Addendum to 600 Area Closure Investigation Work Plan (October 2009)

This addendum presents a revised field investigation strategy to the 600 Area Closure Investigation Work Plan submitted by NASA to the NMED in April, 2009. The following sections have been modified.

5.1.1 Problem Statement

The investigation methodology was developed in accordance with EPA's current guidance entitled "Guidance on Systematic Planning Using the Data Quality Objectives Process" (EPA QA/G-4, 2006).

During historic operations, hazardous constituents were managed in two waste water impoundments in the WSTF 600 Area. These impoundments were previously closed with a low permeability cap completed on August 8, 1989. They are maintained under RCRA post closure care requirements. It is unclear whether residual sources of contamination remain in the vadose zone under the closures that could present an unacceptable risk.

5.1.2 Decision Statement and Alternative Actions

The primary decision is whether additional corrective actions are warranted at this site due to the presence of residual contamination source terms.

Alternative actions for the decisions include:

1. Eliminate the area from further investigation/evaluation; and,
2. Perform a Corrective Measures Evaluation to identify remedial options for mitigation of sources of groundwater contamination and/or human health risk under future direct exposure scenarios.

5.1.3 Decision Inputs

Primary inputs to the decision will be concentrations of COCs measured in vadose zone soil and soil vapor. COCs have been identified based on previous investigations and operational history as described in Work Plan Section 2.2. Analytical methods were selected to quantify COC concentrations at or below SSLs whenever possible.

5.1.4 Study Boundaries

The area of interest is the vadose zone (unsaturated) directly beneath the existing Closure. Proposed investigative soil borings include the perimeter of the Closure (immediately outside of the former impoundment footprint for comparative purposes). Figure 5.1 illustrates the study area.

The primary practical constraint is the subsurface geology. The water table lies below the bedrock/alluvium interface. The bedrock is a relatively impermeable and non-fractured andesite, and previous investigations have shown that potential contaminant pathways through the bedrock fractures cannot be reliably located. As a result, the investigation will be limited to the alluvial fill. The population of interest therefore includes surface and subsurface alluvial soils down to bedrock (i.e. soils from surface or immediately beneath the Closure cap to bedrock, approximately 160 feet below ground surface (bgs)).

Cobbles and boulders expected within the coarse-grained alluvial fan deposits make drilling with a hollow stem auger rig impractical based on previous experience at WSTF. In addition, standard coring techniques typically experience very low recoveries and problems with sidewall sloughing and collapse due to the extremely dry and relatively coarse grained nature of the alluvium.

5.1.5 Decision Rule and Error Limits

NMED has identified the SSLs as screening parameters to identify sites that may require further evaluation. From the New Mexico Soil Screening Guidance (NMED, 2009):

> "*While concentrations above the NMED SSLs presented in this document do not automatically designate a site as "contaminated" or trigger the need for a response action, detected concentration in site soils exceeding screening levels suggest that further evaluation is appropriate. Further evaluation may include additional sampling to further characterize the nature and extent of contamination, consideration of background levels, reevaluation of COCs or associated risk and hazard using site-specific parameters, and/or a reassessment of the assumptions associated with the generic SSLs…*"

In samples where multiple contaminants are detected, the cumulative effects of those contaminants must be considered. In those samples, cumulative effects must be considered as described by NMED (2009):

> *"For screening sites with multiple contaminants, the following procedure should be followed: take the site-specific concentration (represented by the maximum reported concentration or, if deemed appropriate by NMED, the 95% upper confidence limit value for the concentration) and divide by the SSL concentration for each analyte. For multiple contaminants, simply add the ratio for each chemical.*

$$\text{Site Risk} = \left(\frac{\text{conc}_x}{\text{SSL}_x} + \frac{\text{conc}_y}{\text{SSL}_y} + \frac{\text{conc}_z}{\text{SSL}_z} + \ldots + \frac{\text{conc}_i}{\text{SSL}_i} \right)$$

> *If the total ratio is greater than 1, then the concentrations at the site warrant further, site-specific evaluation. A ratio less than 1 indicates that the concentrations at the site are unlikely to result in adverse health impacts, or contaminate groundwater above State of New Mexico water quality standards."*

In samples where none of the detected contaminants exceed SSLs, the cumulative effects of the detected contaminants will be evaluated as discussed above. If the site risk exceeds one, then the site will warrant further evaluation. No further action is required if neither of the above decision criteria are met.

The primary concern for this project is the potential for residual vadose zone contamination to further impact groundwater. The decision rule is best addressed in multiple pieces based on pathways:

1. Do COC concentrations in vadose zone soils exceed risk based screening levels for direct exposure routes under the industrial/construction/residential land use scenarios? In accordance with the NMED soil screening process (NMED 2009), analytical results will be compared to direct exposure screening values for residential, industrial, and construction scenarios. Where multiple contaminants are detected, the cumulative effects of those contaminants will be considered as described in the guidance.

2. Do COC concentrations in vadose zone soils exceed the risk based screening levels for advective transport to groundwater? As discussed below, in accordance with the NMED soil screening process, analytical results will be compared to the NMED DAF-20 value. If COCs are identified in excess of the DAF-20 values, then NASA may develop a site-specific screening approach as described in the guidance.

3. Do COC concentrations in soil vapor have the potential to impact groundwater? There are many uncertainties associated with the use of soil vapor data and there are no applicable "screening

level values". However collection of soil vapor data from multiple depths and multiple locations across the study area may support a qualitative evaluation.

a. If concentration gradients indicate a discrete area(s) with relatively high concentrations (hot spots), then a significant residual source would be expected.

b. Elevated soil vapor concentrations (e.g. 1% of the ideal concentration for soil vapor in contact with a DNAPL source) would also indicate a significant residual source.

c. If contaminant concentrations in soil vapor are in approximate equilibrium with concentrations in groundwater (considering water/air partitioning mechanisms), then a significant residual source term would not be expected.

The original IWP included the residential direct exposure soil screening values in Table 5.2 primarily to evaluate planned analytical methods and reporting limits. It may have not been clear, however, that there is not a complete exposure pathway for ingestion or inhalation of soils at this site. The direct exposure values are only appropriate for evaluations of ingestion/inhalation/dermal contact of contaminated soil under residential or construction/industrial use scenarios, and do not apply to the evaluation of potential impact to groundwater.

The 2009 NMED SSL guidance states that in order to determine which contaminants present in soil have the capacity to leach to underlying groundwater, the SSL leaching values (NMED DAF-20 or site specific equivalent values) should be used (Section 2.5.4, Section 4). The leaching values are to be used as an initial screening; more sophisticated techniques that better represent site geologic conditions may be appropriate for subsequent evaluations. At the 600 Area Closure the water table is expected to be approximately 20 feet below the bedrock surface. The DAF-20 approach assumes uniform distribution of contamination from the surface to the water table. Therefore, the occurrence of 20 feet of poorly fractured to non-fractured andesite between the potentially contaminated soil and the groundwater would actually be expected to reduce the flux of contaminants into the water. Therefore, using the DAF-20 values under these conditions is a conservative approach to evaluate the potential impact to groundwater.

