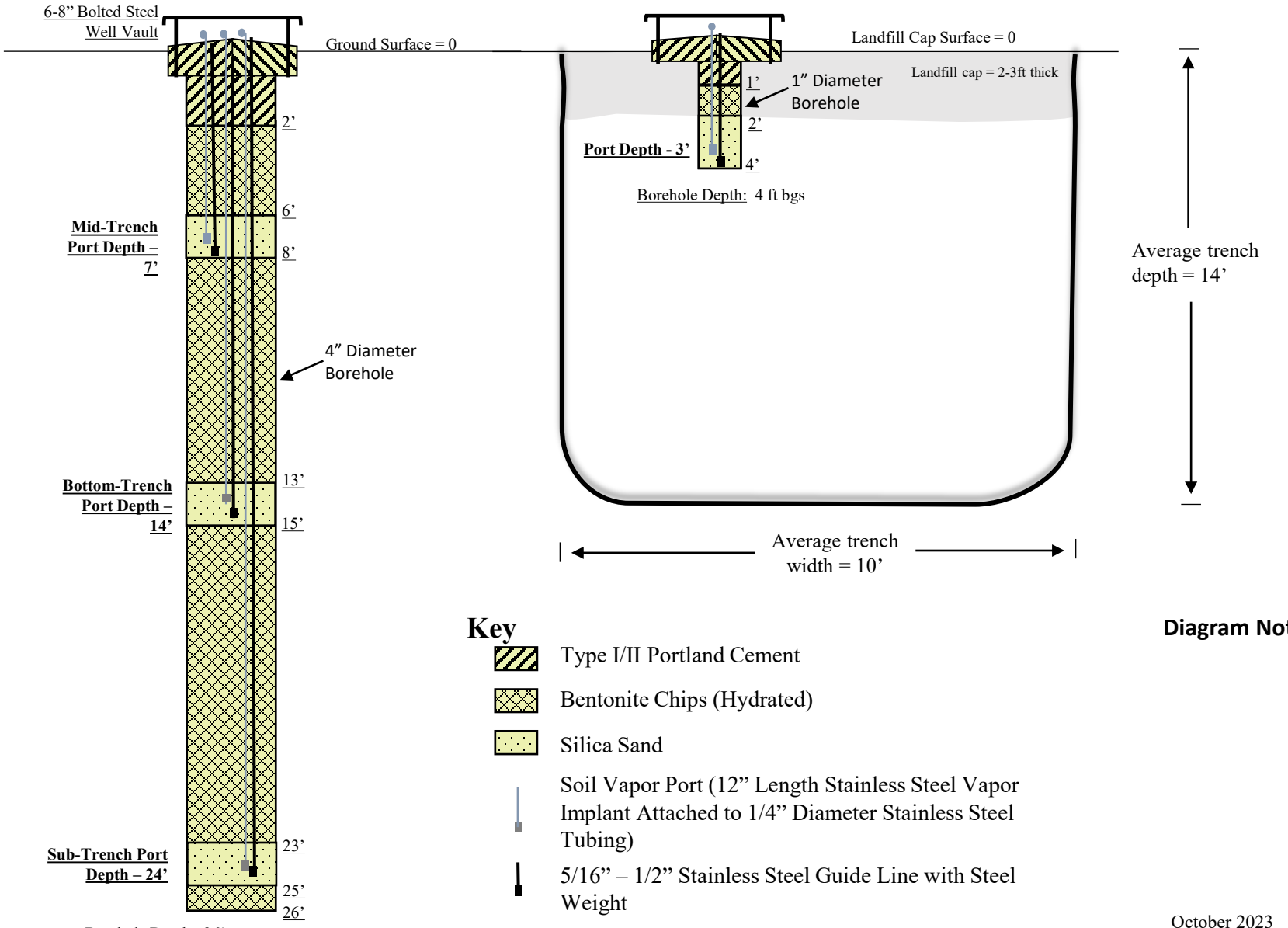
Coordinate System:
NAD 1983 HARN StatePlane New Mexico Cantral FIPS 3002