Because a residential future use scenario is not reasonable for the 600 Area Closure, contaminant concentrations in soil vapor will not be evaluated for potential risk using the Regional EPA screening levels for vapor intrusion (air).

5.1.6 Data Acquisition Plan

The selected sampling design presented below takes into consideration cost and geologic conditions along with the DQO outputs developed in the first five steps.

Eight soil borings are proposed for installation through the vadose zone in the vicinity of the 600 Area Closure (Figure 5.1). Soil borings will be advanced to the depth of bedrock (low conductivity Tertiary Orejon Andesite) anticipated at approximately 160 feet below ground surface (bgs) based on information from other borings and wells installed in the immediate vicinity of the Closure. Four of the soil borings will penetrate the 600 Area Closure as follows: 1) the center of the southeast impoundment cell; 2) the former HWMU discharge location near the south corner of the east cell within the footprint of the former impoundment; 3) the former discharge location for the hazardous waste transmission line along the northeastern edge of the east cell within the impoundment footprint (also adjacent to the former overflow pipe between the two former impoundment cells); and, 4) the center of the northwest impoundment cell. The location of three soil borings within the east cell is supported by information from the 600 Area Closure Report (Appendix 1) indicating that the lower pond contained three kinds of waste (lower wet sludge, salt cake, and upper standing water), as opposed to only dry sludge material in the upper pond.

A second set of four soil borings that are termed “perimeter” soil borings will be placed adjacent and outside the footprint of the former impoundment, outside each of the four corners of the Closure. These borings will allow the evaluation of vadose zone conditions immediately outside of the confines of the Closure cap and former impoundments, and a comparison to those borings installed through the Closure cap. The eight soil borings are strategically placed to delineate any contamination contained within the soils or soil vapor at the 600 Area Closure cap, and to allow comparison of the vadose zone below the Closure (characterized by penetration of the sludge layer) to the perimeter area adjacent and outside the Closure cap. Soil analytical results from uncompromised dry core samples and soil vapor analytical results from soil vapor wells that will subsequently be installed within the boring will also be used to evaluate the requirement for a potential Soil Vapor Extraction (SVE) system.

Soil sample collection for borings that penetrate the Closure will utilize decontaminated rotosonic core barrels to advance into undisturbed native soils just below the 600 Area Closure up to the depth of bedrock. Utilizing the uppermost 10-foot dry core run, chemical soil samples will be collected from each of the four Closure borings within the sludge layer at approximately six to eight feet bgs, and directly below the base of the former impoundment cells at a depth of approximately eight to 10 feet bgs (Table 5.1). A chemical soil sample will also be collected within the upper 10 feet of dry sample for the four peripheral borings at a location supported by head space field screening.

A dry soil sample will also be attempted near the bottom of all eight borings by performing a partial five-foot advance of the outer casing, and attempting to run the 10-foot core barrel through any slough and into dry native formation at the bottom of the core run. Chemical soil samples at intermediate depths may be collected for any of the borings where a dry uncompromised soil sample may be available. Three to four chemical soil sample sets are planned for each boring. Soil vapor will be field screened during drilling activities for dry soil samples using head space analyses for volatile organic compounds (VOCs) in order to support soil sampling locations for chemical laboratory analysis. Soil vapor samples will be collected and analyzed in the field with a portable photoionization detector (PID) equipped with an 11.7eV lamp. The 11.7 eV lamp will allow for the screening of trichloroethene (TCE) and tetrachloroethene (PCE), which have been identified at the low ppb level during previous investigations (Section 2.2). Chemical soil samples will be sent to the analytical laboratory for the testing procedures identified in Section 5.5.

Geotechnical analyses will be performed on soil samples from each distinct lithology during advancement of the soil borings irrespective of the introduced moisture content from rotosonic drilling. The calculated porosity and the initial moisture content parameters of the geotechnical sample suite may be compromised by the introduction of water. If so, the results will be evaluated accordingly. Between one to three geotechnical soil samples are planned for each boring. Geotechnical soil samples will be sent to the analytical laboratory for the testing procedures identified in Section 5.5.

Multiport soil vapor wells consisting of four individual sampling ports will be installed at each of the eight soil boring locations during the removal of drill casing to identify and quantify any vapor constituents within and around the Closure. These wells will be allowed to re-equilibrate for a period of four weeks following installation. The wells will then be purged and sampled, and the results from the soil vapor analyses included within the 600 Area Closure Investigation Report.

Groundwater is confined at a depth in excess of 180 feet bgs within non-fractured Tertiary Orejon andesite and is not anticipated during advancement of the soil borings. If encountered, a Teflon® bailer will be lowered into the boring and a water sample will be collected depending on turbidity issues. Nearby groundwater monitoring wells will also be utilized to collect groundwater samples in order to evaluate “background” groundwater concentrations immediately outside of the Closure cap.

5.2 Soil Boring Installation Activities

5.2.1 600 Area Drilling Conditions

The potential for cobbles and small boulders to anticipated diameters in excess of one foot below the 600 Area Closure render impractical drilling conditions for several drilling methods relative to the collection of alluvial soil samples. Extremely low alluvial sample recovery volumes of <15% have been previously encountered in the WSTF source areas when using alternate drilling methods such as Hollow Stem Auger (HSA), dual wall percussion, or Stratex® associated with split-spoon/Shelby tube sampling methods.

A preliminary field investigation attempted at the 600 Area Closure between September 15 and September 25, 2009 in response to the approved 600 Area Closure IWP (April 2009) utilizing rotosonic drilling provided a detailed insight to the applicability of the rotosonic drilling method to WSTF vadose zone soils. The dry and loose nature of the silty sandy alluvial gravels below the closure make dry rotosonic drilling impractical without the application of water to the boring. In a typical rotosonic setup (Table 5.1), the outer rotosonic casing is advanced to the depth of the inner rotosonic core barrel, which is pushed first into native formation. This procedure has been proved impossible without the addition of water due to the locking of the inner and outer casing by dry formation sediments. The addition of moisture to the dry permeable formation was demonstrated to penetrate to the base of a 10-foot core barrel, with only the lower 1 foot of the core barrel remaining dry, in part due to the excessive heat generated at the drill bit. Rotosonic drilling therefore ensures high soil recovery, with the disadvantage of adding water to the formation. It is anticipated that a considerable amount of any water added to the formation be removed through advance of the core barrel. Stratex® drilling with dual wall casing provides the ability to advance casing without water, but the sampling of dry alluvial gravels with split spoons or Shelby tube setups often results in limited (<15%) to no sample recovery.

5.2.2 Rotosonic and Stratex® Drilling Methods

This modified Work Plan assumes that the addition of water is acceptable and rotosonic drilling will be utilized as discussed between NASA and NMED during an NMED site visit to WSTF on September 30, 2009. Rotosonic drilling with the application of water is believed to be a viable method because of: the reduction in IDW; the maximized return of soil sampling; limited boring refusals; and, cost efficiency. Rotosonic drilling allows sampling to be conducted in an approach that maximizes the return of acceptable data with a minimal impact the integrity of the 600 Area Closure caps.