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Figure 8 General Construction Diagram for 700 Area Landfill Soil Vapor Monitoring Wells

(SEE NEXT PAGE)

General Construction Diagram for 700 Area Landfill Soil Vapor Monitoring Wells



Key

- Type I/II Portland Cement
- Bentonite Chips (Hydrated)
- Silica Sand
- Soil Vapor Port (12" Length Stainless Steel Vapor Implant Attached to 1/4" Diameter Stainless Steel Tubing)
- 5/16" – 1/2" Stainless Steel Guide Line with Steel Weight

Diagram Not to Scale

October 2023

Tables

Table 1 Potential Damage to 700 Area Closure Cap and Protection Strategies

Activity	Potential Damage to Cap	Cap Protection Strategies
All	Minimization	The importance of maximizing the closure cap integrity will be emphasized to all personnel during the project kick-off meeting. This meeting is intended to address health, safety and environmental issues, and project procedures and goals.
Mobilizing drilling equipment onto the cap and movement between soil borings. The drilling rig and associated equipment is estimated to weigh up to 30,000 pounds (total) distributed between the axles of the vehicles.	Drilling equipment tracks or tires may promote disturbance in the form of shallow rutting and potentially damage the surface of the cap.	Strategic progression to each soil boring location including route maps will be used to minimize travel distance of the rig and associated equipment. Protective matting system (DuraDeck or similar) will be used to underlay the drilling equipment to help distribute weight and mitigate rutting effects.
Support vehicle traffic from work crews (pipe truck, forklift, trucks).	Equipment tires may disturb (rut) the surface of the cap.	All support vehicles other than pipe truck and forklift will be parked off the cap unless absolutely necessary to the project. Utilize a strategic advancement plan for equipment on the cap to minimize distance traveled.
Decontamination of drilling and sampling equipment.	Contamination of cap or potential cross-contamination between individual boreholes.	The drilling rig and sampling equipment will be decontaminated upon entering WSTF and the landfill. Impermeable (6 mil) plastic sheeting will be placed under the decontamination areas and bermed. Sampling core barrels will be decontaminated on a temporary decontamination area off of the cap.
Possible fluid leakage from heavy equipment.	Contamination of cap.	Stationary motorized equipment (once located at individual boreholes) will be underlain with impermeable 6 mil (minimum thickness) plastic sheeting with berms. Drilling and downhole equipment will be decontaminated by steam cleaning prior to spudding/re-entry to another borehole.
Drilling soil borings through cap and subsequent MSVM well installation.	Punctures cap.	Drill casing will be retained within the soil borings to prevent collapse until installation of the MSVM well materials. Any annular space between the casing and borehole will be packed and sealed as required. MSVM well design in this AIWP will be reviewed by NMED to ensure that the design provides an effective seal of the cap. Soil borings selected for abandonment will be plugged appropriately in accordance with Permit requirements (NMED, 2023).
Other miscellaneous field activities occurring on cap surface.	Unforeseen damage caused during investigation.	Daily quality assurance/quality control inspections will be performed. Daily reporting and meetings to address improvements in cap protection strategy will be conducted between all personnel as necessary.

Table 2 Soil Boring/MSVM Well Designations, Sample Locations, and Selection Criteria

Soil Boring[1]	Soil Sample Location and Depths (ft bgs)	MSVM Well Ports (ft bgs)	Projected Samples	Location Relative to Trench	Selection Criteria (Trench Age, Depth, Shallow SVS, Magnetic)
700-SB-1	No Sample (Cap) 700-SB1-10[2] 700-SB1-20 700-SB1-30	700-SV1-3 700-SV1-10 700-SV1-20 700-SV1-30	3 soil chemical 4 soil vapor	Trench A (southwest end)	Consistently deep trench, 20' depth
700-SB-2	700-SB2-10 700-SB2-20 700-SB2-30	700-SV2-10 700-SV2-20 700-SV2-30	3 soil chemical 3 soil vapor	Trench A (central)	Consistently deep trench, 20' depth, small magnetic anomalies
700-SB-3	700-SB3-10 700-SB3-20 700-SB3-30[2]	700-SV3-10 700-SV3-20 700-SV3-30	3 soil chemical 3 soil vapor	Trench B (central)	Deep trench, 20' depth, trace 1-2-4 TMB, small magnetic anomalies
700-SB-4	700-SB4-9 700-SB4-18 700-SB4-28	700-SV4-9 700-SV4-18 700-SV4-28	3 soil chemical 3 soil vapor	Trench D (central)	Deep trench, 18' depth, trace F113 and 1,2,4-TMB, larger magnetic anomaly
700-SB-5	700-SB5-8 700-SB5-16[2] 700-SB5-26	700-SV5-8 700-SV5-16 700-SV5-26	3 soil chemical 3 soil vapor	Trench C (northeast half)	Deep trench, 16' depth, trace F113 and 1,2,4-TMB, magnetic anomaly
700-SB-6	700-SB-6-6 700-SB-6-12 700-SB-6-22	700-SV6-6 700-SV6-12 700-SV6-22	3 soil chemical 3 soil vapor	Trench E (southwest end)	Trench 12' depth, trace F113, 1,2,4-TMB, and Chloromethane, larger magnetic anomaly
700-SB-7	No Sample (Cap) 700-SB7-8 700-SB7-15 700-SB7-25	700-SV7-3 700-SV7-8 700-SV7-15 700-SV7-25	3 soil chemical 4 soil vapor	Trench F (northeast half)	Trench, 15' depth, F113 anomaly, trace 1,2,4-TMB
700-SB-8	700-SB8-6 700-SB8-12 700-SB8-22	700-SV8-6 700-SV8-12 700-SV8-22	3 soil chemical 3 soil vapor	Trench H (southwest end)	Trench 12' depth, trace F113, 1,2,4-TMB, 1,3,5-TMB, small magnetic anomaly
700-SB-9	700-SB9-9 700-SB9-18 700-SB-9-28	700-SV9-9 700-SV9-18 700-SV9-28	3 soil chemical 3 soil vapor	Trench G (central)	Deep trench, 18' depth, trace F113, 1,2,4-TMB
700-SB-10	700-SB10-6 700-SB10-12 700-SB10-22[2]	700-SV10-6 700-SV10-12 700-SV10-22	3 soil chemical 3 soil vapor	Trench I (northeast half)	Trench 12' depth, trace F113, 1,2,4-TMB, larger magnetic anomalies
700-SB-11	No Sample (Cap) 700-SB11-9 700-SB11-18 700-SB11-28	700-SV11-3 700-SV11-9 700-SV11-18 700-SV11-28	3 soil chemical 4 soil vapor	Trench K (southwest half)	Deep trench 18' depth, trace F113, 1,2,4-TMB, 1,3,5-TMB, PCE, larger magnetic anomaly
700-SB-12	700-SB12-10 700-SB12-20 700-SB12-30	700-SV12-10 700-SV12-20 700-SV12-30	3 soil chemical 3 soil vapor	Trench K (northeast half)	Deep trench 20' depth, trace 1,2,4-TMB, 1,3,5-TMB, small magnetic anomalies
700-SB-13	700-SB13-9 700-SB13-18 700-SB13-28	700-SV13-9 700-SV13-18 700-SV13-28	3 soil chemical 3 soil vapor	Trench L (central)	Deep trench 18' depth, trace 1,2,4-TMB, 1,3,5-TMB, larger magnetic anomaly
700-SB-14	No Sample (Cap) 700-SB14-7 700-SB14-14 700-SB14-24	700-SV14-3 700-SV14-7 700-SV14-14 700-SV14-24	3 soil chemical 4 soil vapor	Trench M (southwest half)	Trench 14' depth, 1,2,4-TMB anomaly, trace 1,3,5-TMB, larger magnetic anomaly