It is estimated that between five to 75 gallons of unchlorinated WSTF drinking supply water from Production Well K located west of the site outside of the groundwater plume would be utilized for each 10-foot advance of the boring depending on drilling conditions. Unchlorinated water is preferred to eliminate the potential interference of chlorine with any geochemical samples collected. In the event that rotosonic drilling cannot be effectively performed to bedrock, the Stratex® drilling method is proposed as an alternate drilling method should any problems be encountered with the rotosonic boring advancement. NASA has contacted prospective drilling subcontractors and has been informed that backup Stratex® drilling equipment is available within a 24-hour period for the projected field work interval. The primary objective of both drilling methods is to allow the effective installation of soil vapor monitoring wells through the closure cap and around the periphery of the Closure for vapor phase investigation.

Rotosonic drilling (table 5.1) is recommended as the optimum strategy for this work because it is capable of yielding continuous core samples with 70 - 100% recovery and penetrating cobbles and even soft bedrock. Rotosonic drilling generates less than 50% of the drill cuttings relative to HSA drilling. The rotosonic drilling method involves driving a core barrel using vibration, rotation and a downward force to collect soil samples. Once the core barrel has been advanced, a secondary casing will be advanced down

to the same depth as the inner core barrel utilizing the addition of unchlorinated water. The over-ride casing keeps the boring from collapsing, and will require the addition of water to the boring. The core barrel is then removed, and the soil core extruded from the core barrel through the use of gravity-aided vibration.

The soil sample cores will be rigidly supported through the use of a stainless steel carrying device, which will be decontaminated between each core run. Disturbance of the soil core will be minimized during extrusion of the soil from the core barrel. Polycarbonate liners within the cores for the purpose of collecting samples were considered for this project. The liners can be used for softer formations; however it is anticipated that these would be damaged within the core barrels due to the frequency of boulders within the alluvial formation.

Rotosonic drilling may still produce elevated temperatures in the core barrel during difficult drilling conditions. The ASTM standard on rotosonic drilling for site characterization (ASTM D 6914-04; ASTM, 2004) indicates that the effects of drilling generated heat can be mitigated by shortening sampling runs, changing vibration level and rotation speed, using cooled sampling barrels, collecting larger diameter samples to reduce the effect on the interior of the sample, and using fluids to cool the core barrel. The issue of heating of the inner core barrel for the 600 Area Closure will be addressed as follows:

- Use of a “neutral” casing bit, which provides the best bit face to cut through formation boulders. A “crowd-in” casing bit will be considered depending on the size of clasts encountered in the formation. The “crowd-in” bit moves most of the formation into the core barrel and can shear the formation with minimal resistance. This style of bit face provides the best service in dense, dry, or cohesive formations. The “crowd-in” bit also helps avoid forcing soil particles into the boring walls by directing material into the core barrel.

- Soil cores for the 600 Area closure will be collected over 10 foot intervals. If excessive core barrel heating is encountered, shorter core runs may be attempted.

- Sample barrels as small as two inches are often used; however, this project will utilize core barrels from between four to six inches in diameter. Although wider diameter core may reduce the severity of heating effects on the sample, smaller diameter cores may be required to penetrate boulders in the alluvial formation.

- The addition of five to 75 gallons of unchlorinated water per 10-foot core run and the drilling subcontractors experience will be called upon to adjust vibration and rotation to reduce heating to the extent possible.

Stratex® dual wall casing is recommended as the backup drilling strategy (Table 5.1). It is anticipated that a backup Stratex® drilling rig can be acquired within 24 hours of a request. Stratex® technology allows the advance of casing without the use of moisture. Sample recoveries will however be drastically reduced due to the inability to drive a core barrel with this method. Although rotosonic drilling is the best strategy for evaluating the 600 Area vadose zone soils, both drilling methods readily support multiport soil vapor well construction through the inside of the over-ride casing.

Soil boring cuttings from individual borings will be stockpiled until final TCLP analytical results are received as indicated in Section 4.2 of the IWP. The cuttings from individual borings will be contained within one cubic yard bulk bags, stockpiled on, and covered with six-mil minimum plastic sheeting. The soil cutting waste stream will be characterized as hazardous or nonhazardous, as indicated in Section 4.2 of the IWP, and the management of the cuttings coordinated between NASA and the NMED.. In order to protect the upper synthetic liner for the four closure borings, the large gravel surface and sand cover

(approximately the top foot) will be removed by hand using a shovel prior to drilling each boring. Plastic sheeting will be laid out over the drilling area to contain drilling cuttings (see Section 4.2 Investigation-Derived Waste Plan).

5.2.3 Soil Boring and Soil Vapor Well Description

Eight nominal 7 5/8-inch diameter rotosonic soil borings (600-SB-01 through 600 SB-08, Figure 5.1) yielding 6-inch inner cores will be installed through the 600 Area HWMU Closure cap and peripheral area to assess subsurface contamination to the depth of bedrock at 160 feet bgs. Four Closure borings will be installed through the cap as follows: the center of the southeast Closure cell (600-SB-1); the former HWMU discharge location near the south corner of the Closure within the footprint of the former impoundment (600-SB-02); the former discharge location for the hazardous waste transmission line within the impoundment footprint, which is also adjacent to the former overflow pipe between the two former impoundment cells (600-SB-03); and, the center of the northwest Closure cell (600-SB-04). Four perimeter borings will be installed adjacent and outside of the north (600-SB-08), south (600-SB-06), east (600-SB-05), and west (600-SB-07) corners of the closure. Multiport soil vapor wells will be installed at each of the soil boring locations during the removal of drill casing to identify and quantify any vapor constituents within and around the Closure.

Soil borings 600-SB-01 to 600-SB-04 that penetrate the Closure are located inside the footprint of the former impoundments, and are planned to further characterize the nature and extent of contamination beneath the interior of the impoundments where liquid wastes were most likely to accumulate, infiltrate, and percolate through the vadose zone. These four borings are anticipated to penetrate the mixed soil/sludge layer documented in the 600 Area Closure Report (Appendix 1). The four peripheral borings 600-SB-05 to 600-SB-08 will allow the comparison of soil and soil vapor sample results inside and outside of the former footprint of the impoundment cells below the Closure. The rotosonic cores planned for the soil borings will also provide detailed information on site stratigraphy and soil geotechnical parameters, which will be beneficial relative to the interpretation of soil vapor results and can be considered during the design of an SVE system if necessary. To minimize the influx of any precipitation or surface water to the boring during the drilling activities, each boring will be securely covered with plastic sheeting and a clean fill berm will be constructed around the boring to prevent potential run-on.

Following the installation of soil borings, a multiport soil vapor well will be installed within each boring inside of the over-ride casing (Figure 5.2). Soil vapor well construction will be based on several design parameters discussed in DBSA (1995). Each well will comprise four sample ports that are located with the objective of providing vertical delineation of the vadose zone. Sample ports will be located at approximately 40 to 50-foot intervals. The uppermost port will be located within the upper 10 to 15 feet of the well immediately below the level of the former impoundment cells. The lowest port will be located toward the base of the boring in the vicinity of bedrock at 150 to 155 feet. The remaining zone(s) in the well will be strategically placed at intermediate intervals or at any horizons of specific interest as identified during lithological logging and/or field headspace screening.