Soil Boring[1]	Soil Sample Location and Depths (ft bgs)	MSVM Well Ports (ft bgs)	Projected Samples	Location Relative to Trench	Selection Criteria (Trench Age, Depth, Shallow SVS, Magnetic)
700-SB-15	700-SB15-7[2] 700-SB15-14 700-SB15-24	700-SV15-7 700-SV15-14 700-S-15-24	3 soil chemical 3 soil vapor	Trench N (central)	Trench 14' depth, trace F113, larger magnetic anomaly
700-SB-16	No Sample (Cap) 700-SB16-6 700-SB16-12 700-SB16-22	700-SV16-3 700-SV16-6 700-SV16-12 700-SV16-22	3 soil chemical 4 soil vapor	Trench P (central)	Older trench with 12' depth, 1,2,4-TMB and 1,3,5-TMB anomalies, large magnetic anomalies
700-SB-17	700-SB17-5 700-SB17-10 700-SB17-20	700-SV17-5 700-SV17-10 700-SV17-20	3 soil chemical 3 soil vapor	Trench R (southwest half)	Older trench with 10' depth, trace F113, small magnetic anomalies
700-SB-18	No Sample (Cap) 700-SB18-8 700-SB18-16 700-SB18-26	700-SV18-3 700-SV18-8 700-SV18-16 700-SV18-26	3 soil chemical 4 soil vapor	Trench T (central)	Older trench with 16' depth, F113 anomaly, landfill coverage location
700-SB-19	700-SB19-9 700-SB19-18 700-SB19-28	700-SV19-9 700-SV19-18 700-SV19-28	3 soil chemical 3 soil vapor	Trench U (southwest half)	Older deep trench with 18' depth, F113 anomaly, landfill coverage location
700-SB-20	700-SB20-5 700-SB20-10[2] 700-SB20-20	700-SV20-5 700-SV20-10 700-SV20-20	3 soil chemical 3 soil vapor	Trench V (central)	Older trench with 10' depth, F113 anomaly, large magnetic anomaly, landfill coverage location
700-SB-21	No Sample (Cap) 700-SB21-7 700-SB21-14 700-SB21-24	700-SV21-3 700-SV21-7 700-SV21-14 700-SV21-24	3 soil chemical 4 soil vapor	Trench W (central)	Older trench with 14' depth, F113 anomaly, large magnetic anomaly, landfill coverage location
700-SB-22	No Sample (Cap) 700-SB22-9 700-SB22-18 700-SB-22-28[2]	700-SV22-3 700-SV22-9 700-SV22-18 700-SV22-28	3 soil chemical 4 soil vapor	Trench Y (central)	Deep trench 18' depth, F113 anomaly, landfill coverage location
700-SB-23	700-SB23-8 700-SB23-16 700-SB-23-26	700-SV23-8 700-SV23-16 700-SV23-26	3 soil chemical 3 soil vapor	Trench Y (northwest end)	Trench 16' depth, F113 anomaly, landfill coverage location
700-SB-24	700-SB24-5 700-SB24-10 700-SB24-20	700-SV24-5 700-SV24-10 700-SV24-20	3 soil chemical 3 soil vapor	Trench Z (central)	Trench 10' depth, larger magnetic anomaly, landfill coverage
700-SB-25	700-SB25-7 700-SB25-14 700-SB25-24[2]	700-SV25-7 700-SV25-14 700-SV25-24	3 soil chemical 3 soil vapor	Peripheral (upgradient)	Assumes average trench depth of 14 ft, upgradient background
700-SB-26	700-SB26-7 700-SB26-14 700-SB26-24	700-SV26-7 700-SV26-14 700-SV26-24	3 soil chemical 3 soil vapor	Peripheral (upgradient)	Assumes average trench depth of 14 ft, upgradient background
700-SB-27	700-SB27-7 700-SB27-14 700-SB27-24	700-SV27-7 700-SV27-14 700-SV27-24	3 soil chemical 3 soil vapor	Peripheral (southwest side)	Assumes average trench depth of 14 ft, southwest side background
700-SB-28	700-SB28-7[2] 700-SB28-14 700-SB28-24	700-SV28-7 700-SV28-14 700-SV28-24	3 soil chemical 3 soil vapor	Peripheral (northeast side)	Assumes average trench depth of 14 ft, northeast side background
700-SB-29	700-SB29-7 700-SB29-14 700-SB29-24	700-SV29-7 700-SV29-14 700-SV29-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background