Each soil vapor port in the monitoring system will comprise 0.25-inch diameter type 304 stainless steel sampling tubing, secured to the outside of a central 1 to 2-inch diameter Schedule 80 PVC flush thread support tube. Nylon cable ties will be placed every five feet to effectively secure the stainless steel tubing to the support tube. The end of each length of tubing is secured at the desired monitoring depth for each port and fitted with a porous high-density polyethylene (HDPE) filter. The tube from each soil vapor sampling port is permanently labeled at the surface with the appropriate sampling port depth. The surface connection for each sampling port is comprised of a 0.25-inch stainless steel union, part number SS-QC-4-D 400. Preliminary soil gas well designs will be provided to the NMED immediately following completion of the soil boring and prior to installation via email or FAX for review and approval. It is

anticipated that the well designs can be reviewed and approved as the drilling subcontractor prepares for well installation. Multiport soil gas wells will be installed following the installation of each individual borehole to minimize the mobilization of equipment across the Closure and reduce the potential for any Closure damage.

Once the multiport well has been installed through the outer 7 5/8” drive casing, annular materials will be installed between the multiport well and the eight-inch diameter boring through a 1.5-inch diameter tremie pipe to prevent bridging. Annular material emplacement will be performed in stages by adding calculated volumes of annular materials into a calculated volume of boring. The over-ride casing will be gradually removed from the boring as the annular materials are added to prevent collapse of the boring. The boring will be sounded continually during the backfilling procedure, and the various footages for annular materials recorded in the well construction diagram. Any bridging effects during the annular material emplacement will be addressed and resolved prior to the emplacement of any additional materials.

Hydrated bentonite chips will be placed at the base of the boring and continued to the base of the sand at the lowermost monitoring zone at approximately 150 to 155 feet bgs. Annular materials at each soil vapor monitoring zone will consist of approximately five feet of Colorado Silica sand (10/20 mesh) centered on each soil vapor sampling port. A 10-foot plug comprising hydrated bentonite chips will be placed below and above each monitoring zone to seal the zone. Between the bentonite plugs separating individual monitoring zones, the annulus will comprise a cement grout with 5% bentonite by weight. NASA contractor and drilling subcontractor personnel will exercise their best professional judgment when determining and installing the intervals of cement grout annulus. Seepage of the grouted material into the formation is undesirable, particularly within the coarser and more permeable intervals of the alluvial formation. The use of expanded intervals of bentonite chips may be required under certain lithological conditions. Above the uppermost soil vapor monitoring zone anticipated at approximately 10 to 15 feet bgs, hydrated bentonite and cement will be installed to the surface.

Following well and annular material installation, a six-inch diameter steel vault will be permanently installed to protect the multiport well materials. A four-foot square cement pad that slopes away from the well (2 inches in height over a 2-foot distance) will be constructed at ground level. Final global positioning system (GPS) coordinates will be recorded, and the well name and pad elevation will be stamped on a brass cap embedded in each cement pad. No record is required for soil vapor monitoring wells by the Office of the State Engineer. The cap in the vicinity of the completed soil vapor wells and across the entire Closure surface will be inspected in consultation with a New Mexico Certified Geotechnical Engineer experienced with compacted closure caps. Any repairs or modifications will be made as necessary, and documented within the formal 600 Area Closure Investigation Report.

5.3 Field Sampling Methods

The suite of head space screen, soil, soil vapor, and QA/QC sampling methods proposed for each individual boring is presented in Table 5.2. Soil samples will be collected during boring installation to characterize the lithological, chemical and physical conditions in the vadose zone. The rotosonic drilling rig, casing and all down hole drilling and sampling equipment will be decontaminated using >180 °F pressurized steam prior to the start of drilling and sampling, following the installation of each boring, and upon completion of the last boring. The core barrel will be decontaminated between each individual sample collected.

Soil lithology will be determined from the core sample by the on-site geologist and logged pursuant to ASTM D 2488-00 (ASTM, 2000b). Information to be logged will include soil classification using the Unified Soil Classification System pursuant to ASTM D 2487-00 (ASTM 2000a). Detailed soil boring

logs will be prepared for each boring installed during the investigation. Soil boring logs will be recorded in the field with subsequent conversion to electronic logs using LogPlot software. At a minimum, the soil boring logs will include: general information (name, location, dates, depths, and drilling details); USCS classification; core depth intervals and recoveries; head space, chemical, and physical sample locations with identification; and, a detailed lithologic description using standard USCS criteria. Soil boring logs, boring locations, and pertinent cross-sections will be included in the final 600 Area site IR.

Core soil sampling for chemical and geotechnical parameters will be carried out pursuant to ASTM D 6914-04 (ASTM, 2004). The rotosonic drilling method allows continuous 10-foot core samples to be collected. In the event that the drilling methods has to be changed from rotosonic to Stratex® and soil sample recovery is potentially low, chemical analyses will be given priority over the geotechnical analyses. Core samples will be extruded and recovered into a new or decontaminated sample container that is chemically inert. Inert containers may include stainless steel, aluminum foil-lined core boxes, or Teflon®-lined plastic core bags. Following the collection of each sample run, the core barrels will be decontaminated using a steam cleaner or pressure washer with water temperature exceeding 180 degrees Fahrenheit.

5.3.1 Soil Vapor Head Space Screening Procedures

Prior to use, two portable field PIDs, one equipped with a 10.6 eV lamp and one with an 11.7eV lamp will be calibrated using isobutylene gas at a known concentration and ambient air readings will be recorded for a baseline. Soil vapor head space field screening procedures (Table 5.2) will be conducted in accordance with guidance from the EPA Field Screening Method Catalog, User's Guide (1988). During core sampling activities, a representative soil sample will be immediately placed in airtight Ziploc® (or equivalent) plastic bags. The soil will be agitated, and after a period of two minutes of exposure the head space soil vapors within the bags will be analyzed in the field for total ionizable volatile compounds (TIVC).

The 11.7 eV lamp will allow for the screening of trichloroethene (TCE) and tetrachloroethene (PCE), which have been identified at the low ppb level during previous investigations (Section 2.2). Field head space screening samples will be taken at two locations for each of the 10 foot core intervals during drilling advancement. The meter readings for TIVC will be recorded in the field lithologic logs along with any laboratory samples collected. Head space readings will be used to assist with the selection of soil chemical samples as applicable. Extra samples may be taken from sections of borings exhibiting significant TIVC concentrations for analysis.

5.3.2 Soil Boring Geochemical and Geotechnical Sampling

Utilizing the uppermost 10-foot dry core run for each of the planned borings, chemical soil samples will be collected from each of the four Closure borings within the sludge layer at approximately six to eight feet bgs, and directly below the base of the former impoundment cells at a depth of approximately eight to 10 feet bgs (Table 5.1). A chemical soil sample will also be collected within the upper 10 feet of dry sample for the four perimeter borings at a location supported by head space field screening.