Soil Boring[1]	Soil Sample Location and Depths (ft bgs)	MSVM Well Ports (ft bgs)	Projected Samples	Location Relative to Trench	Selection Criteria (Trench Age, Depth, Shallow SVS, Magnetic)
700-SB-30	700-SB30-7[2] 700-SB30-14 700-SB30-24	700-SV30-7 700-SV30-14 700-SV30-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background
700-SB-31	700-SB31-7 700-SB31-14 700-SB31-24	700-SV31-7 700-SV31-14 700-SV31-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background
700-SB-32	700-SB32-7 700-SB32-14 700-SB32-24	700-SV32-7 700-SV32-14 700-SV32-24	3 soil chemical 3 soil vapor	Peripheral (downgradient)	Assumes average trench depth of 14 ft, downgradient background
Totals			**96 soil chemical 104 soil vapor**		

Notes:

[1] Refer to Figure 7 for soil boring locations.

[2] Geotechnical soil sample location (collected at a rate of 10%).

Field duplicates shall be collected at a rate of 10%.

Equipment blanks shall be collected from all sampling apparatus at a frequency of 10% for chemical analysis.

Equipment blanks shall be collected at a frequency of one per day if disposable sampling equipment is used.

Field blanks shall be collected at a frequency of one per day for each media.

Reagent blanks shall be used if chemical analytical procedures requiring reagents are employed.

Table 3 List of COPCs with Chemical Analytical Method for Soil Samples

Constituent	Sample Type	Analytical Method
Cyanide	CYANIDE	SW-846 Method 9012A
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)[1]	Dxns/Frns	SW-846 Method 8290
Hydrazine	HYDRAZINE	SW-846 Method 8315A M
Aluminum	METALS	SW-846 Method 6010C
Antimony	METALS	SW-846 Method 6010C
Arsenic	METALS	SW-846 Method 6010C
Barium	METALS	SW-846 Method 6010C
Beryllium	METALS	SW-846 Method 6010C
Boron	METALS	SW-846 Method 6010C
Cadmium	METALS	SW-846 Method 6010C
Calcium	METALS	SW-846 Method 6010C
Chloride	ANION	EPA Method 300.0
Fluoride	ANION	EPA Method 300.0
Phosphorus	ANION	EPA Method 300.0
Sulfate	ANION	EPA Method 300.0
Chromium (Total)	METALS	SW-846 Method 6010C
Chromium (VI)	METALS	SW-846 Method 7199
Cobalt	METALS	SW-846 Method 6010C
Copper	METALS	SW-846 Method 6010C
Lead	METALS	SW-846 Method 6010C
Mercury	METALS	SW-846 Method 7471B
Molybdenum	METALS	SW-846 Method 6010C
Nickel	METALS	SW-846 Method 6010C
Selenium	METALS	SW-846 Method 6010C
Silver	METALS	SW-846 Method 6010C
Strontium	METALS	SW-846 Method 6010C
Thallium	METALS	SW-846 Method 6010C
Tin	METALS	SW-846 Method 6010C
Vanadium	METALS	SW-846 Method 6010C
Zinc	METALS	SW-846 Method 6010C
N-Nitrodimethylamine	NDMA	EPA Method 607M
N-Nitrosodimethylamine	NDMA	EPA Method 607M
Nitrate	NITROGEN	EPA Method 300.0
Nitrite	NITROGEN	EPA Method 300.0
Perchlorate	PERCHLORATE	EPA Method 331.0M