A dry soil sample for chemical analyses will also be attempted near the bottom of all eight borings by performing a partial five-foot advance of the outer casing, and attempting to run the 10-foot core barrel through any slough and into dry native formation at the bottom of the core run. The location of chemical soil samples aside from the potentially dry samples at the base of the closure or bottom of the boring will be supported by field soil vapor screening results if applicable. Chemical soil samples at alternate locations may be collected for any of the borings in the event that a dry and uncompromised section of core becomes available for sampling. An uncompromised sample may become available in the event that

minimal infiltration of water into the top of the core barrel takes place. Low infiltration may be due to a smaller volume of water being added to the boring during outer casing advancement,or the presence of a finer grained and relatively low permeability lithology by the core barrel. These samples are anticipated to be uncommon. Two to three chemical soil sample sets are anticipated for each boring. Chemical soil samples will be sent to the analytical laboratory for the testing procedures identified in Section 5.5.

Chemical soil samples will be sent to the analytical laboratory for testing to identify VOCs by EPA Method 8260B, SVOCs by EPA Method 8270C (including low level polynuclear aromatic hydrocarbons (PAH)), total metals by TCLP metals, perchlorate by EPA Method 331.0, NDMA, DMN and Bromacil by EPA Method 607M, and nitrate/nitrite by EPA Method 300.0 or the best available method. Samples from selected borings will be tested for hexavalent chromium by EPA Method 7199. Chemical samples will be collected in laboratory-specified glass jars with Teflon lids and placed on ice for storage and transport. Volatile samples will be preserved via methanol extraction in sample containers provided by the analytical laboratory or in Encore samplers.

Geotechnical analyses will be performed on soil samples from each primary lithologic unit during advancement of the soil borings irrespective of the introduced moisture content. Where possible, geotechnical soil samples will be carefully transferred from core trays into laboratory approved sample sleeves to retain in situ texture and soil properties. If any void space exists within the sample sleeve, these areas will be carefully packed prior to sealing the ends of the container with lids with tape. The sleeves will be placed in large Ziploc® bags and labeled for porosity, bulk density, volumetric moisture content, and saturated/unsaturated hydraulic conductivity analyses. The sample sleeves will be packed horizontally on ice. An additional soil geotechnical sample for particle size analysis will be placed into two seven-inch by eight-inch (1 gallon) Ziploc® bags. Air will be evacuated from the bag, and the sample was sealed, double bagged, and labeled for particle size analyses.

The calculated porosity and the initial volumetric moisture content parameters of the geotechnical sample suite may be affected by the introduction of water, and the results will be evaluated accordingly. Between one to three geotechnical soil samples are planned for each boring. Geotechnical samples will be collected and sent to the analytical laboratory for soil classification using the testing procedures identified in Section 5.5.

5.3.3 Soil Vapor Sampling

Soil vapor samples will be collected from multiport soil vapor wells installed at the eight soil boring locations provided on Figure 5.1. Multiport soil vapor wells and the disturbed vadose zone will be allowed to equilibrate for approximately four weeks following installation. Sampling of the monitoring wells will take place following well installation, purging, and equilibration activities. Soil vapor samples will be collected pursuant to procedures outlined in ASTM D 5314-92, “Standard Guide for Soil Gas Monitoring in the Vadose Zone” (ASTM, 1993).

Soil vapor samples will be analyzed for Volatiles by EPA Method TO-15 as presented in the RCRA draft permit (2007). Method TO-15 requires that the six-liter Summa passivated canisters required for sampling soil vapor be pressure-tested to 30 pounds per square inch gauge (psig) over a period of 24 hours in the laboratory. All canisters will be certified clean by the laboratory, and all field sampling systems must be certified initially clean, with < 0.2 parts per billion by volume (ppbv) of targeted VOCs through a humid zero air certification program. Field sampling systems must also pass an initial humidified calibration gas certification (at VOC concentration levels expected in the field) with a greater than 90 percent recovery. The six-liter Summa canisters will be cleaned, evacuated, certified, and shipped by the laboratory prior to use.

Prior to sampling, the vapor port will be purged for a minimum of five minutes. Once the sampling port has been purged, the Summa sampling canister inlet port will be opened, allowing air to fill the canister to ambient pressure. After each sample is collected, the canister valve will be closed, and an identification tag attached to the canister. A chain of- custody form will be completed, and the canisters shipped to the contracted laboratory for analysis.

The moisture content of soil vapor samples will not be collected for the following reasons. First, the moisture content of soil vapor nearly always approaches 100% except at the soil surface during prolonged dry spells (Hillel, 1980). Second, the analytical method for VOC vapors (EPA TO-15) includes a drying step in the sample preparation process. This eliminates the interference of water with the VOC analysis. Third, NASA was unable to identify a soil moisture analysis method in SW-846.

5.3.4 Groundwater Sampling

Groundwater is confined at variable depths in excess of 180 feet bgs within non-fractured Tertiary Orejon andesite, and is not anticipated to be encountered under the scope of work in this Work Plan. In the unlikely event that groundwater is intercepted during advancement of the soil borings, a steam-cleaned Teflon® bailer will be lowered into the boring and a water sample will be collected if its quality is not compromised with high turbidity. Where possible, three casing volumes of groundwater will be removed from the wells prior to sampling. Groundwater samples collected with acceptable turbidity levels will be analyzed using the same methods as the chemical soil samples. Analytical methods will produce reporting limits for all analytes that will be lower than available SSLs in order to effectively evaluate results as discussed in Section 5.1.5. In addition to any groundwater samples collected in soil borings, analytical results from nearby groundwater monitoring wells will be utilized to evaluate “background” groundwater concentrations within the contaminated plume in the vicinity of the 600 Area. An evaluation of the relationships between groundwater and vapor phase contaminant concentrations is important to this investigation.

7.0 Schedule

A revised project timeline for the 600 Area Closure investigation Work Plan Addendum submittal, associated field work, and preparation of the Investigation Report is presented in Figure 7.1. The proposed schedule assumes NMED HWB approval of the Addendum to the 600 Area Closure Work Plan by October 27, 2009. Drilling subcontractor procurement activities will progress concurrently with NASA submittal of the Addendum and NMED HWB review and will also be completed by October 27, 2009. It is anticipated that drilling equipment will be mobilized to WSTF on or about October 30, 2009. Fieldwork activities will be performed between November 2, 2009 and December 18, 2009. The multiport soil gas wells will be allowed to re-equilibrate and will be purged and sampled by January 29, 2010. Final 600 Area IWP analytical data is anticipated by February 26, 2010. A formal Investigation Report detailing the results of activities conducted according to the IWP is scheduled to be submitted to NMED following the receipt and evaluation of all analytical on May 7, 2010. If modifications to the schedule are required by the NMED, the project timeline will be modified to NASA’s best ability.