Constituent	Sample Type	Analytical Method
Bis(2-ethylhexyl) Phthalate	SVOA	SW-846 Method 8270D
Di-n-butyl Phthalate	SVOA	SW-846 Method 8270D
Naphthalene	SVOA	SW-846 Method 8270D
1,1,1-Trichloroethane	VOA	SW-846 Method 8260C
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC 113)	VOA	SW-846 Method 8260C
1,1-Dichloroethane	VOA	SW-846 Method 8260C
1,1-Dichloroethene	VOA	SW-846 Method 8260C
1,2-Dichloroethane	VOA	SW-846 Method 8260C
2-Butanone (MEK)	VOA	SW-846 Method 8260C
Acetone	VOA	SW-846 Method 8260C
Acrilonitrile	VOA	SW-846 Method 8260C
Bromodichloromethane	VOA	SW-846 Method 8260C
Bromoform	VOA	SW-846 Method 8260C
Bromomethane	VOA	SW-846 Method 8260C
Chlorobenzene	VOA	SW-846 Method 8260C
Chloroform	VOA	SW-846 Method 8260C
Chloromethane	VOA	SW-846 Method 8260C
Dibromochloromethane	VOA	SW-846 Method 8260C
Dichlorodifluoromethane (CFC 12)	VOA	SW-846 Method 8260C
Methyl tert-Butyl Ether	VOA	SW-846 Method 8260C
Methylene Chloride	VOA	SW-846 Method 8260C
m-Xylene & p-Xylene	VOA	SW-846 Method 8260C
Styrene	VOA	SW-846 Method 8260C
Tetrachloroethene (PCE)	VOA	SW-846 Method 8260C
Toluene	VOA	SW-846 Method 8260C
trans-1,2-Dichloroethene	VOA	SW-846 Method 8260C
Trichloroethene (TCE)	VOA	SW-846 Method 8260C
Trichlorofluoromethane (CFC 11)	VOA	SW-846 Method 8260C
Vinyl Chloride	VOA	SW-846 Method 8260C
Explosive Residues[2]	Nitroaromatics	EPA Method 8330b
Polyfluoroalkyl and Perfluoroalkyl Substances[3]	PFAS	EPA ~~Draft~~ Method 1633
Total Petroleum Hydrocarbons[4]	TPH	SW-846 Method 8015C or best method available
Polychlorinated Biphenyls	PCB	SW-846 Method 8082A

Notes:

[1] – Dioxins and furans will be evaluated in accordance with the RA Guidance (NMED, 2022) Section 2-1. The 17 dioxin and furan congeners listed in Table 2.1 of the RA Guidance will be analyzed by the listed method and

evaluated by application of toxicity equivalency factors to determine the toxicity equivalent quotient that will be compared with the established screening levels for 2,3,7,8-TCDD.

[2] – Explosive constituents analyzed using EPA Method 8330b includes 17 constituents. NASA will evaluate all constituent concentrations using NMED SSLs or EPA RSLs as required by the RA Guidance.

[3] - Polyfluoroalkyl and Perfluoroalkyl Compounds (PFAS) will be evaluated in accordance with the RA Guidance (NMED, 2022) Section 5.4. The 24 PFAS constituents listed in Table 5-2 of the RA Guidance will be analyzed by the listed method and evaluated using established NMED or EPA screening levels.

[4] – Total Petroleum Hydrocarbons (TPH) analyses will include analyses of gasoline range organics, diesel range organics, and oil range organics by the listed method and the results will be evaluated using established NMED or EPA screening levels.