Figure 5.1 Proposed Soil Boring Location Map

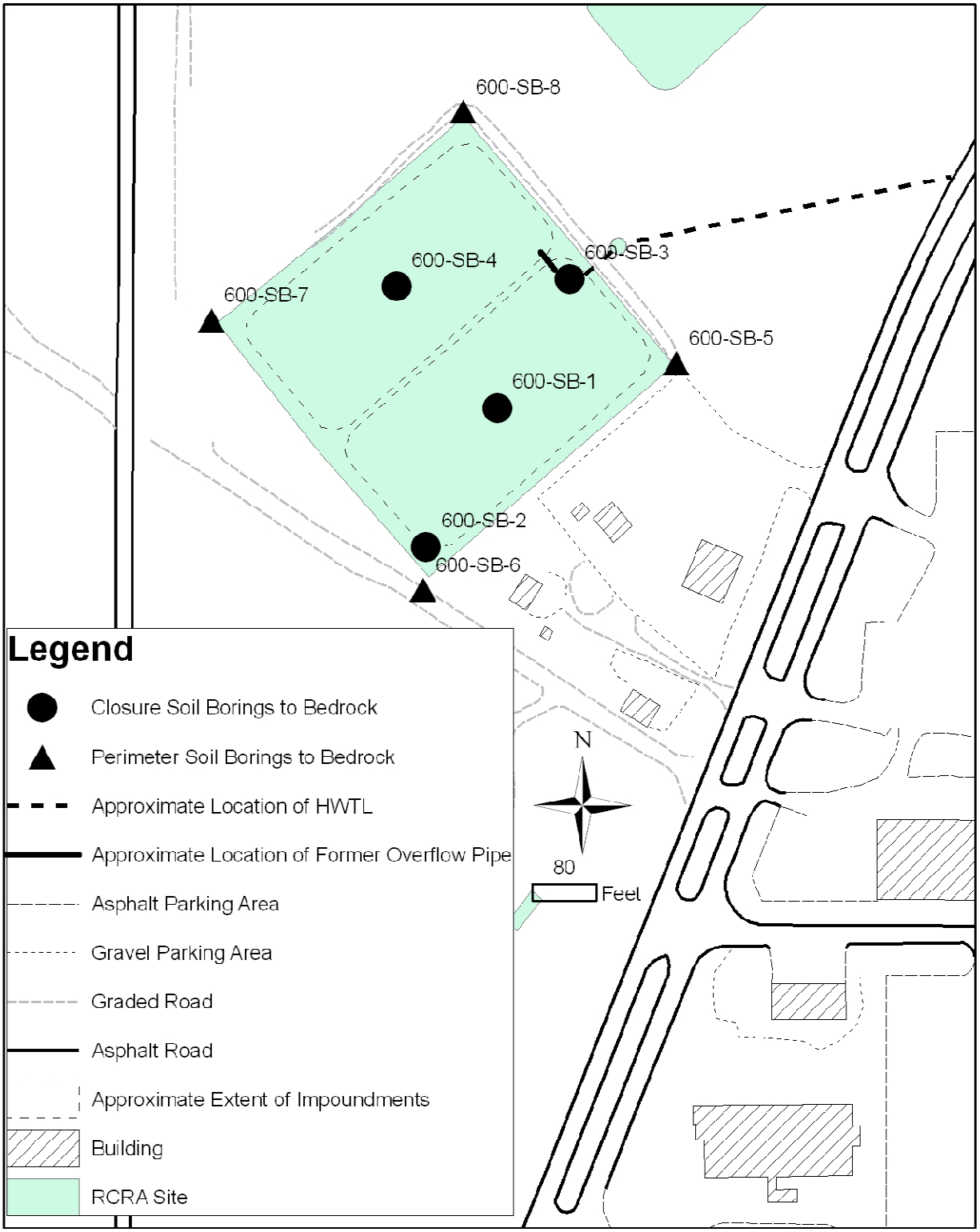


Figure 5.2 General Construction Diagram for Multiport Soil Vapor Monitoring Well

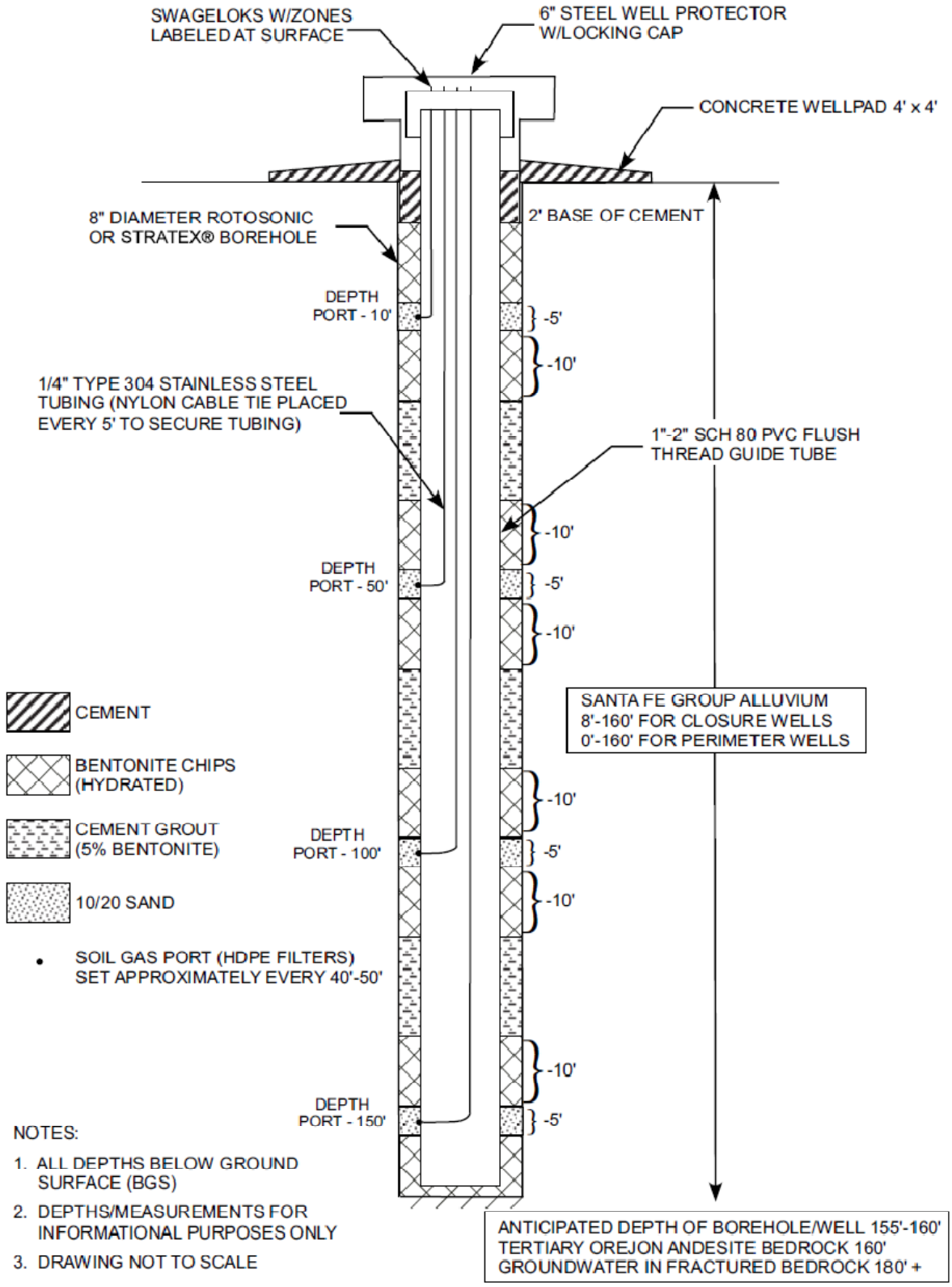


Table 5.1 Drilling and Sampling Strategy for the 600 Area Closure Soil Borings

Concepts/Concerns Associated with 600 Area Closure Drilling /Sampling	Primary Strategy : Rotosonic Drilling w/ Water	Backup Strategy: Stratex® Drilling (Dry)
Drill 6” to 8” diameter borings through unconsolidated alluvial gravels to bedrock at 160’ bgs. Install multiport soil vapor monitoring wells.	Method provides the ability to install soil vapor wells in most formations to 300’ bgs, with the benefit of providing a continuous core of the formation. Soil vapor wells installed inside the outer casing.	Provides the ability to install soil vapor wells to depths of 750’ bgs in any formation. Telescoping may be required. Provides a clean boring for soil vapor well construction. Soil vapor wells installed inside the outer casing.
Water requirement for soil boring installation	A test rotosonic boring installed adjacent to the 600 Area Closure on 9/25/09 indicated that the addition of water to the boring significantly increases the chance of successful boring installation.	No water typically required. Dry drilling to bedrock with Stratex® does not present significant problems. Clay layers with higher moisture may require the addition of water to wash cuttings from the ID of the drive pipe (due to block in the casing and increased pressures).
Advantages/disadvantages of Water	Keeps formation fines out of the annulus between the core barrel OD and the casing ID. With successful advance of the outer casing advanced to the same depth as the core barrel prior to removal of the core, no sloughing is encountered. Under dry conditions, sandy gravel cascades into the boring as the outer casing is advanced without the core barrel. Non-cohesive dry formation material cannot be removed from the boring via the core barrel.	No moisture required. No problems anticipated.

Sampling Activities	Rotosonic Drilling	Stratex® Drilling
Recovery of sloughed formation	Slough material generated when pushing the outer casing in the absence of a core barrel collects in the boring. This is impossible to retain within core barrel when dry. Effectiveness of slough recovery increased when moist.	No slough generated. Cuttings extruded through cyclone at surface using circulated compressed air.
Soil sample quality and recovery	Provides a continuous lithologic record of the formation through cores (70 – 100% recovery). Abundant sample material for geotechnical sample collection. Will allow the collection of chemical samples where water is not used (the upper 10 feet of formation), or encountered (where core barrel advances into native formation ahead of the moisture front).	Highly irregular record of lithologic, geotechnical, and geochemical samples based on the 0 – 30% recovery from drive tube sampling devices. Sample recoveries may preclude the collection of any or all of the soil samples at any given interval.
Soil vapor sample quality during boring installation	Open boring screen samples using packer assembly in dry formation not feasible. Use of water may impact integrity of soil vapor screen samples during drilling.	Airflow discharge mechanism for cuttings may preclude the collection of representative soil vapor samples during drilling.
Soil vapor well installation	Installation of soil vapor wells recommended. Multiport soil vapor wells readily installed during following drilling through the center of the drill stem.	Installation of soil vapor wells recommended. Multiport soil vapor wells readily installed during following drilling through the center of the drill stem. Rotosonic vibration during casing removal allows settling of annular materials.

Investigation Derived Waste (IDW)	**Rotosonic Drilling**	**Stratex® Drilling**
Drill Cuttings	Method produces minimal drill cuttings outside of the core barrel. Cores may be preserved in core boxes, or transferred to the one cubic yard IDW bulk bags used for the project.	Cuttings can be discharged directly to the one cubic yard IDW bulk bags utilized for this project.
Drilling Equipment	**Rotosonic Drilling**	**Stratex® Drilling**
Drilling Rig, Pipe Truck, and Associated Equipment	Drilling equipment of standard size and can be adapted to maneuver into difficult locations.	Drilling equipment generally larger and may cause an increase in disturbance of the Closure.

Table 5.2 Sample Analysis Plan for 600 Area Closure Investigation Soil Borings								
Soil Boring ID and Location[1]	**Boring Depth[2]**	**Number of Soil Vapor/Soil Samples**	**Soil Vapor/Soil Sample Collection Summary[9]**					
			Head Space[3]	**Soil Vapor[4]**	**Soil Chemical[5]**	**Soil Geotech[6]**	**Field Blanks[7]**	**Field Duplicates[8]**
600-SB-01 – Center of southeast impoundment cell	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Hexavalent Cr (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate* Lab Blank (EPA) Lab Blank (non-EPA)	Field Duplicate Matrix Duplicate
600-SB-02 - Former HWMU discharge location, south corner	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Hexavalent Cr (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate*	
600-SB-03 - Former Transmission Line discharge location, southeast impoundment cell	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Hexavalent Cr (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate*	

Table 5.2 Sample Analysis Plan for 600 Area Closure Investigation Soil Borings								
Soil Boring ID and Location[1]	**Boring Depth[2]**	**Number of Soil Vapor/Soil Samples**	**Soil Vapor/Soil Sample Collection Summary[9]**					
			Head Space[3]	**Soil Vapor[4]**	**Soil Chemical[5]**	**Soil Geotech[6]**	**Field Blanks[7]**	**Field Duplicates[8]**
600-SB-04 – Center of northwest impoundment cell	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Hexavalent Cr (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate* Lab Blank (EPA) Lab Blank (non-EPA)	Field Duplicate Matrix Duplicate
600-SB-05 - Outside impoundment, east corner	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate* Lab Blank (non-EPA)	Field Duplicate
600-SB-06 - Outside impoundment, south corner	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate*	

Table 5.2 Sample Analysis Plan for 600 Area Closure Investigation Soil Borings								
Soil Boring ID and Location[1]	**Boring Depth[2]**	**Number of Soil Vapor/Soil Samples**	**Soil Vapor/Soil Sample Collection Summary[9]**					
			Head Space[3]	**Soil Vapor[4]**	**Soil Chemical[5]**	**Soil Geotech[6]**	**Field Blanks[7]**	**Field Duplicates[8]**
600-SB-07 - Outside impoundment, west corner	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate* Lab Blank (EPA) Lab Blank (non-EPA)	Field Duplicate Matrix Duplicate
600-SB-08 - Outside impoundment, north corner	Bedrock @ 160’	Head Space Soil vapor lab (3-5) Soil chemical (3-5) Soil geotech (1-3)	Where Applicable	**X**	**X**	**X**	Field Rinsate*	

Table 5.2
Sample Analysis Plan for 600 Area Closure Investigation Soil Borings

Soil Boring ID and Location[1]	Boring Depth[2]	Number of Soil Vapor/Soil Samples	Soil Vapor/Soil Sample Collection Summary[9]					
			Head Space[3]	Soil Vapor[4]	Soil Chemical[5]	Soil Geotech[6]	Field Blanks[7]	Field Duplicates[8]

Notes:

[1] Refer to Figure 5.1 for soil boring locations

[2] Soil borings will be drilled to a depth of approximately 160 feet bgs.

[3] Analysis for TIVC using a PID equipped with a 10.6 and/or 11.7eV lamp

[4] Soil vapor samples will be collected from multiport soil vapor wells at the following approximate locations: 1) near the base of the former impoundment at 10 – 15 feet bgs; 2) near the boring TD at 150 – 155 feet bgs; and 3) 1-2 additional intermediate multiport samples. Each analysis for VOCs (EPA Method TO-15 or best available equivalent as stated in the RCRA Draft Permit (2007))

[5] Soil chemical samples to be collected at: 1) base of former impoundment; 2) boring TD; and 3) 1-3 additional screen sample. VOCs (EPA Method 8260B); SVOCs (EPA Method 8270C – including low level PAH); total metals (TCLP metals); perchlorate (EPA Method 331.0); NDMA, DMN, Bromacil (EPA Method 607M); nitrate/nitrite (EPA Method 300.0 or best available). Where applicable, hexavalent chromium (EPA Method 7199)

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

[7] Field blanks: 1 x trip blank for each VOC shipping cooler , 1 x field rinsate per boring, 1 x field rinsate per sampling day, 1 x laboratory blank per 20 samples (EPA method), 1 x laboratory blank per 10 samples (non-EPA)

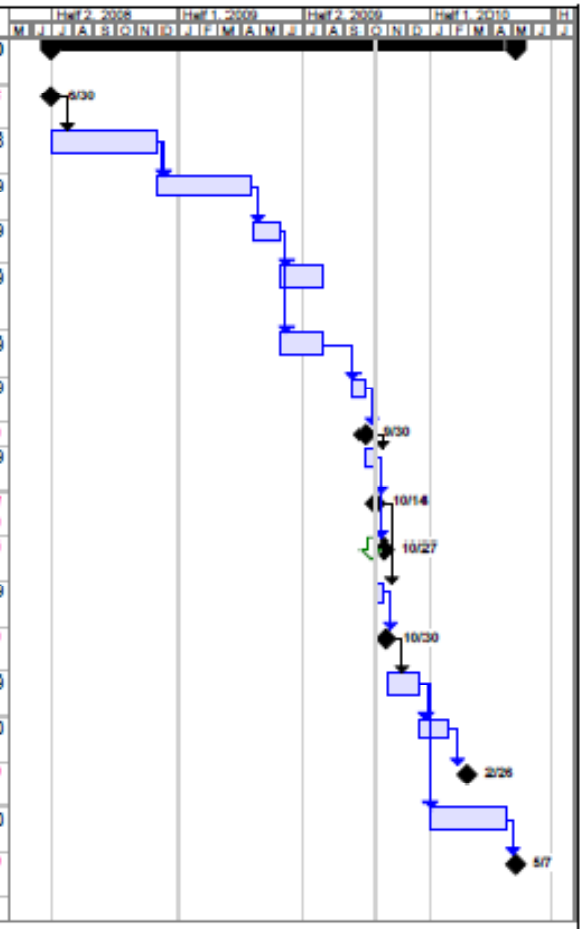
* Note one field rinsate sample per sampling day if soil boring duration is several days, one trip blank per shipping cooler

[8] Field duplicates: 1 x field duplicate per 10 samples, 1 x matrix duplicate per 20 samples

[9] A groundwater sample will only be attempted if the boring is advanced to bedrock and the water table is intercepted. Turbidity issues may preclude the collection of a sample meeting laboratory criteria for analysis

Figure 7.1 Proposed Timeline for 600 Area Closure Investigation

ID	ID	Task Name	Predecessors	Duration	Start	Finish
1	1	**600 Area Closure Investigation Work Plan Proposed Schedule**		**485 days**	**Mon 6/30/08**	**Fri 5/7/10**
2	2	*NASA Submits 600 Area Closure Investigation Work Plan for NMED*		*0 days*	*Mon 6/30/08*	*Mon 6/30/08*
3	3	NMED HWB Reviews/Provides Modifications for Work Plan	2	111 days	Mon 6/30/08	Mon 12/1/08
4	4	NASA Adresses NMED HWB Comments for two NOIDs and Resubmits Work Plan	3	99 days	Tue 12/2/08	Fri 4/17/09
5	5	Final NMED HWB Approval of 600 Area Closure Investigation Work Plan	4	30 days	Mon 4/20/09	Fri 5/29/09
6	6	Procurement of Rotosonic Drilling Subcontractor, Analytical Laboratories, and Soil Gas Field Screen Equipment	5	45 days	Mon 6/1/09	Fri 7/31/09
7	7	600 Area Closure Cap Preparatory Activities for Equipment Access & Setup	5	45 days	Mon 6/1/09	Fri 7/31/09
8	8	Initial Field Work at 600-SB-10 to Test Feasibility of IWP Strategy	+30 days	12 days	Mon 9/14/09	Tue 9/29/09
9	9	*NMED Site Visit to 600 Area Closure*	day	*0 days*	*Wed 9/30/09*	*Wed 9/30/09*
10	10	Development of Work Plan Addendum to NMED	9	9 days	Thu 10/1/09	Tue 10/13/09
11	11	*Submittal of Investigation Work Plan Addendum to NMED*	9+1 day	*0 days*	*Wed 10/14/09*	*Wed 10/14/09*
12	12	*NMED Approval of Work Plan Addendum*	+10 days	*0 days*	*Tue 10/27/09*	*Tue 10/27/09*
13	13	Re-Procurement of Rotosonic/Stratex Drilling Subcontractor	11	9 days	Thu 10/15/09	Tue 10/27/09
14	14	*Mobilization of Drilling Subcontractor*	9+3 days	*0 days*	*Fri 10/30/09*	*Fri 10/30/09*
15	15	Soil Boring Installation, Soil Sampling, and Multiport Soil Vapor Well Installation	14	35 days	Mon 11/2/09	Fri 12/18/09
16	16	Allow Multiport Wells to Re-Equilibrate, Purge and Collect Soil Vapor Samples	15	30 days	Mon 12/21/09	Fri 1/29/10
17	17	*Receive Final Analytical Data (Soil Vapor Data)*	+20 days	*0 days*	*Fri 2/26/10*	*Fri 2/26/10*
18	18	Write/Review 600 Area Investigation Report	+10 days	60 days	Mon 1/4/10	Fri 4/23/10
19	19	*NASA Submittal of 600 Area Investigation Report to NMED HWB*	+10 days	*0 days*	*Fri 5/7/10*	*Fri 5/7/10*
20	20					



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Date: Wed 10/14/09

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline