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U.S. Environmental Protection Agency
Region VII SUPR/MOKS
11201 Renner Boulevard
Lenexa, KS 66219

ATTENTION: Mr. Bradley Vann

SUBJECT: Revised Work Plan for Additional Characterization of Extent of Radiologically-Impacted Material in Areas 1 and 2 West Lake Landfill Operable Unit-1, Bridgeton, Missouri

Dear Mr. Vann,

On behalf of Cotter Corporation (N.S.L.), Bridgeton Landfill, LLC, Rock Road Industries, Inc., and the United States Department of Energy (the "Respondents"), Engineering Management Support Inc. ("EMSI") submits this Work Plan for Additional Characterization of the Extent of Radiologically-Impacted material ("RIM") in Areas 1 and 2 (the Areas 1 and 2 Work Plan, or simply "the Work Plan"). This Work Plan is being submitted in response to the request made in EPA's April 20, 2015 letter to the Respondents and in accordance with the West Lake Landfill Administrative Order on Consent, Docket No. VII-93-F-005. This Work Plan addressed comments provided by EPA on July 31, 2015 and August 21, 2015 and MDNR comments provided on July 31, 2015 on the July 6, 2015 draft version of this Work Plan.

This Work Plan is based on and incorporates the procedures set forth in the May 1, 2015 Work Plan Addendum for the Phase 1D Investigation previously prepared by EMSI, which was approved by the U.S. Environmental Protection Agency Region VII (EPA) on May 4, 2015, and the related plans, including the Core Sampling (Phase 1B, 1C and 2) Work Plan – Revision 1 (dated January 8, 2014) and related Addendums No. 1 (dated February 11, 2014) and No. 2 (dated February 27, 2014), all of which were prepared by Feezor Engineering, Inc. and others, and previously approved by EPA.

<u>Scope of Work and Objectives of the Investigation</u>

The purpose of this Work Plan is to describe the scope and procedures to be used to conduct additional investigation of the extent of RIM within Areas 1 and 2 of Operable Unit-1 (OU-1) at the West Lake Landfill.

Based on the results of evaluations presented in Attachments A and B to this Work Plan, discussions that occurred during a technical meeting at EPA's offices on May 5, 2015, and subsequent direction from EPA, twenty-five (25) additional borings will be drilled, logged and sampled, including 7 borings in Area 1 and 18 borings in Area 2. The proposed boring locations are shown on Figures 1 and 2 attached to this letter. Subject to prior coordination with and approval by EPA, the proposed drilling locations may be relocated as necessary prior to or during drilling activities based on potential physical constraints to drill rig access.

As discussed in Attachment B, the additional soil boring locations have been selected to provide further definition of the distribution of RIM containing radionuclides at levels greater than those that would allow for unrestricted use per OSWER Directives 9200.4-18 and 9200.4-25 (i.e., combined radium-226 and radium-228 greater than 5 pCi/g plus background which equates to 7.9 pCi/g total radium or combined thorium-230 and thorium-232 greater than 7.9 pCi/g that through radioactive decay would result in radium levels above the unrestricted use criteria). The additional soil boring locations have also been developed to provide additional definition of the distribution of RIM containing radionuclides at activity levels greater than the 79 pCi/g and 1,000 pCi/g criteria identified by EPA as a basis for potential partial excavation alternatives.

These borings are intended to augment the results obtained from the currently ongoing Phase 1D investigation in the southwestern portion of Area 1; the previously completed Phase 1 work (which included Phases 1A, 1B and 1C), the results of which were presented in the December 2014 report prepared by Feezor Engineering, Inc. and others (Feezor Engineering, Inc., et al., 2014a); and the results of earlier investigations of OU-1 (EMSI, 2000, McLaren Hart 1996a and 1996b, NRC, 1988 and RMC, 1982). It is expected that the results of the additional characterization of Areas 1 and 2, when combined with the results of the prior Phase 1 and Phase 1D investigations, the earlier Remedial Investigation ("RI") and the pre-RI investigations conducted by the Nuclear Regulatory Commission ("NRC"), will provide sufficient additional information to support the assessment of the extent of RIM within Areas 1 and 2 for development and evaluation of potential remedial alternatives in a Supplement to the Supplemental Feasibility Study ("the Supplemental SFS") and ultimately to support selection of a remedial action for OU-1 by EPA.

The goal of the additional characterization of Areas 1 and 2 is to obtain additional data regarding the lateral and vertical extent of radionuclide occurrences in Areas 1 and 2. Results of the field investigations (e.g., Sonic core samples, downhole gamma scans of the Sonic borings, borehole scans, etc.) will be reviewed as they are developed to assess the potential for the occurrence of RIM (based on gamma emissions from radium) at each location. Final determination of the extent of RIM will be based on review and evaluation of the results of additional Area 1 and 2 investigation activities and laboratory analyses to account for possible thorium occurrences which cannot be readily detected by the gamma scans, as well as for gamma emissions from potassium-40 which may be unrelated to possible RIM occurrences.

Field Investigation and Sample Collection and Analyses

Tasks associated with the additional investigation are anticipated to occur as follows:

1. The 25 boring locations will be surveyed and staked in the field, and on-site personnel familiar with the locations of any underground utilities or infrastructure will inspect the locations to verify the absence of utilities or infrastructure. The proposed drilling locations will be relocated as necessary prior to the start of drilling activities based on potential physical constraints to drill rig access.

   Gravel access paths will be constructed to each boring location and drilling pads at each boring location will be constructed in the same manner as those that were constructed during the Phase 1 work. Removal of aboveground portions of the existing vegetation will be required in order to construct the access roads and drill pads. The extent of the anticipated vegetation clearing is very small, approximately a quarter acre in Area 1 and approximately one acre in Area 2. Please note that a large portion of the anticipated road/drill pad construction in Area 2 is expected to occur over areas where inert fill was previously placed where no vegetation clearing is expected to be needed.

   Vegetation removal and construction of access roads and drill pads will be performed using the procedures previously employed for these activities during the prior Phase 1 and Phase 1D investigations in Area 1. Specifically, the vegetation will be cut near but above the ground surface using a “brush hog” and/or a skid steer with a forestry cutter/grinder attachment. This attachment can cut and grind woody vegetation without disturbing the underlying ground surface or vegetation roots. The vegetation cuttings will be chipped and placed on the ground surface. Any significantly sized wood vegetation (approximately 1 inch in diameter) that needs to be removed will be cut with tree shears and chipped in a wood chipper. The woody vegetation will be moistened with a water cannon prior to grinding, if necessary to minimize chipping dust. The chipped woody vegetation will be placed on the road paths prior to geotextile deployment. A geotextile will be laid on top of the cleared area and vegetation chips over which approximately 8 inches of road base material will be placed. It is anticipated that placement of the geotextile and road base material will generally occur the same day as the vegetation removal activities but in any event should be completed within two days of the vegetation clearing in any particular area.

   Adherence to these procedures will eliminate, or at the very least greatly minimize, the potential for erosion of the soil beneath the access roads, drill pads and command post areas. During the Phase 1 investigation, the brush clearing was accomplished by using a skid steer rotary brush and tree cutter. Prior to using the rotary brush cutter, a demonstration of this machine was provided to the EPA On-Scene Coordinator to show that the machine would not generate dust if operated with moist vegetation. While the natural dew provided this moisture during the demonstration, a water truck was made available during the entire clearing operation to add moisture, if needed, to the vegetation. The rotary brush cutter was attached to the front of a track-mounted

skid steer tractor, so the cutting and grinding platform advanced ahead of the tractor and operator. The operator placed the cutting surface a few inches above the ground surface, and the ground wood chips were coarsely ground and left in place. This method provided an adequate surface for the geotextile.

Vegetation clearing and road/drill pad construction activities will not be scheduled during periods when severe thunderstorms or major precipitation events (rainfall of a rate of over ½ inch per hour) are forecast for the site area or when observations by on-site personnel indicate a potential for a severe thunderstorm or major precipitation event. Additionally, on days when precipitation is anticipated to occur, placement of geotextile and road base will be coordinated to closely follow the vegetation clearing activities and the vegetation clearing will be closely monitored and/or suspended as necessary to insure that the geotextile and sufficient road base material necessary to anchor the geotextile can be placed prior to the occurrence of thunderstorms.

Particular attention will be paid to activities associated with the few locations with a possible potential for erosion to occur including those borings located on the northern edge/slope of Area 1 (e.g., proposed borings Nos. 6 and 7 [EPA locations "C" and "E"]). Clearing of vegetation and construction of roads and drill pads will not be performed in or around drilling locations Nos. 6 and 7, or at any other locations which, based on field observations by on-site personnel at the time of initial location and surveying of the drilling locations or during the site preparation work, identify a potential for soil erosion during periods when the potential for significant precipitation events exists. Additional geotextile material will be available to temporarily cover any exposed areas in the event that a significant precipitation event were to occur after the vegetation had been cut but before placement of the geotextile and associated roadbase material. Lastly, hay bales will be placed adjacent to the perimeter drainage such that they can be rapidly installed across the perimeter drainage to restrict erosional transport of soil in the event of an unanticipated precipitation event that results in potential soil erosion.

Soil that may be eroded from either of these locations could potentially be transported down the slope of Area 1 to the perimeter drainage ditch located along the south side of the main Bridgeton Landfill/Transfer Station access road. RI sediment sample location SED-1 (Figure 1) is located within this drainage ditch at the northeastern corner of Area 1 and therefore is downslope/down-drainage from the two locations (Borings Nos. 6 and 7) with the highest potential for offsite soil transport in the event a major precipitation event were to occur after the vegetation had been cut but before the geotextile and road base material has been placed. The remaining borings are located in areas where the natural surface grade and/or the presence of berms act to contain any runoff near the boring locations.

In the unlikely event that a major precipitation event were to occur after clearing of vegetation but before placement of the geotextile and road base material at a location(s) with a potential for erosion and runoff transport of eroded soil to one of

the perimeter drainage ditches, one or more sediment samples will be obtained. Sediment samples will be obtained from the three locations shown on Figures 1 and 2. These locations are proposed as a contingency, in case of a major precipitation event that could potentially erode soil from any areas subject to vegetation clearing and road/drill pad construction activities. The three sediment sampling locations (SED-1, SED-2 and SED-4) shown on Figures 1 and 2 are some of the same locations from which sediment samples were obtained during the RI. The fourth location from which sediment samples were obtained during the RI (SED-3, shown on Figure 2) was located along the northeast side of the Closed Demolition Landfill and is not proposed for sampling because transport of sediment from Area 1 or 2 would first pass through either the SED-1 or SED-2 locations, which are included in the contingent sediment sampling effort. Sediment samples would be obtained from whichever prior RI sediment sampling sites are located downstream of the potential erosional location. The sediment samples would be submitted to Eberline Laboratory for analyses of radium, thorium and uranium isotopes. The analytical results would be compared to the results obtained from the same locations during the RI sampling.

2. A drilling rig will be brought on site to drill soil borings and collect soil core samples at each location. Currently, there is only one method approved for drilling and core recovery (Sonic Drilling). A percussion geoprobe method was approved for discrete sample interval recovery. For the additional characterization work we are planning on initially using a percussion geoprobe method for the drilling and coring. Presuming this technique provides adequate core recovery, the work will be completed using this method. The percussion geoprobe is a 4” sampling machine that advances a continuous clear plastic liner within the waste mass using an outer steel casing. This system uses percussion vibration to advance the casing, then the casing sampling tube is ejected from the casing. This method does not generate any cuttings for disposal. The percussion geoprobe casings will be scanned and decontaminated between borings.

   Alternatively, a rotary auger drilling method may be employed. The rotary auger method uses a hollow stem auger with a minimum 6” outer diameter (maybe greater diameter subject to availability). The auger will be advanced with continuous samplers, and the samplers will be lined with plastic clear plastic liners which will be used inside the sample tube to retain the sample. The use of the clear plastic liners allows the visual examination of the sample in the field. The rotary auger method will generate cuttings which will be disposed within the OU-1 area next to the drilling site. The cuttings will be leveled and covered with an 8 ounce geotextile and 8 inches of gravel (the same gravel that will be used in the road building effort). The rotary auger will be scanned and dry denominated between borings.

   Both the rotary auger method and the percussion geoprobe will advance the auger / casing through the entire profile of waste. The drill rig will drill down through the solid waste materials and through approximately 5 feet of the underlying native materials, collecting continuous soil/waste samples (to the extent possible given

actual core recoveries). Once the bottom of waste has been verified, a 2" PVC pipe will be installed in the borehole to conduct the downhole gamma scan. Once the downhole gamma has been conducted, the auger / drill casing will be reinstalled to the entire depth of the boring, then the boring will be grouted in accordance with the previously approved methodology using a tremie pipe.

Use of the geoprobe or hollow stem auger drilling methods are being proposed due to potentially faster drilling rates, availability of local drilling contractors and crews which will allow for a more typical work schedule (i.e., 5 days per week rather than the 8-9 days with 4-5 day off periods required by the Sonic drilling contractor), and potential for use of multiple drill rigs if field conditions and crew/technical staff are available to support such activities. However, in the event that neither the percussion geoprobe nor the hollow stem auger drilling methods are able to penetrate the entire waste column or provide sufficient core recovery, a Sonic drilling rig will be mobilized to the site to complete the drilling and sampling. If necessary, such a change in drilling equipment in the middle of the investigation does pose a potential impact to the overall schedule (i.e., a Sonic drill rig may not be available at the time it is determined that such equipment may be required). Every attempt will be made to complete the drilling in as rapid a manner as possible without creating health and safety or data quality issues. In order to minimize potential delays due to the possible need for a change in drilling methodology, use of a Sonic rig has been included in the field schedule. Specifically, a Sonic drilling rig has been scheduled to arrive on site at the start of the third week of drilling activities such that it will be readily available in the event that the other drilling methods prove unsuccessful or otherwise are demonstrated to have limited applicability.

Because the purpose of the additional investigation of Areas 1 and 2 is to obtain additional data regarding the nature and distribution of RIM in areas where the extent of RIM was previously defined, and to provide additional laboratory analytical data to refine the understanding of the extent of RIM in these areas, the gamma cone penetrometer (GCPT) rig that was previously used during the Phase 1 and 1D investigations in Area 1 will not be required for the Area 1 and 2 investigations. The purpose of the GCPT soundings during the Phase 1 investigations was to provide the field crew with a preliminary indication of the extent of RIM based on occurrences of gamma radiation and to provide infill locations to help refine the definition of the extent of RIM in areas with limited to no prior investigatory data. Conversely, the majority of the additional borings to be drilled in Areas 1 and 2 are located within the interior portions of Area 1 and 2 inside the previously defined extent of RIM.

It is anticipated that with the exception of those items noted above (i.e., the drilling equipment), the equipment and procedures used to perform this work will be generally the same as those used to perform the Phase 1 work described in the January 2014 Phase 1B, 1C and 2 Work Plan (Feezor Engineering. Inc., et al., 2014b), the related Addendum No. 1 dated February 11, 2014 (Feezor Engineering, Inc., et al., 2014c) and the December 2014 Phase 1 report (Feezor Engineering, Inc., et al., 2014a).

3. All soil borings will be drilled through the entire waste column and into the underlying alluvium/natural materials to insure that all potential RIM at depth is identified. Upon completion of each borehole, any portion of the boring that extends below the base of refuse, will be backfilled with dry bentonite and an upper one-foot interval of sand to extend to within one foot below the base of refuse. A PVC pipe will be installed on top of the sand interval to maintain the borehole opening and the borehole will be downhole logged for gamma radiation. The collected core samples will be visually inspected (with color and appearance noted), geologically logged, and scanned for gamma radiation. Upon completion of the downhole gamma logging, the PVC pipe will be removed from the boring, the sand and dry bentonite material will be drilled out, and the entire borehole will be grouted using a tremie pipe from the bottom of the hole up to the ground surface. The final, as-drilled locations for each Sonic boring will be surveyed.

4. Based on the results of the downhole logging of the boreholes, and the visual and geologic logging and alpha and gamma scans of the core samples, grab samples will be collected from each core sample for submittal to offsite analytical laboratories for radiological, trace metal and inorganic analyses.

   Samples will be collected from the intervals with the highest alpha and/or gamma readings and/or at the discretion of the site health physicist/engineer/geologist from any intervals where visual inspection identifies potentially anomalous materials. For planning purposes, it is anticipated that two sample intervals will be selected from each boring for laboratory analyses. For cores exhibiting only one small interval (e.g., a foot or less) with elevated gamma readings, the second sample will be collected randomly. For any location at which the downhole gamma scans or core sample scans do not provide clear and sufficient data to define the lower boundary of potential RIM occurrence (e.g., where refusal was encountered at a depth where the gamma readings may potentially still be elevated), one or more samples will be obtained from the lower portion of the core material for laboratory analyses to provide data for defining the lower extent of RIM occurrence at that location.

   EPA will be provided an opportunity to collect split samples for performance of duplicate sample analyses or such other additional testing that EPA desires to conduct, subject to the availability of sufficient material from the interval(s) of interest. Priority will be given to obtaining sufficient sample volumes for the samples to be sent to the offsite laboratories for the additional characterization of Areas 1 and 2.

5. Upon completion of the core logging and gamma scan of the core material, samples for laboratory analyses will be identified, collected and shipped or otherwise delivered in batches to the analytical laboratories (as opposed to shipping all of the samples at the end of the field investigation). Upon arrival at the radiological laboratory, the samples will be dried and ground to promote homogeneity and analyzed for Radium-226; Radium-228; Thorium-230 and Thorium-232; Uranium-

234, Uranium-235 and Uranium-238; Actinium-227; Potassium-40; Protactinium-231; and Lead-210. The samples will also be analyzed for pH, Target Analyte ("TAL") trace metals, plus Scandium, Niobium, Tantalum, Sulfate, Carbonate, and Fluoride. The purpose for collection of TAL metals, transition metals (e.g., Scandium, Niobium and Tantalum), and Sulfate, Carbonate and Fluoride is to provide multiple lines of evidence to delineate and differentiate radiological constituents associated with leached barium sulfate residue ("LBSR") disposed of at the site from radiological constituents associated with other waste materials and/or naturally occurring radionuclides.

The analytical results of samples with elevated alpha and/or gamma readings will be reviewed to evaluate the potential source of the observed radiation (e.g., radium, thorium, potassium-40, etc.). Samples with radium and thorium levels above the unrestricted use criteria will also be assessed for the relative proportions of radium-226 to radium-228 and thorium-230 to thorium-232. RIM associated with LBSR should contain substantially higher levels of radium-226 and thorium-230, whereas samples containing naturally occurring radium and thorium should contain a higher proportion of radium-228 and thorium-232. Samples associated with LBSR also are likely to contain higher proportions of thorium-230 compared to radium-226, which is reflective of the secular disequilibrium in these radionuclides resulting from historic processing of ore material for uranium recovery that resulted in production of the LBSR. Additionally, chemical data will be used to further differentiate the presence of non-LBSR RIM.

It is possible that the data may not provide a basis to conclusively differentiate sources of RIM. In the event that a clear differentiation cannot be made, subsequent evaluations will presume that all occurrences of radionuclides above particular trigger levels (e.g., levels established by EPA for "complete rad removal" alternatives or for partial excavation alternatives) will be included in the scope of subsequent evaluations.

In the event that perched water is identified within the landfilled materials during drilling, an attempt will be made to collect samples of any perched water. The ability to identify possible perched water will depend upon whether water is added to the boring during drilling (water may need to be added during Sonic drilling, if Sonic drilling is used, to reduce heat generated by the Sonic drilling method). Collection of perched water samples will require stopping drilling activities to allow any perched water to flow into and accumulate within the boring and for collection of sample volumes. Samples will be collected using disposal bailers and submitted for the same analytes as are being included for the soil/waste samples (see above) plus total dissolved solids and total suspended solids.

6. Upon receipt of the laboratory analytical reports and electronic data deliverables, the data will be subjected to data validation in general accordance with the procedures set forth in the Multi-Agency Radiation Laboratory Analytical Protocol ("MARLAP") for radionuclides or EPA functional guidelines for validation of inorganic data (EPA,

2008) and entered into an electronic database with the appropriate data validation qualifiers.

7. In addition to the above analyses, samples will be collected from select locations and depth intervals for additional testing to obtain site-specific data for use in the fate and transport evaluations requested by EPA. Testing is designed to identify and distinguish the chemical composition of the materials containing radionuclides and the speciation of the radionuclides in these materials, and to provide data to parameterize the geochemical fate and transport model (EPA 2007; EPA 2010). Specifically, two samples will be collected from each of four borings in Area 1, and two samples from each of six borings in Area 2 (resulting in a total of 20 solid samples). The first sample obtained from each boring will be selected from a depth interval that displays high gamma readings (based on the gamma scans of the core samples). Analytical data from these samples will be used to evaluate the geochemistry and overall stability/leachability of the radionuclide occurrences in Areas 1 and 2. The second sample will be collected from a deeper interval that does not display elevated gamma readings. Analytical data from these samples will be used to evaluate potential attenuation of radionuclides that may be mobilized from the overlying RIM. Table 1 presents a summary of the proposed number and type of samples to be collected to support the geochemical characterization for the fate and transport evaluations. Samples will be placed in plastic bags, vacuum-sealed, and subsequently shipped to the laboratory on ice in order to preserve the *in-situ* chemical oxidation state of the samples (EPA 2006). Also, prior to analysis, samples will be air-dried and homogenized by the laboratory in a glove box.

   Table 2 presents both a summary of the proposed laboratory analyses to be performed in support of the fate and transport evaluations and the intended use of the data from each of the tests. Samples to be tested for fate and transport-related parameters will be subject to the following analyses:

   - Uranium, thorium, and radium isotopes;
   - Major cations and anions (including calcium, magnesium, sodium, potassium, barium, carbonate, sulfate, fluoride and phosphate);
   - Redox indicators (Fe(II), Fe(III), sulfide, and U(VI));
   - Total organic carbon (TOC), which assesses the levels of humic and fulvic acids that affect partitioning and mobility of radionuclides (and the longevity of potentially-reducing conditions within the landfill);
   - X-Ray Diffraction (XRD), which quantifies the abundance of major minerals (e.g. barite and/or calcite in the waste) that potentially-affect leachate composition and radionuclide speciation (XRD provides a semi-quantitative description of the

primary minerals present in a sample to corroborate the calculated mineralogy based on cation and anion analyses);

- Sequential extraction analysis, which consists of sample digestion in a series of sequential extraction steps designed to dissolve specific minerals (and associated radionuclides). Results of the sequential extractions will be used to assess the speciation of U, Ra, Th in the specific minerals within the samples (such as barite), and the concentrations of iron oxyhydroxides for adsorption. The seven sequential extraction steps selected for this study (Table 3) is based on Liu and Hendry (2011), and is designed to sequentially-remove radionuclides associated with the following: clay exchange sites, carbonate minerals, organic material, amorphous iron and manganese oxides (and secondary uranium phosphates), crystalline iron oxides, barite and finally residual minerals (including clays and primary uranium and thorium oxides). Results of the sequential extraction tests will be used to assign radionuclides to specific mineral phases and simulate solid solutions (e.g., by measuring radium, barium and sulfate in the sixth extraction step, it is possible to estimate the solid solution concentration of radium in barite);

- Electron Microprobe Analysis (EMPA), which directly evaluates the composition and grain sizes of important minerals that are potentially-present in the samples (e.g., barite, gypsum, calcite, and oxides);

- Cation-Exchange-Capacity (CEC), which estimates the potential capacity of the waste/soil to adsorb radionuclides; and,

- Sequential batch leaching tests (SBLT), which will primarily be used to evaluate the parameterization of the fate and transport model by comparing measured and simulated SBLT results. A six-step sequential batch leaching test is proposed that will consist of three tests using a synthetic landfill leachate solution [similar in composition to that expected under current conditions, that is a neutral to slightly alkaline pH, lower total dissolved solids and organic acid concentrations than those expected in much younger municipal solid waste (MSW) and organics dominated by humic and fulvic acids rather than acetic acid used in the TCLP test to simulate the early, acid-generating phase of an MSW landfill] and three tests using a synthetic precipitation leaching procedure (SPLP) leachate.

Discussions were undertaken with Hazen Research Laboratory for performance of the XRD and EMPA analyses and with Pacific Northwest National Laboratory (PNNL) for performance of the radionuclide, sequential extraction tests, and the sequential leaching tests. Based on communications with Hazen to date, it does not appear that they will be capable of performing the requested analyses with the level of quality control were are requesting. Discussions are now underway with PNNL for performance of all of the testing and radionuclide analyses. Major cation and anion and TOC analyses would be performed by Test America.

Specific sample locations/depth intervals for testing in support of the Fate and Transport Evaluations will be made from borings/core intervals that display elevated downhole gamma readings and/or elevated core scan alpha and/or gamma readings. Because the focus of the fate and transport related testing is on the occurrence, distribution and leachability of radionuclides, we expect that, subject to the availability of sufficient core material, the sample intervals selected for the fate and transport related analyses will be obtained from the same core sample intervals as the samples obtained for characterization of radionuclide occurrences.

Evaluation of the results of the testing will incorporate multiple lines of evidence that are consistent with recommendations of EPA (e.g., Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Vol. III: Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium, USEPA-600-R-07-140).

An addendum to the Phase 1 Work Plan documents or a separate stand-alone Quality Assurance Project Plan (QAPP) is being developed to address the data quality objectives, sample collection and handling procedures and laboratory analyses of samples to obtained to support the Fate and Transport Evaluations. This work plan addendum/QAPP addendum will be provided separately for EPA review and approval in advance of collection or laboratory testing of any samples obtained to support the Fate and Transport Evaluations.

EPA has indicated that completion of the 25 borings and associated sample collection and laboratory analyses required to define the extent of RIM is the highest priority for the additional investigation. Completion of work related to these tasks will have priority over performance of any other work such as the collection and analysis of samples to support the Fate and Transport evaluations. All other work, though important, is secondary and will not delay the Area 1 and Area 2 primary effort.

Other than deletion of the GCPT soundings and the changes described above, it is anticipated that all of the work will be performed in general accordance with the procedures set forth in the Phase 1 Work Plans (Feezor Engineering, Inc., 2014a, b, and c and 2013) and associated documents (e.g., Health and Safety Plans) used for the prior Phase 1 investigations.

Reporting

The progress of the field work and laboratory analyses will be reported to EPA as part of the monthly progress reports for OU-1. The as-received, un-validated results of the laboratory analyses of the samples will be included in the monthly progress reports.

Upon receipt of the laboratory analytical results, the results will be subjected to data validation. A report of the results of the additional characterization of Areas 1 and 2 will be prepared documenting the results of the field investigations and the laboratory analyses.

In addition to a narrative description of the field investigation, a summary of the field investigation results and laboratory analyses, and an updated evaluation of the extent of RIM, the data summary report for the additional characterization of Areas 1 and 2 is anticipated to also include the following information:

- Copies of the daily field logs,
- Downhole gamma scans of the Sonic boreholes,
- Final soil core geologic logs,
- Alpha and gamma scans of the soil cores,
- Photographs of the core samples,
- Chain-of-custody records,
- Analytical laboratory reports,
- Data validation reports,
- Records of radiation exit scans for workers exiting Areas 1 and 2,
- External exposure monitoring (TLD) results,
- Worker and work area related health and safety air monitoring results,
- Equipment release survey results,
- Investigative derived waste volumes and test results,
- Copies of pages from any field notebooks (to the extent they are used), and
- General photographs of the field investigation activities (if any are obtained).

Schedule

It is anticipated that the additional characterization of Areas 1 and 2, including preparation of a data summary report, will require approximately 7 months to complete from the date of EPA approval of this Work Plan Addendum.

In accordance with prior EPA requests, this Work Plan includes a calendar date schedule in addition to an estimated duration schedule. For purposes of preparing such a schedule, the Respondents initially assumed that EPA approval of the Work Plan was to have been received on or before August 31, 2015 and that the work would begin one week later (on or about September 7, 2015). Instead, however, EPA, after initially partially approving the Work Plan on September 3, 2015, directed the Respondents to delay the commencement of the mobilization and work. On September 17, 2015, EPA authorized the Respondents to begin commencing the approved portion of the work set forth in this proposed scope of work. Respondents are currently working diligently to get the respective Project Team members under contract for this work, and will commence work as soon as those contracts are finalized and executed.

The schedule for the primary activities associated with the additional characterization of Areas 1 and 2, based on this September 17, 2015 date of receipt of EPA approval to proceed is as follows:

Activity	Duration (weeks)	Estimated Completion
Mobilization	1	October 5
Construction of access paths/drilling pads	4	November 2
Drilling, geologic logging and core scanning (presumes drilling can begin within 2 weeks of the start of construction of access paths/drill pads)	10	January 4, 2016
Laboratory Analyses (begins approximately 2 weeks after the start of drilling and is completed within 6 weeks of the completion of drilling)	14	February 15, 2016
Data validation/data management (begins approximately 4 weeks after the start of laboratory analyses and is completed within 3 weeks of receipt of the final laboratory data package)	14	March 7, 2016
Data evaluation/preparation of boring logs, summary tables and figures (begins upon completion of the drilling activities and is completed within 4 weeks of receipt of the validated analytical data)	13	April 4, 2016
Preparation and internal review of draft Additional Area 1 and 2 Characterization Data Summary Report and submittal to EPA (begins upon completion of the drilling activities and is completed within 8 weeks of receipt of the validated analytical data)	17	May 2, 2016
EPA review of draft report (duration to be determined by EPA)	4	May 30
Preparation of final Additional Area 1 and 2 Characterization Data Summary Report and submittal to EPA (begins upon receipt of EPA comments on the draft report)	4	June 27
Total Duration	39	

The above schedule is estimated and subject to change based on the actual levels of effort required for each task, the availability of the drilling subcontractors and their equipment, and potential impacts from adverse weather conditions (e.g., temperature extremes, thunderstorms, high winds, or other violent weather conditions, etc. that would necessitate work stoppages or delays). Any potential change to the above schedule will be identified and discussed with EPA and followed-up with a written request to modify the schedule. In the event that it is determined that a percussion drilling rig is required to obtain samples and/or complete the borings (as was necessary for some of the Phase 1C borings), additional time will be required to complete the work.

Completion of the 25 borings and associated sample collection and laboratory analyses required to define the extent of RIM are the highest priority for the additional investigation. Sample collection will be performed upon completion of the downhole gamma logging and the geologic logging and scanning of the core samples. This work will be performed as quickly as possible subject to constraints posed by the need for personnel (e.g., rig/field geologist, health physicist, etc.) to support multiple ongoing activities. Proposed work in addition to that necessary to complete the additional investigation of Areas 1 and 2 is of secondary importance to and will not delay the completion of the additional characterization of Areas 1 and 2.

Project Team

EMSI will provide overall coordination of the field investigation, data validation and management, data evaluation, and reporting. Feezor Engineering, Inc. will be responsible for the field investigations, including all drilling, geologic logging of boreholes and core samples, and job site health and safety. Auxier & Associates will be responsible for (1) conducting downhole logging of the boreholes; (2) performing the gamma logging of the core samples; (3) in conjunction with Feezor Engineering's geologist/engineer, selecting/collecting/submitting sample intervals for laboratory analyses, (4) monitoring and documentation of radiological conditions in and around the work area; and (5) providing assistance to Feezor Engineering with implementation and monitoring of health and safety practices and radiation scanning for equipment release.

Radiological analyses of the samples will be performed by Eberline Analytical in Oak Ridge, Tennessee. Trace metal, transition metal, anion and pH analyses will be performed by Test America, St. Louis, Missouri. Laboratory analyses conducted to support the Fate & Transport Evaluations are expected to be performed by Pacific Northwest National Laboratory (PNNL) in Richland, Washington. Surveying will be performed by Weaver Consulting Group. Construction of paths and drill pads will be performed by Sharp STL Service, Inc. (or its affiliate Hunt Environmental) under supervision by Feezor Engineering, Inc. Drilling will be conducted by Roberts Drilling, and Frontz Drilling if Sonic drilling is required, both of which were the same drilling contractors used for the prior Phase 1 work. Frontz Drilling was also used for the Sonic drilling during the Phase 1D investigation.

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If you have any questions or desire additional information related to this Work Plan or any other aspect of the project, please do not hesitate to contact me.

Sincerely,
ENGINEERING MANAGEMENT SUPPORT, Inc.

Paul V. Rosasco, P.E.

Attachments:
- Table 1: Proposed Solids Testing to Support Fate and Transport Evaluations
- Table 2: Rationale for Solids Testing to Support the Fate and Transport Model
- Table 3: Sequential Extraction Procedure for Characterizing Source Materials
- Figure 1: Proposed Additional Borings in Area 1
- Figure 2: Proposed Additional Borings in Area 2
- Attachment A: Evaluation of EPA's Proposed Additional Boring Locations in Areas 1 and 2
- Attachment B: Evaluation of Potential Additional Soil Boring Locations in Areas 1 and 2

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Steven Miller - U. S. Department of Energy
Philip Dupre – U.S. Department of Justice
Joe Benco – Republic Services, Inc.
Brian Power – Bridgeton Landfill, LLC
Dan Feezor – Feezor Engineering, Inc.
Mike Bollenbacher – Auxier & Associates
Peter Carey – Peter J. Carey & Associates

Tables

Table 1. Proposed Solids Testing to Support Fate and Transport Evaluations

Fate and Transport Model Input Parameter	Description	Number of Samples					
		Area 1		Area 2			
		Radiological Waste	Underlying Refuse	Radiological Waste	Underlying Refuse	Replicate	Total
Radionuclide Concentrations	Ra-226; Ra-228; Th-230; Th-232; U-234, U-235; U-238	4	4	6	6	1	**21**
Major Cations and Anions	Barium, Calcium, Iron, Magnesium, Manganese, Potassium, Sodium, Sulfate, Carbonate, Fluoride, Phosphate	4	4	6	6	1	**21**
Redox Indicators	Sulfide, Iron(II), Iron(III), Uranium(VI)	4	4	6	6	1	**21**
Organic Carbon Content	TOC	4	4	6	6	1	**21**
Major Minerals	X-Ray Diffraction (XRD)	4	4	6	6	1	**21**
Radionuclide Speciation	Sequential Extraction Analysis[1]	4	--	6	--	1	**11**
Mineral Reactivity	Electron Microprobe Analysis (EMPA)	2	--	2	--	--	**4**
Attenuation Capacity	Cation Exchange Capacity (CEC)	4	4	6	6	1	**21**
Leachate Composition	Sequential Batch Leaching Test (SBLT)[2]	4	--	6	--	1	**11**
	SPLP Test (EPA Method 1312; pH 5.0)	--	4	--	6	1	**11**

[1]See Table 3 for a description of the sequential extraction tests.

[2]SBLT consists of 6 extractions using methodology of SPLP Test (L:S of 20:1). Extractions 1-3 use 0.05 M NaCl + 1000 mg/L humic acid (HA) at pH 7.0. Extractions 4-6 based on SPLP Test at pH 5.0 (EPA Method 1312). All extractions analyzed for U, Th, Ra, pH, cations, anions, and DOC.

[3]SPLP (pH 5; EPA Method 1312) to analyze for major cations and anions, pH, and DOC

Table 2. Rationale for Solids Testing to Support the Fate and Transport Model

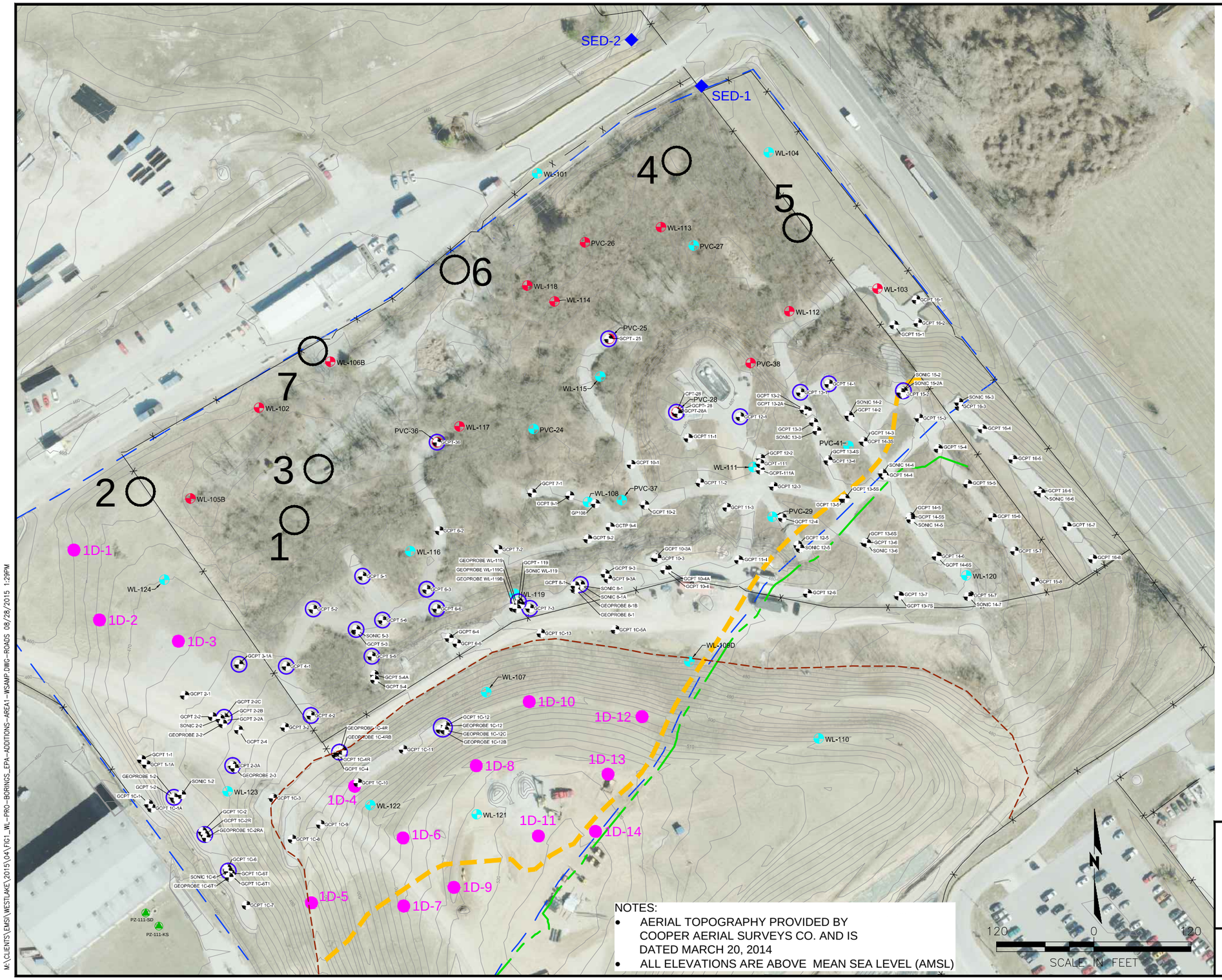
Parameter	Description	Rationale
Radionuclides	Ra-226; Ra-228; Th-230; Th-232; U-234, U-235; U-238	Initial concentrations of isotopes in model
Major Cations and Anions	Barium, Calcium, Iron, Magnesium, Manganese, Potassium, Sodium, Sulfate, Carbonate, Fluoride, Phosphate	Initial concentrations of elements in model
Redox Indicators	Sulfide, Iron(II), Iron(III), Uranium(VI)	Distribution of redox-sensitive elements between possible redox states
Organic Carbon	TOC	Initial organic carbon concentrations
Major Minerals	X-Ray Diffraction (XRD)	Corroborate mineralogical association of major cations and anions in solid samples determined through cation and anion analysis
Radionuclide Speciation	Sequential Extraction Analysis	Operationally-defined mineralogical association of uranium, thorium, and radium in solid samples
Mineral Reactivity	Electron Microprobe Analysis (EMPA)	Properties of potential radionuclide host phases (i.e. grain sizes and solid solution compositions of oxides, barite, gypsum, and/or calcite)
Attenuation Capacity	Cation Exchange Capacity (CEC)	Quantification of clay and/or organic carbon exchange sites for radionuclide adsorption
Leachate Composition	Sequential Batch Leaching Test (SBLT) of radiological depth-interval	SBLT to evaluate reactive transport model input parameters by comparing data to model-simulated leachate tests
	SPLP of refuse depth-interval	SPLP to evaluate potential leachate generated by the interaction of refuse with water

Table 3. Sequential Extraction Procedure for Characterizing Source Materials

Step	Targeted Phases	Reagant
1	Soluble / Exchangeable: Exchangeable ions	10 mL of 1 M $Mg(NO_3)_2$, pH 7, 4 hr, 25 °C + 1 water wash (10 mL)
2	Acid Soluble: Carbonates	25 mL of 1 M CH_3CO_2Na, pH 5, 6 hr, 25 °C + 1 water wash (10 mL)
3	Organics/Sulfides: Humic materials and Fe-sulfides	30 mL of 0.1 M $Na_4P_2O_7$, pH 10, 20 hr, 25 °C + 1 water wash (10 mL)
4	Amorphous Oxides: Mn-oxides, ferrihydrite, and secondary U minerals	10 mL of 0.2 M $(NH_4)_2C_2O_4$, pH 3, 4 hr, 25 °C (dark) + 1 water wash (10 mL)
5	Crystalline Oxides: Goethite and Magnetite	25 mL of 0.2 M $(NH_4)_2C_2O_4$ in 0.1 M ascorbic acid, pH 3, 0.5 hr, 95 °C + 1 water wash (10 mL)
6	Alkaline-earth sulfates: Barite	200 mL of 0.11 M Na_2EDTA + 1.7 M NH_4O_4, 4 hr, 95 °C + 1 water wash (10 mL)
7	Residual: Clays, primary U- and Th-oxides	HF-$HClO_4$ (Complete digestion)

Notes: Method based on Liu et al. (2011). All extractions use 1 gram of solid and all solutions analyzed for U, Ra, Th, pH, Fe, Mn, Ca, Ba, inorganic carbon, TDS, and SO4; Procedure includes digestion/centrifugation, wash/centrifugation, and analysis steps. Finally, steps 1 and 2 will be conducted in a glove box.

Figures



NOTES:

- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

LEGEND

1	PROPOSED SOIL BORING LOCATION AND NUMBER
	PROPOSED PHASE 1D BORING LOCATION
	PHASE 1 BORING LOCATION
	LOCATIONS WITH ELEVATED PHASE I GAMMA READINGS AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
	RI BORINGS WITH ELEVATED GAMMA AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
	RI BORINGS WITHOUT ELEVATED GAMMA AND RADIUM AND THORIUM BELOW UNRESTRICTED USE LEVELS
	BEDROCK GROUNDWATER WELL
SED-1	RI SEDIMENT SAMPLING LOCATION
	APPROXIMATE INTERSECTION OF 1971 AND 1975 TOPOGRAPHY
	EDGE OF NORTH QUARRY HIGH WALL
	APPROXIMATE AREA 1 BOUNDARY
	NORTH TOE OF ABOVE GRADE PORTION OF NORTH QUARRY LANDFILL UNIT
	FENCE
480	03-20-14 TOPOGRAPHIC CONTOUR

Figure 1

Proposed Additional Borings in Area 1

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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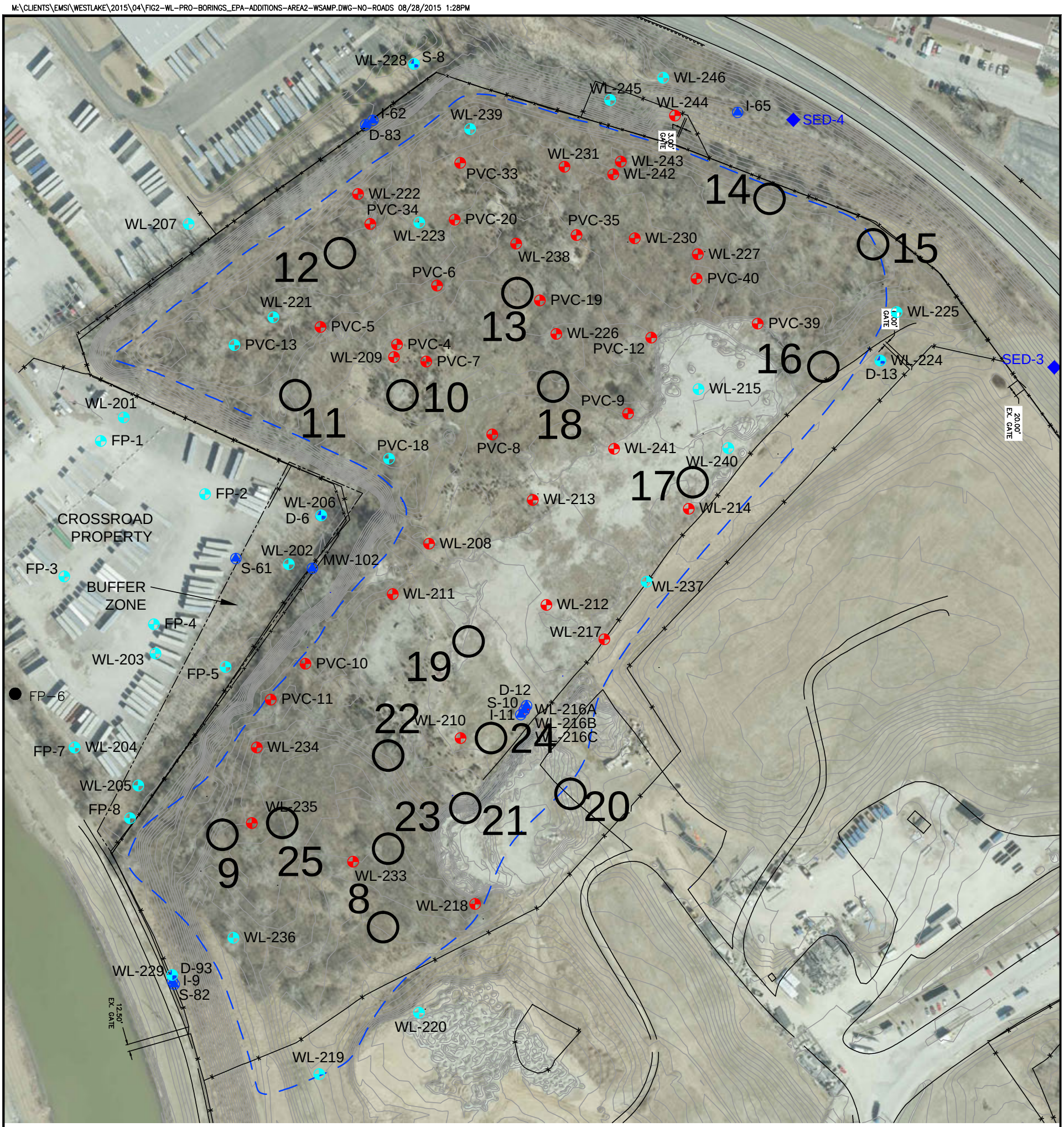

LEGEND

8	PROPOSED SOIL BORING LOCATION AND NUMBER
	RI BORINGS WITH ELEVATED GAMMA AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
	RI BORINGS WITHOUT ELEVATED GAMMA AND RADIUM AND THORIUM BELOW UNRESTRICTED USE LEVELS
SED-3	RI SEDIMENT SAMPLING LOCATION
	ALLUVIUM GROUNDWATER WELL
	AREA 2 BOUNDARY
	FENCE
	03-20-14 TOPOGRAPHIC CONTOUR

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SCALE IN FEET

Figure 2

Proposed Additional Borings in Area 2

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

Attachment A

Evaluation of EPA's Proposed Additional Boring Locations in Areas 1 and 2

Attachment A: Evaluation of EPA's Proposed Additional Boring Locations in Areas 1 and 2

EPA's April 20, 2015 letter requesting additional characterization of Areas 1 and 2 included two figures displaying proposed additional boring locations identified by EPA's Office of Research and Development (ORD) contractor Lockheed Martin. Based on discussions during a May 5, 2015 technical meeting at EPA's Region 7 offices, we understand that the locations identified in EPA's April 20, 2015 letter were not selected using any type of statistical evaluation. Instead, EPA's proposed boring locations were identified based on review of the locations of the soil borings drilled during the Remedial Investigation and the results of evaluations of the extent of Radiologically-Impacted Material (RIM) included in the Supplemental Feasibility Study (SFS) report and in the February 24, 2015 responses to EPA's comments on the preliminary volume estimates for the partial excavation options identified by EPA.

As part of the Respondents' evaluation of potential additional soil boring locations, an evaluation of EPA's proposed boring locations relative to the necessity and value of each location, specifically, whether each location was located within waste materials and/or within the extent of Areas 1 and 2 and the proximity of previous soil borings (e.g., 2013-2014 Bridgeton Landfill Thermal Isolation Barrier Phase 1 Investigation in Area 1 soil borings) was performed. The physical accessibility (i.e., drillability) of each location identified by EPA was also evaluated. Figures A-1 and A-2 of this attachment display EPA's proposed additional boring locations on the site aerial photograph. For purposes of this evaluation, letter designations (e.g., A through Y) were assigned to each of EPA's proposed 25 additional drilling locations.

Table A-1 presents a summary of the results of EMSI's evaluation of EPA's proposed drilling locations. Based on our review, we concluded that ten (10) of EPA's proposed drilling locations (five associated with Area 1 and five associated with Area 2) are located outside of the extent of waste materials (i.e., the potential RIM that may be the subject of "complete rad removal" or partial excavation alternatives) associated with Areas 1 and 2 or alternatively are located in areas that had already been the subject of additional soil borings. Specifically, three of the proposed borings associated with Area 1 (locations C, D and E on Figure A-1) are located within the area of the landfill access road/landfill office building which review of historical aerial photographs indicates that no waste materials were ever disposed and only native soil is expected to be present. (Note: Discussions during the May 5, 2015 technical meeting at EPA indicated that ORD's contractor was not provided or otherwise did not consider the boundaries of the various waste disposal units during its evaluation of potential additional boring locations.) Two additional borings associated with Area 1 (locations G and H on Figure A-1) are located in an area where additional borings were previously drilled as part of the Phase 1 investigation (Note: Discussions during the May 5, 2015 technical meeting at EPA indicated that ORD's contractor was not provided or otherwise did not review any of the information associated with the Phase 1 investigation).

Two of EPA's proposed additional boring locations associated with Area 2 (Figure A-2) are actually located outside of Area 2 within waste disposal units associated with Operable Unit-2 (e.g., within the footprint of the Closed Demolition Landfill or the Inactive Sanitary Landfill). (Note: Again, discussions during the May 5, 2015 technical meeting at EPA indicated that ORD's contractor was not provided or otherwise did not consider the boundaries of the various

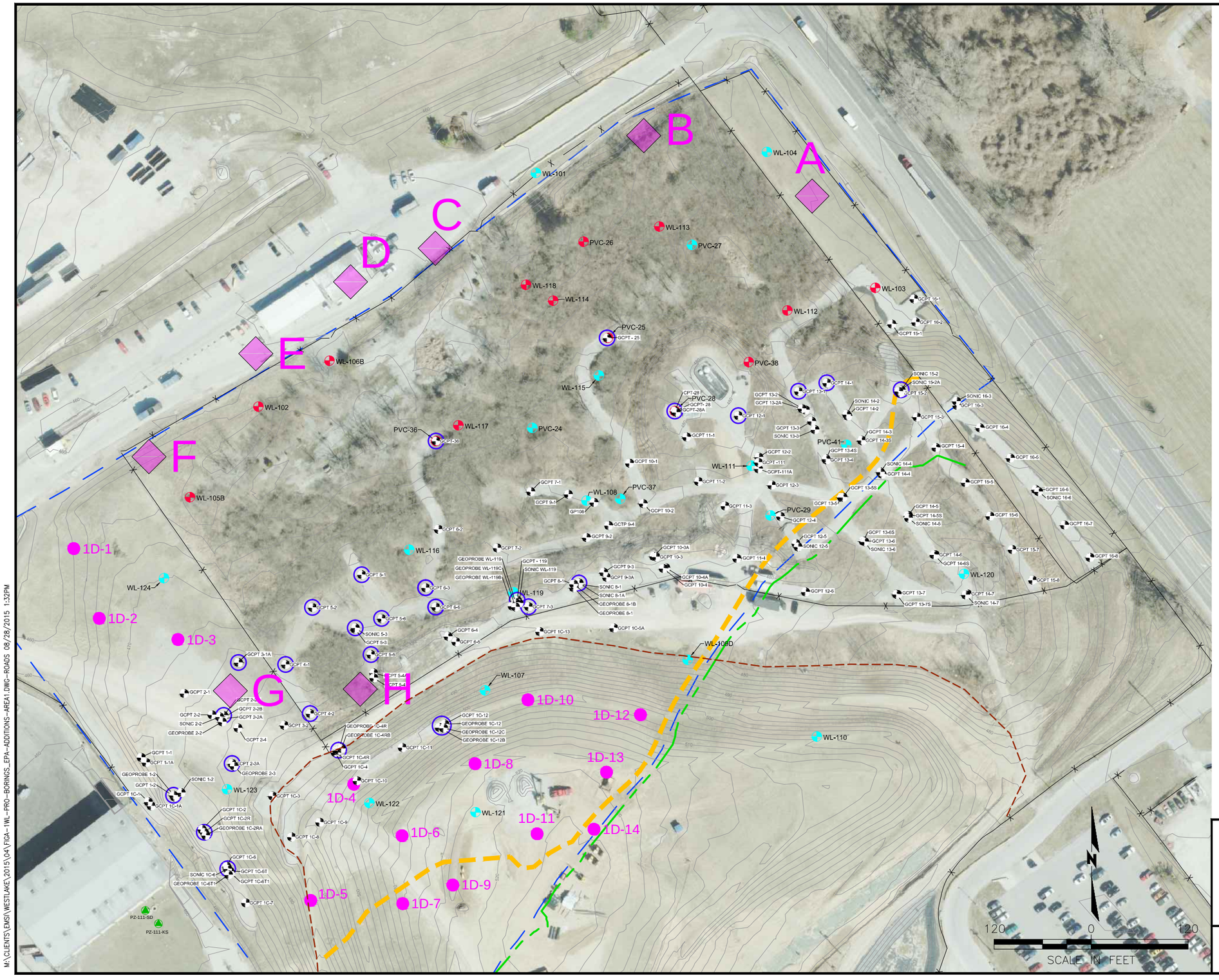
waste disposal units during its evaluation of potential additional boring locations.) Three of EPA's proposed locations for additional soil borings are located on the Buffer Zone/AAA Trailer property which are outside the extent of waste deposits associated with Area 2. Although occurrences of radionuclides have previously been detected in surface soil on these properties, such occurrences reflect historic transport of impacted surface soil from the Area 2 landfill berm onto the adjacent Buffer Zone and AAA Trailer properties. The only occurrences of radionuclides on these properties that were identified based on the RI and FS soil sampling were located within the upper 3-inches of the soil on these properties. In addition, grading activity was performed by AAA Trailer after the completion of the RI and FS soil sampling of these properties. Therefore, there is no RIM on these properties that would be the subject of either "complete rad removal" or partial excavation alternatives and soil borings are not needed to evaluate the extent of radionuclide occurrences above the unrestricted use criteria, if any, that may still be present on these properties. Consequently, it has always been expected that these properties would be treated as vicinity properties under UMTRCA and as such would be subjected to a MARSIM style free-release sampling effort during the Remedial Design phase to determine if, and where any radionuclides above unrestricted use criteria may still remain on these properties.

In addition to the 10 proposed locations identified by EPA that are located outside of the extent of Area 1 and 2 waste materials, five (5) of the locations identified by EPA are located in areas that are physically inaccessible to a drill rig including four (locations Q, T, U and V on Figure A-2) that are located on the steep slopes associated with the Area 2 landfill berm and one (location P) which is located on a steep slope beneath overhead power lines.

In conclusion, fifteen (15) of the 25 locations proposed by EPA ORD's contractor are actually located outside of the extent of waste materials associated with Areas 1 and 2 or are located in areas that are physically inaccessible by a drill rig. The remaining 10 locations (Locations A, B, and F in Area 1 and Locations I, K, L, N, O, R and S in Area 2) were considered as part of the evaluation of potential additional borings presented in Attachment B of this work plan. In addition, the proposed boring locations identified by EPA's contractor that were either located outside the extent of the waste materials or were located in areas that were inaccessible were further examined to determine if a nearby location inside of the extent of the waste materials and/or in an accessible area could potentially provide useful information (i.e., if they could be relocated into a nearby area not already covered by the prior NRC or RI borings). The results of these evaluations are described in Attachment B to this work plan.

Table A-1: Evaluation of EPA Identified Additional Soil Borings

EPA Boring No.	Recommendation	Reason
Area 1		
A	Relocate and drill	Drill at proposed boring No. 5 (see Attachment B) as EPA location A is located in native materials outside the extent of Area 1
B	Relocate and drill	Drill at proposed boring No. 4 as EPA location B is located on a steep slope at the edge of Area 1
C	Relocate and drill	EPA location in native material beneath landfill access road outside of Area 1; relocated to boring No. 6 to the southeast inside Area 1
D	Don't drill	Located in native material beneath landfill office building outside of Area 1
E	Relocate and drill	Original location in landfill access road outside of Area 1; per EPA direction relocate approximately 50 ft to the east; proposed boring No. 7
F	Relocate and drill	Drill at proposed boring No. 2 for easier access due to avoid the need for extensive vegetation clearing and road building
G	Don't drill	Characterization of this area already completed by Phase 1 investigation
H	Don't drill	Characterization of this area already completed by Phase 1 investigation
Area 2		
I	Drill	Proposed boring No. 8
J	Don't drill	Located outside of Area 2 in inactive sanitary landfill (OU-2)
K	Drill	Proposed boring No. 20
L	Relocate and drill	Relocated to proposed boring No. 19, approximately 50 - 75 ft to the northwest to avoid having to drill through a large concrete rubble pile
M	Don't drill	Located outside of Area 2 in closed demolition landfill (OU-2)
N	Drill	Proposed boring No. 16
O	Drill	Proposed boring 15
P	Relocate and drill	Location inaccessible due to steep slope and presence of overhead powerlines; relocated to boring No. 14 inside of Area 2 fence
Q	Relocate and drill	EPA location on steep slope along north side margin of Area 2; relocated to the south to boring No. 12.
R	Drill	Proposed boring No. 11
S	Drill	Proposed boring No. 10
T	Don't drill	Located on steep slope along north side margin of Area 2; prior boring PVC-18 located at top of berm in this area
U	Don't drill	Located on steep slope along north side margin of Area 2; prior boring WL-211 located at top of berm in this area
V	Don't drill	Located on steep slope along north side margin of Area 2; prior boring PVC-10 located at top of berm in this area
W	Don't drill	Location in Buffer Zone where only surficial occurrences are expected based on prior investigations, would not yield data useful to amend the volume calculations
X	Don't drill	Location on AAA Trailer where only surficial occurrences are expected based on prior investigations, would not yield data useful to amend the volume calculations
Y	Don't drill	Location on AAA Trailer where only surficial occurrences are expected based on prior investigations, would not yield data useful to amend the volume calculations



PROPOSED ADDITIONAL BORINGS

PROPOSED ADDITIONAL EPA BORING LOCATION

LEGEND -EXISTING CONDITIONS

- PHASE 1 BORING LOCATION
- LOCATIONS WITH ELEVATED PHASE I GAMMA READINGS AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
- RI BORINGS WITH ELEVATED GAMMA AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
- RI BORINGS WITHOUT ELEVATED GAMMA AND RADIUM AND THORIUM BELOW UNRESTRICTED USE LEVELS
- BEDROCK GROUNDWATER WELL
- APPROXIMATE INTERSECTION OF 1971 AND 1975 TOPOGRAPHY
- EDGE OF NORTH QUARRY HIGH WALL
- APPROXIMATE AREA 1 BOUNDARY
- NORTH TOE OF ABOVE GRADE PORTION OF NORTH QUARRY LANDFILL UNIT
- FENCE
- 480 — 03-20-14 TOPOGRAPHIC CONTOUR

NOTES:

- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

Figure A-1

EPA Proposed Borings in Area 1

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WESTLAKE\2015\QA\FIGA--1WL--PRO--BORINGS_EPA--ADDITIONS--AREA1.DWG--ROADS 08/28/2015 1:32PM

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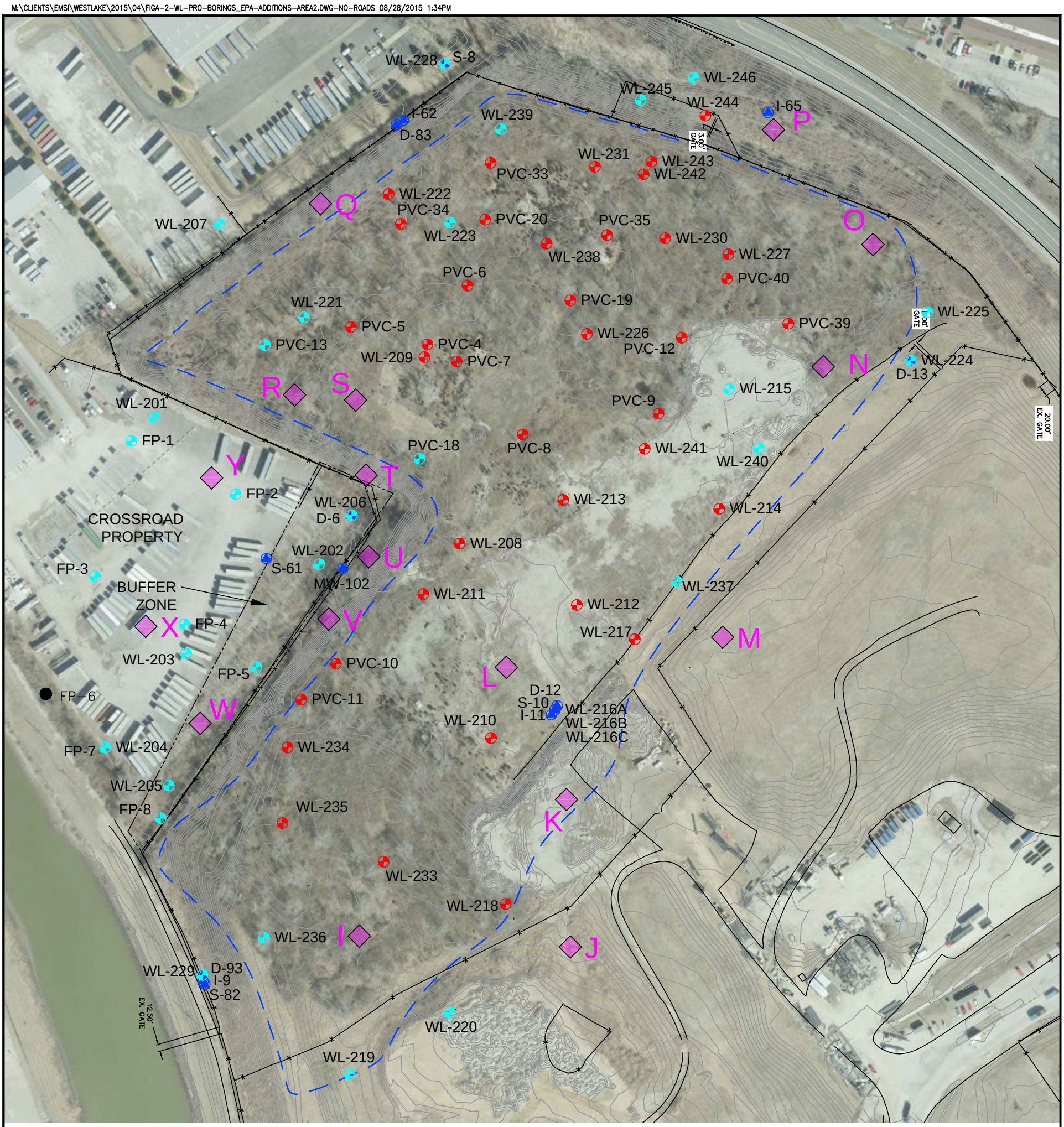

PROPOSED ADDITIONAL BORINGS

PROPOSED ADDITIONAL EPA BORING LOCATION

LEGEND - EXISTING CONDITIONS

RI BORINGS WITH ELEVATED GAMMA AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS

RI BORINGS WITHOUT ELEVATED GAMMA AND RADIUM AND THORIUM BELOW UNRESTRICTED USE LEVELS

ALLUVIUM GROUNDWATER WELL

AREA 2 BOUNDARY

FENCE

03-20-14 TOPOGRAPHIC CONTOUR

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SCALE IN FEET

Figure A-2

EPA Proposed Additional Borings in Area 2

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

Attachment B

Evaluation of Potential Additional Soil Boring Locations in Areas 1 and 2

Attachment B: Evaluation of Potential Additional Soil Boring Locations in Areas 1 and 2

EMSI evaluated potential locations for additional soil borings. Specifically, EMSI examined the results of the Supplemental Feasibility Study (SFS) [EMSI, 2011] evaluations of the extent of Radiologically-Impacted Material (RIM) containing radionuclides above the levels that would allow for unrestricted use (i.e., combined radium-226 and radium-228 activity levels greater than 5 pCi/g plus background for a total of 7.9 pCi/g or combined thorium-230 and thorium-232 activity levels greater than 7.9 pCi/g) to identify areas where larger degrees of uncertainty regarding the extent of RIM may exist. EMSI also evaluated the extent of RIM associated with the partial excavation options previously identified by EPA (i.e., 79 pCi/g or 1,000 pCi/g), described in the report titled "Estimated Volumes for Partial Excavation Options Identified by EPA, West Lake Landfill Operable Unit-1" (EMSI, 2014) and the "Responses to EPA (D. Kappleman) Comments on Preliminary Volume Estimates for EPA's Partial Excavation Options, West Lake Landfill" (EMSI, 2015) to identify areas of possibly greater uncertainty associated with the extents of RIM above the partial excavation alternative criteria selected by EPA.

Possible Additional Soil Boring Locations in Area 1

Figure B-1 presents the results of the SFS evaluation of extent of RIM above unrestricted use criteria in Area 1 (i.e., SFS Appendix B-2 Drawing 004). Please note that the SFS evaluation of the extent of RIM was conducted in 2011 prior to performance of the 2013-2014 Bridgeton Landfill Thermal Isolation Barrier Phase 1 Investigation (Feezor Engineering, Inc., et al., 2014) in Area 1 and therefore will need to be revised in the future to include the results of the Phase 1 and the currently ongoing Phase 1D investigations. Review of the previously defined extent of RIM identified four locations (indicated by the large blue dots on Figure B-1) where some uncertainty exists regarding the extent of RIM. These uncertainties arise from the distances between known occurrences of RIM and the perimeter boundary of Area 1 (e.g., outward to the Area 1 boundary from RI boring locations WL-105B, WL-112 and WL-113). Due to the overall distances between the soil borings, there also is some uncertainty regarding the interpolation of the extent of RIM between borings WL-105B, WL-124, WL-116 and PVC-36/WL-117. Therefore, four possible additional boring locations (indicated by the blue dots on Figure B-1) were identified to provide additional control on the extent of RIM above unrestricted use criteria in Area 1.

Figure B-2 presents the preliminary extent of RIM above the 79 pCi/g criteria (i.e., combined radium-226 and -228 or combined thorium-230 and -232 above 79 pCi/g) identified by EPA as a possible option for a partial excavation alternative (see Drawing 001 in the February 13, 2015 "Responses to EPA Comments on the October 31, 2014 "Estimated Volumes for Partial Excavation Options Identified by EPA"). Review of this figure identified three locations where greater uncertainty exists with respect to the extent of RIM above 79 pCi/g in Area 1 (shown by orange dots on Figure B-2). Specifically, uncertainty exists regarding the extrapolation of the extent of RIM from boring WL-105B to the edge of Area 1; relative to the interpolation of the extent of RIM between borings WL-105B, WL-124, WL-116 and PVC-36; and between borings WL-103, WL-112, PVC-38, WL-111, PVC-41 and the edge of Area 1.

Figure B-3 presents the preliminary extent of RIM above the 1,000 pCi/g criteria (i.e., combined radium-226 and -228 or combined thorium-230 and -232 above 1,000 pCi/g) identified by EPA as a possible option for a partial excavation alternative (see Drawing 002 in the February 13, 2015 "Responses to EPA Comments on the October 31, 2014 "Estimated Volumes for Partial Excavation Options Identified by EPA"). Review of this figure identified two locations where greater uncertainty exists with respect to the extent of RIM above 1,000 pCi/g in Area 1 (shown by yellow dots on Figure B-3). Specifically, uncertainty exists relative to the interpolation of the extent of RIM between borings WL-105B, WL-124, WL-116 and PVC-36; and between borings WL-103, WL-112, PVC-38, WL-111, PVC-41 and the edge of Area 1.

The various locations where additional soil borings may potentially provide data that could allow for refinement of the estimated extent of RIM in Area 1 for the "complete rad removal" or EPA's partial excavation options are summarized on Figure B-4. A total of five (5) potential additional boring locations were identified (Nos. 1 -5 on Figure B-4). With respect to the locations of possible additional borings in the southeastern portion of Area 1 (i.e., the area between the NRC borings PVC-38 and PVC-41 and the RI borings WL-103, -111 and -112), review of the potential locations relative to the previously drilled borings indicates that additional characterization was conducted in this area as part of the Phase 1 investigation (which was not performed/reported until after the SFS and preliminary volume estimates for EPA's partial excavation options were prepared). Therefore, no additional boring is needed in this area.

The potential boring locations identified by EPA were also reviewed relative to the potential additional boring locations. Review of Figure B-4 indicates that EPA proposed boring location "F" generally coincides with proposed boring location No. 2. Boring location No. 2 was selected over location "F" because drilling at location No. 2 would require no vegetation clearing and only very minimal road construction compared to the need to perform significant vegetation clearing and road construction to reach EPA-proposed boring location "F". EPA proposed boring location "B" generally coincides with proposed boring location No. 4. EPA proposed boring location A is located in an area of native soil outside of the extent of waste materials associated with Area 1 and therefore is not needed for purposes of collection of additional data in support of preparing volume estimates for either the "complete rad removal" or EPA's partial excavation alternatives. Per direction from EPA, EPA-proposed boring location "A" was relocated to the south-southwest, just inside the Area 1 fence. Therefore, proposed boring location No. 5 was relocated approximately 50-ft to the north-northeast to coincide with this location. Also per direction from EPA, EPA-proposed boring location "C" was relocated approximately 50-feet to the southeast to place it just inside the limits of the Area 1 waste materials. Proposed boring location No. 6 was added to reflect this revised location for EPA proposed location "C". With the addition of boring location No. 6, combined with the presence of prior RI borings WL-102 and WL-106B, relocation of EPA-proposed boring locations "D" and "E" to inside of Area 1 were considered unnecessary; however, EPA directed that proposed boring "E" be relocated approximately 60 feet to the east, just inside the Area 1 fence line near the location of RI boring WL-106. Proposed boring No. 7 was added at this location. The presence of numerous Phase 1 borings in the area of EPA-proposed borings "G" and "H" provided coverage at these two locations.

In conclusion, seven (7) potential additional soil boring locations have been identified for Area 1. These are identified on Figure B-4 by black circles numbered 1 – 7. The rationale for each of these boring locations is described above and is also summarized on Table B-1.

Possible Additional Soil Boring Locations in Area 2

Figure B-5 presents the results of the SFS evaluation of extent of shallow RIM above unrestricted use criteria in Area 2 (i.e., SFS Appendix B-2 Drawing 008). Please note that two generally defined depth intervals of RIM occurrences were identified in the SFS relative to Area 2, a shallow interval of more or less continuous RIM occurrences and a deeper interval of discrete occurrences of RIM beneath Area 2. Figure B-5 displays the estimated extent of RIM in the shallow interval. Review of Figure B-5 indicates five areas (shown as blue dots on Figure B-5) where some uncertainty exists relative to the extent of the shallow occurrences of RIM in Area 2, principally due to extrapolation of the extent of RIM from borings of known RIM occurrence to the margins of Area 2. These include the following

- Between RI boring WL-233 and the southern margin of Area 2;
- Between RI boring WL-235 and the southwest corner of Area 2;
- Between RI boring WL-209 to the southwest to the landfill berm and boundary of Area 2;
- Between RI borings WL-221 and WL-222 and NRC borings PVC-5 and PVC-34 to the west to the landfill berm and the boundary of Area 2; and
- From RI boring WL-227 and NRC boring PVC-40 to the northeast to the northeastern boundary of Area 2.

Figure B-6 presents a similar evaluation for the deeper occurrences of RIM in Area 2 (i.e., SFS Appendix B-2 Drawing 013). Review of this figure indicates six potential locations (indicated by the blue dots on Figure B-6) where additional soil borings may allow for a refinement in the estimated extent of RIM including:

- Between RI boring WL-235 and the western edge of Area 2;
- Between RI borings WL218, WL-235 and WL-236;
- To the north of RI borings WL-210 and WL-235;
- To the northwest of RI boring WL-214 (Note: the extent of RIM to the southeast of WL-214 is bounded by the extent of the waste deposits associated with Area 2);
- Between RI boring WL-209 and NRC boring PVC-18; and
- Between NRC borings PVC-6 and PVC-19.

Figure B-7 presents the preliminary extent of RIM associated with EPA's partial excavation option that is based on a criteria of 79 pCi/g (see Drawing 001 in the February 13, 2015 "Responses to EPA Comments on the October 31, 2014 "Estimated Volumes for Partial Excavation Options Identified by EPA"). Four possible additional boring locations (indicated by the orange dots on Figure B-7) were identified that may allow for refinement of the Area 2 extent of RIM above EPA's 79 pCi/g criteria including:

- Between RI boring WL-233 and RI boring WL-220 to the south;

- Between RI boring WL-210 and the boundary of Area 2 to the southeast;
- In the area between RI borings WL-210, WL-216, WL-212, WL-208, and WL-211 and NRC boring PVC-10; and
- Between RI boring WL-209 to the southwest to the landfill berm and boundary of Area 2.

Figure B-8 presents the preliminary extent of RIM associated with EPA's partial excavation option that is based on a criteria of 1,000 pCi/g (see Drawing 002 in the February 13, 2015 "Responses to EPA Comments on the October 31, 2014 "Estimated Volumes for Partial Excavation Options Identified by EPA"). Five possible additional boring locations (indicated by the yellow dots on Figure B-8) were identified that may allow for refinement of the Area 2 extent of RIM above EPA's 1,000 pCi/g criteria including:

- Between RI boring WL-210 and RI borings WL-218 and WL-233 to the south;
- Between RI boring WL-210 and the boundary of Area 2 to the southeast;
- In the area between RI borings WL-210, WL-216, WL-212, and WL-211 and NRC boring PVC-10;
- Between RI boring WL-209 to the southwest to the landfill berm and boundary of Area 2; and
- Between NRC borings PVC-7 and PVC-9.

In addition, EPA previously requested that an alternative RIM volume estimate be developed for Area 2, based on exclusion of the deeper intervals of RIM identified in borings WL-210 and WL-235. As an alternative to preparation of an alternative volume estimate and the resultant increase in the number of remedial alternative permutations that would need to be developed and evaluated in the Supplemental SFS report, it is proposed that additional borings be drilled at these two locations to provide data that can be used to make a decision about the presence or absence of RIM in the deeper interval at these two locations.

Lastly, the potential additional boring locations identified by EPA were reviewed relative to the potential soil boring locations identified by the above evaluations. Beginning in the southern portion of Area 2, review of Figure B-9 shows that EPA location I coincides with potential additional soil boring location No. 8. EPA-proposed location "J" is located in the Inactive Sanitary Landfill (part of OU-2) outside of Area 2 and prior RI boring WL-218 was previously drilled just inside Area 2 in this area. EPA-proposed location "K" coincides with potential additional soil boring location No. 20. EPA location "L" generally coincides with potential additional location No. 19, although location No. 19 is located approximately 50-75 ft to the northwest to avoid having to drill through a large concrete rubble pile. EPA-proposed boring location "M" is located within the area of the Closed Demolition Landfill (part of OU-2) outside of Area 2 and prior RI borings WL-217 and Wl-237 already cover the portion of Area 2 near location "M". Our evaluation did not identify a specific need for an additional boring at EPA location "N"; however, per direction from EPA, EPA-proposed boring locations that were not specifically determined to be outside of Area 2 or in undrillable locations were to be included in the identification of potential additional soil boring locations. Therefore, proposed boring No. 16 was added to address EPA location "N". EPA-proposed location "O" was not considered to be immediately necessary and was originally considered as a contingent location with a

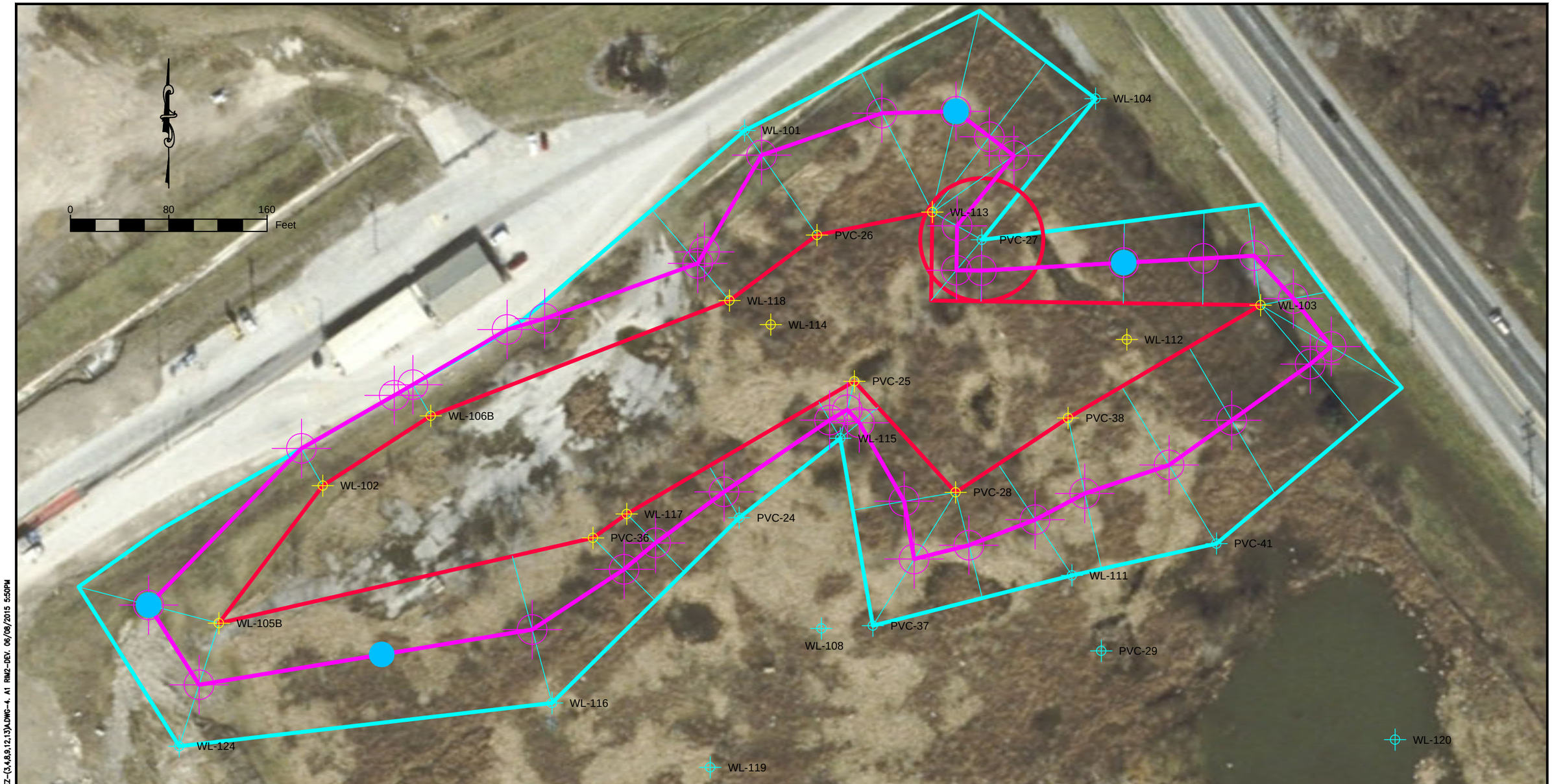
determination to drill at this location to be based on the results of the downhole and core gamma scans from proposed boring locations 14 and 16; however, EPA directed that this location be drilled regardless and therefore proposed boring location No. 15 was added.

EPA-proposed location "N" coincides with proposed boring No. 16. EPA-proposed boring location "P" is located outside of Area 2 in an area of steep slope, heavy vegetation, limited access and overhead powerlines that greatly limit the ability to drill at this location. Per direction from EPA, this location was relocated to be inside of Area 2 approximately 100 ft to the south of the original location. Proposed boring No. 14 was moved approximately 50-75 ft to the north to coincide with this location. EPA-proposed boring location "Q" is located in a heavily vegetated area with large trees on the steep northern slope of Area 2 and is therefore undrillable. This boring location was relocated to location No. 12 approximately 75 ft to the south-southeast to the top of the slope to provide an accessible location for this boring. Our evaluation did not identify a specific need for an additional boring at EPA location "R"; however, per direction from EPA, EPA-proposed boring locations that were not specifically determined to be outside of Area 2 or in undrillable locations were to be included in the identification of potential additional soil boring locations and therefore, proposed boring No. 11 was added to address EPA location "R". EPA proposed location "S" generally coincides with potential additional location No. 10. EPA-proposed boring locations "T", "U", and "V" are all located on the steep, heavily vegetated northern slope of Area 2 and relocation of these borings to the top of the slope was not considered necessary due to the presence of prior NRC and RI borings PVC-18, WL-208, WL-211, and PVC-10 at the top of the northern landfill slope in these areas. Lastly, EPA-proposed boring locations "W", "X", and "Y" are located in the Buffer Zone or AAA Trailer property outside the extent of Area 2. Although occurrences of radionuclides were previously detected in surface soils in the Buffer Zone and southern portion of the AAA Trailer property, these occurrences reportedly resulted from, and their occurrence and distribution is consistent with, historic erosion of surficial soil from the slope of the landfill berm located along the northern boundary of Area 2. Therefore, drilling at these locations will not yield data useful for revising the estimates of RIM that would be removed under either the "complete rad removal" or EPA's partial excavation alternatives. It should be noted that additional sampling to determine the current nature and extent of radionuclide occurrences in surface soil on the Buffer Zone and the AAA Trailer property were previously proposed and are anticipated to be included as part of the Remedial Design investigation and any soil containing radionuclides at levels above the unrestricted land use criteria would be identified and removed from these properties as part of any remedial actions to be undertaken at the site.

The various locations where additional soil borings may potentially provide data that could allow for refinement of the estimated extent of RIM in Area 2 for the "complete rad removal" alternative or EPA's partial excavation options are summarized on Figure B-9. A total of eighteen (18) additional boring locations were identified (Nos. 8 – 25 as shown on Figure B-9).

Table B-1: Summary Evaluation of Potential Additional Soil Borings, Areas 1 and 2

Proposed Boring No.	OU-1 Area	Rationale
1	1	Provide additional control relative to interpolation of extent of RIM above the unrestricted use criteria
2	1	Provide additional control relative to extrapolation of extent of RIM above the unrestricted use criteria near the Area 1 boundary (west of WL-105B)
		Additional control relative to extrapolation of the extent of RIM above EPA's 79 pCi/g partial excavation criteria
		Near EPA proposed location F
3	1	Provide additional control relative to interpolation of the extent of RIM above EPA's 1,000 pCi/g partial excavation criteria
4	1	Provide additional control relative to extrapolation of extent of RIM above the unrestricted use criteria near the Area 1 boundary
		Near EPA proposed location B
5	1	Provide additional control relative to extrapolation of extent of RIM above the unrestricted use criteria near the Area 1 boundary
		Near EPA proposed location A
6	1	EPA location C relocated from site access road to just inside Area 1
7	1	EPA location E relocated from site access road approximately 50 ft to the east just inside Area 1
8	2	Provide additional control relative to extrapolation of extent of RIM above the unrestricted use criteria near the Area 2 boundary
		Additional control relative to extrapolation of the extent of RIM above EPA's 79 pCi/g partial excavation criteria
		EPA proposed location I
9	2	Additional control relative to extrapolation of extent of RIM above the unrestricted use criteria in shallow and deeper intervals near the Area 2 boundary
10	2	Additional control relative to extrapolation of extent of RIM above the unrestricted use criteria in shallow and deeper intervals near the Area 2 boundary
		Additional control relative to extrapolation of the extent of RIM above EPA's 79 and 1,000 pCi/g partial excavation criteria
		EPA proposed location S
11	2	EPA proposed location R
12	2	Additional control relative to extrapolation of extent of RIM above the unrestricted use criteria in shallow interval near the Area 2 boundary
		EPA location Q relocated from steep-sloped heavily-treed area.
13	2	Additional control relative to interpolation of extent of RIM above the unrestricted use criteria in the deeper interval between PVC-6 and PVC-19
14	2	EPA location P relocated inside of Area 2, also provides control on extrapolation of extent of RIM above the unrestricted use criteria in shallow interval NE of WL-217
15	2	EPA proposed location O
16	2	EPA proposed location N
17	2	Provide additional control on the extent of RIM above unrestricted use criteria in the deeper interval found at WL-214
18	2	Additional control relative to interpolation of the extent of RIM above EPA's 1,000 pCi/g partial excavation criteria
19	2	Relocation of EPA boring L; provides additional control relative to extrapolation of the extent of RIM above EPA's 79 and 1,000 pCi/g partial excavation criteria
20	2	Provide additional control relative to extrapolation of the extent of RIM above EPA's 79 and 1,000 pCi/g partial excavation criteria
		EPA proposed location K
21	2	Additional control relative to interpolation of the extent of RIM above EPA's 1,000 pCi/g partial excavation criteria
22	2	Provide additional control on the extent of RIM above unrestricted use criteria in the deeper interval (between WL-210 and WL-234)
23	2	Provide additional control on the extent of RIM above unrestricted use criteria in the deeper interval found at WL-233
24	2	Re-drill RI boring to verify the deeper occurrences of RIM identified at WL-210 (for Area 2 revised volume calculations)
25	2	Re-drill RI boring to verify the deeper occurrences of RIM identified at WL-235 (for Area 2 revised volume calculations)



SFS "COMPLETE RAD REMOVAL" ALTERNATIVE

NON-RIM LIMIT

EXTRAPOLATED RIM LIMIT

KNOWN RIM LIMIT

West Lake Landfill Operable Unit-1	Radiological-Impacted Material (RIM) Analysis	FEEZOR ENGINEERING, INC. (Engineering for a Better World)	DATE: MARCH 2010 DESIGNED BY: APPROVED BY:	DRAWING NO.:
AREA 1 - RIM 2 Development			REVISION / DATE	**004**
PROJECT NUMBER: BT-005	FILE PATH: M:\clients\EMSI\westlake\2015\04\WL-Pro-Borings-Feez-(3,4,8,9,12,13)A.dwg			

Figure B-1

Additional Area 1 Borings for RIM Delineation
SFS "Complete Rad Removal" Alternative

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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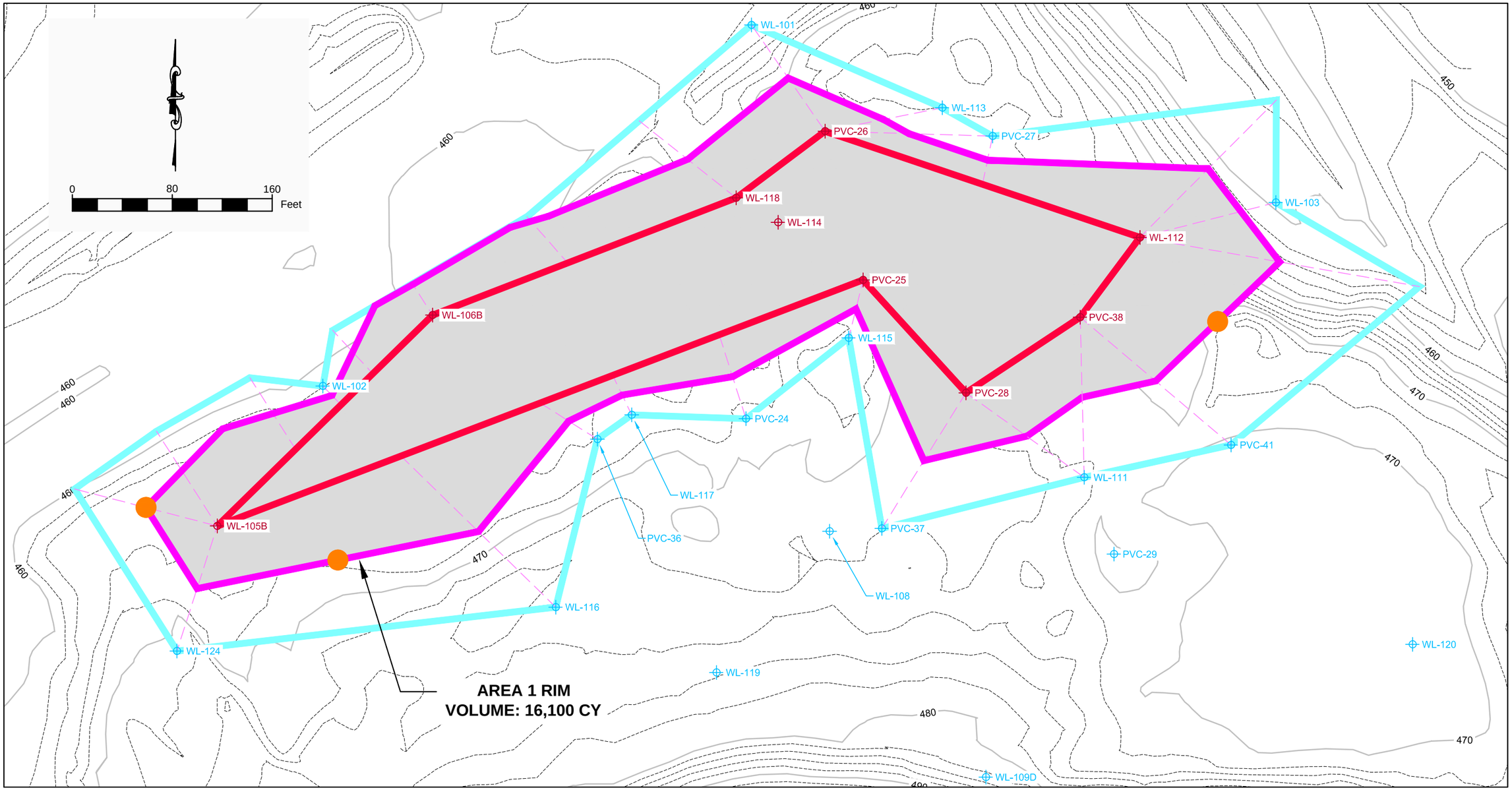

LEGEND

- 470 — 2005 TOPOGRAPHY (10' CONTOUR)
- 2005 TOPOGRAPHY (2' CONTOUR)
- BOUNDARY OF ELEVATED READINGS
- BOUNDARY OF NON-ELEVATED READINGS
- INTERPOLATED LIMITS
- EPA's 79 pCi/gm PARTIAL EXCAVATION OPTION

WEST LAKE LANDFILL 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	WEST LAKE LANDFILL OU-1 SFS ADDITIONAL STUDIES PARTIAL EXCAVATION	Engineering for a Better World FEEZOR ENGINEERING, INC.	SEPTEMBER 2014 DESIGNED BY: PML APPROVED BY: ---
SOIL ACTIVITIES GREATER THAN 79 pCi/g			REVISION DATE
PROJECT NUMBER: BT-006 FILE PATH:			

DRAWING NO.: **001**

Figure B-2

Additional Area 1 Borings for RIM Delineation
EPA's 79 pCi/gm Partial Excavation Option

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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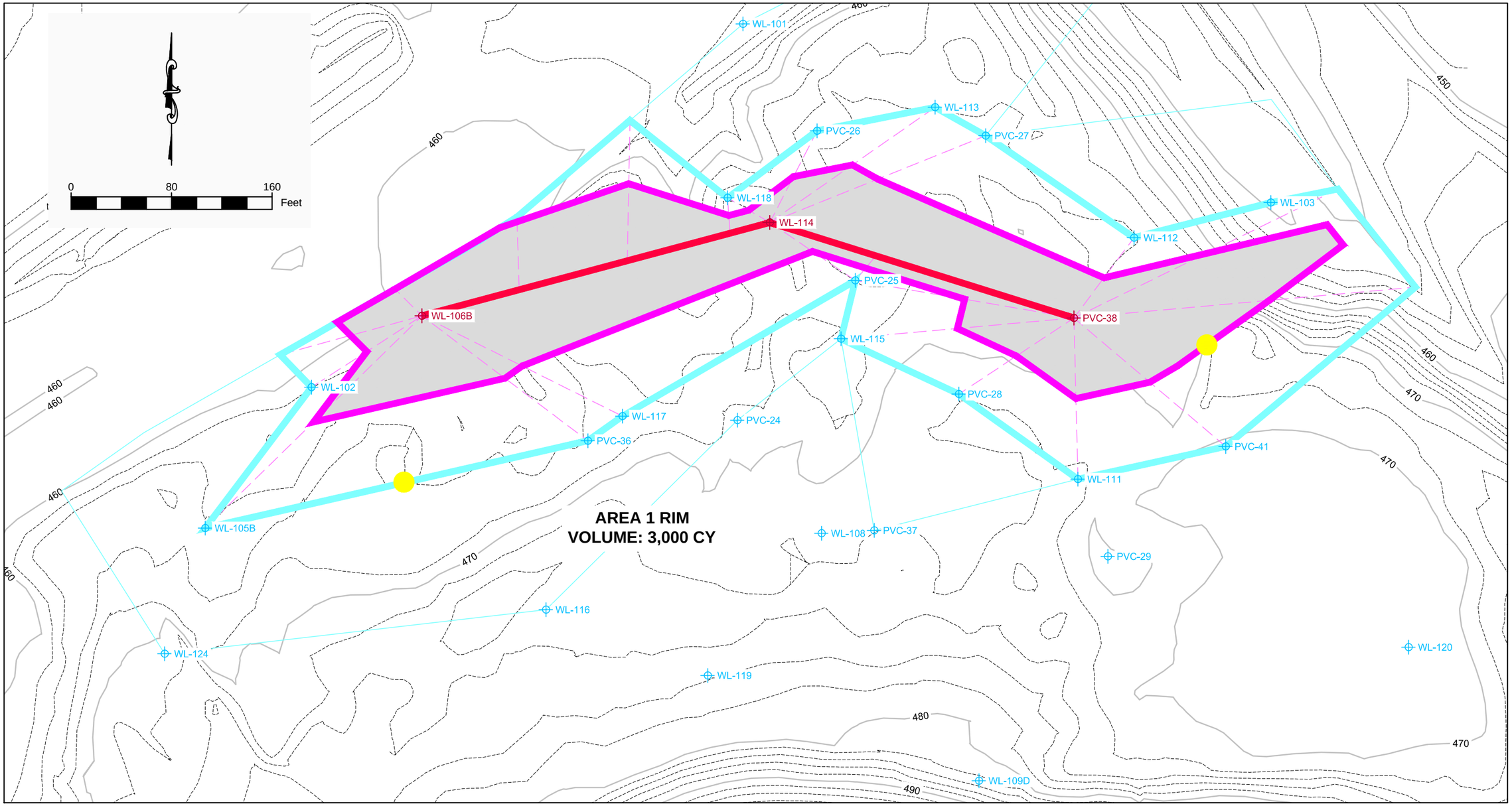

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- EPA's 1,000 pCi/gm PARTIAL EXCAVATION OPTION

WEST LAKE LANDFILL 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	WEST LAKE LANDFILL OU-1 SFS ADDITIONAL STUDIES PARTIAL EXCAVATION	FEEZOR ENGINEERING, INC. (Engineering for a Better World)	SEPTEMBER 2014 DESIGNED BY: PML APPROVED BY: ---
SOIL ACTIVITIES GREATER THAN 1,000 pCi/g			REVISION DATE
PROJECT NUMBER: BT-006	FILE PATH:		

DRAWING NO.: **002**

Figure B-3

Additional Area 1 Borings for RIM Delineation
EPA's 1,000 pCi/g Partial Excavation Option

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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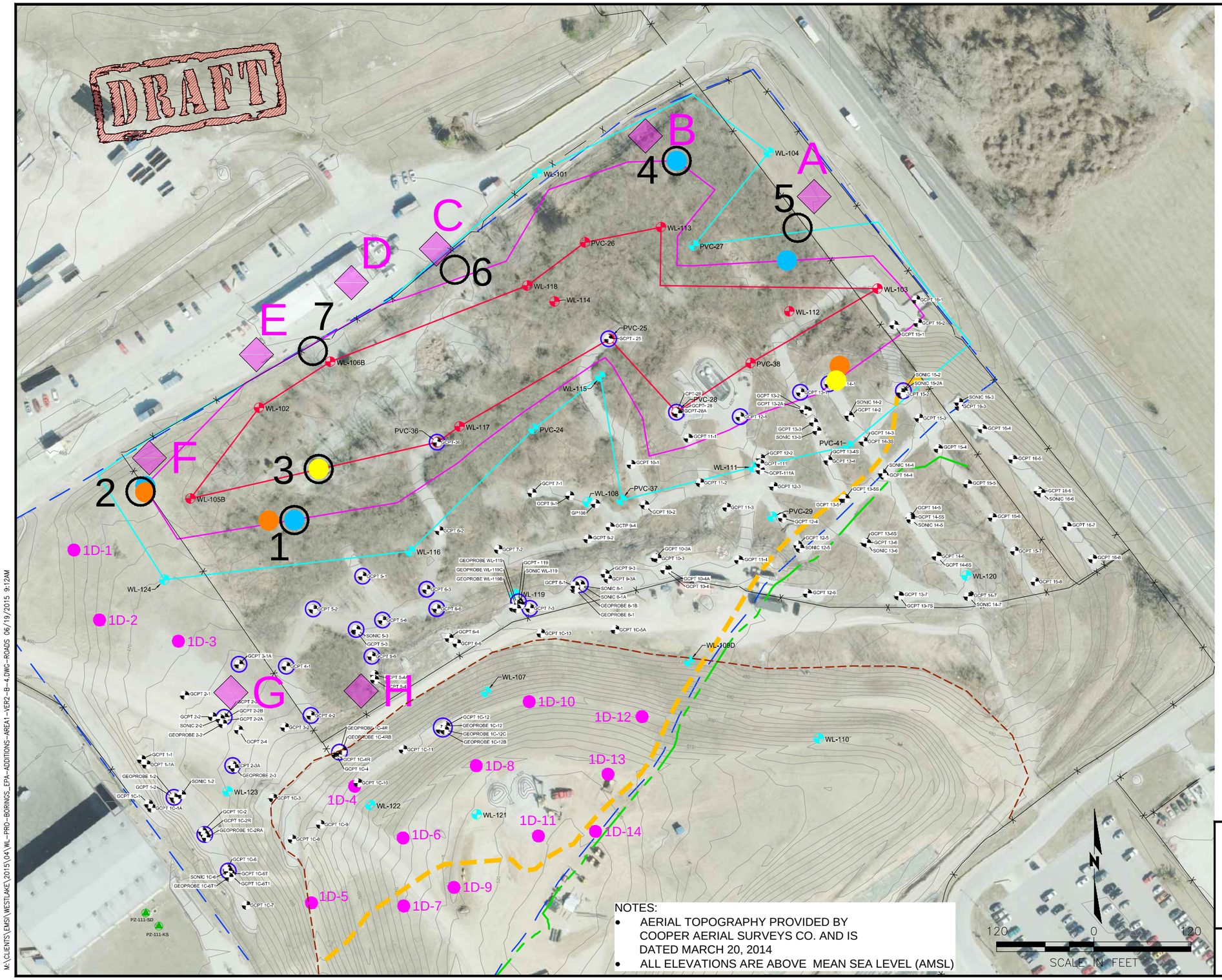

NOTES:

- AERIAL TOPOGRAPHY PROVIDED BY COOPER AERIAL SURVEYS CO. AND IS DATED MARCH 20, 2014
- ALL ELEVATIONS ARE ABOVE MEAN SEA LEVEL (AMSL)

PROPOSED ADDITIONAL BORINGS

- PROPOSED ADDITIONAL EPA BORING LOCATION
- "COMPLETE RAD REMOVAL"
- PARTIAL EXCAVATION - 1,000 Pc:/gm
- PARTIAL EXCAVATION - 79 Pc:/gm
- 1 PROPOSED SOIL BORING LOCATION AND NUMBER

LEGEND -EXISTING CONDITIONS

- PROPOSED PHASE 1D BORING LOCATION
- PHASE 1 BORING LOCATION
- LOCATIONS WITH ELEVATED PHASE I GAMMA READINGS AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
- RI BORINGS WITH ELEVATED GAMMA AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
- RI BORINGS WITHOUT ELEVATED GAMMA AND RADIUM AND THORIUM BELOW UNRESTRICTED USE LEVELS
- BEDROCK GROUNDWATER WELL
- SFS ESTIMATED MINIMUM EXTENT OF RIM
- SFS ESTIMATED EXTENT OF RIM
- SFS ESTIMATED POTENTIAL OUTER EXTENT OF RIM
- APPROXIMATE INTERSECTION OF 1971 AND 1975 TOPOGRAPHY
- EDGE OF NORTH QUARRY HIGH WALL
- APPROXIMATE AREA 1 BOUNDARY
- NORTH TOE OF ABOVE GRADE PORTION OF NORTH QUARRY LANDFILL UNIT
- FENCE
- 480 03-20-14 TOPOGRAPHIC CONTOUR

Figure B-4

Combined Rational for Proposed Additional Borings in Area 1

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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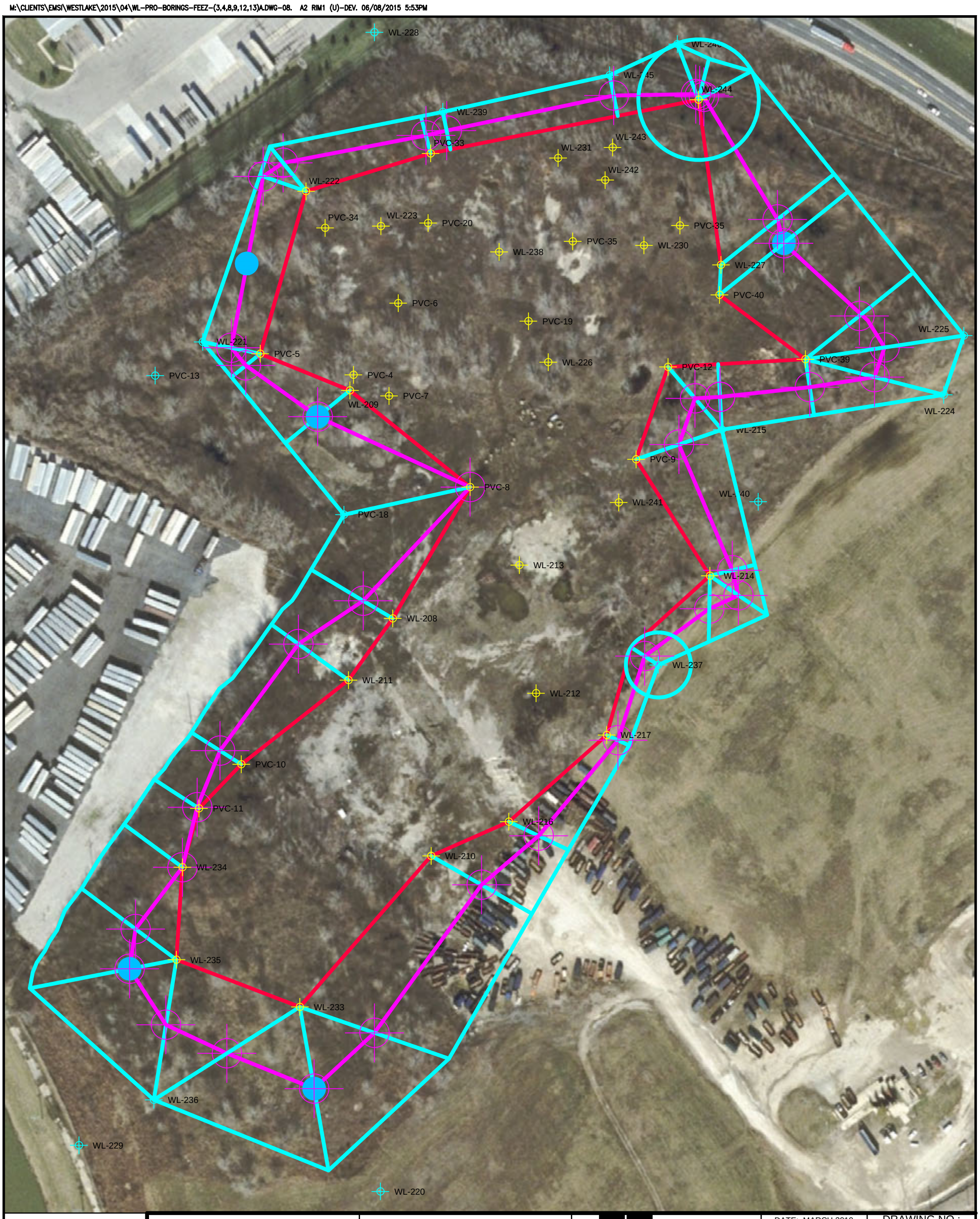

West Lake Landfill Operable Unit-1	Radiological-Impacted Material (RIM) Analysis	FEEZOR ENGINEERING, INC. (Engineering for a Better World)	DATE: MARCH 2010	DRAWING NO.:
AREA 2 - RIM 1 (Upper) Development			DESIGNED BY:	**008**
			APPROVED BY:	
PROJECT NUMBER: BT-005	FILE PATH: M:\clients\EMSI\westlake\2015\04\WL-Pro-Borings-Feez-(3,4,8,9,12,13)A.dwg		REVISION / DATE	

SFS "COMPLETE RAD REMOVAL" ALTERNATIVE

Non-RIM Limit

Extrapolated RIM Limit

Known RIM Limit

0 150 300 Feet

Figure B-5

Additional Area 2 Borings for Delineation of Shallow RIM Occurences
SFS "Complete Rad Removal" Alternative
West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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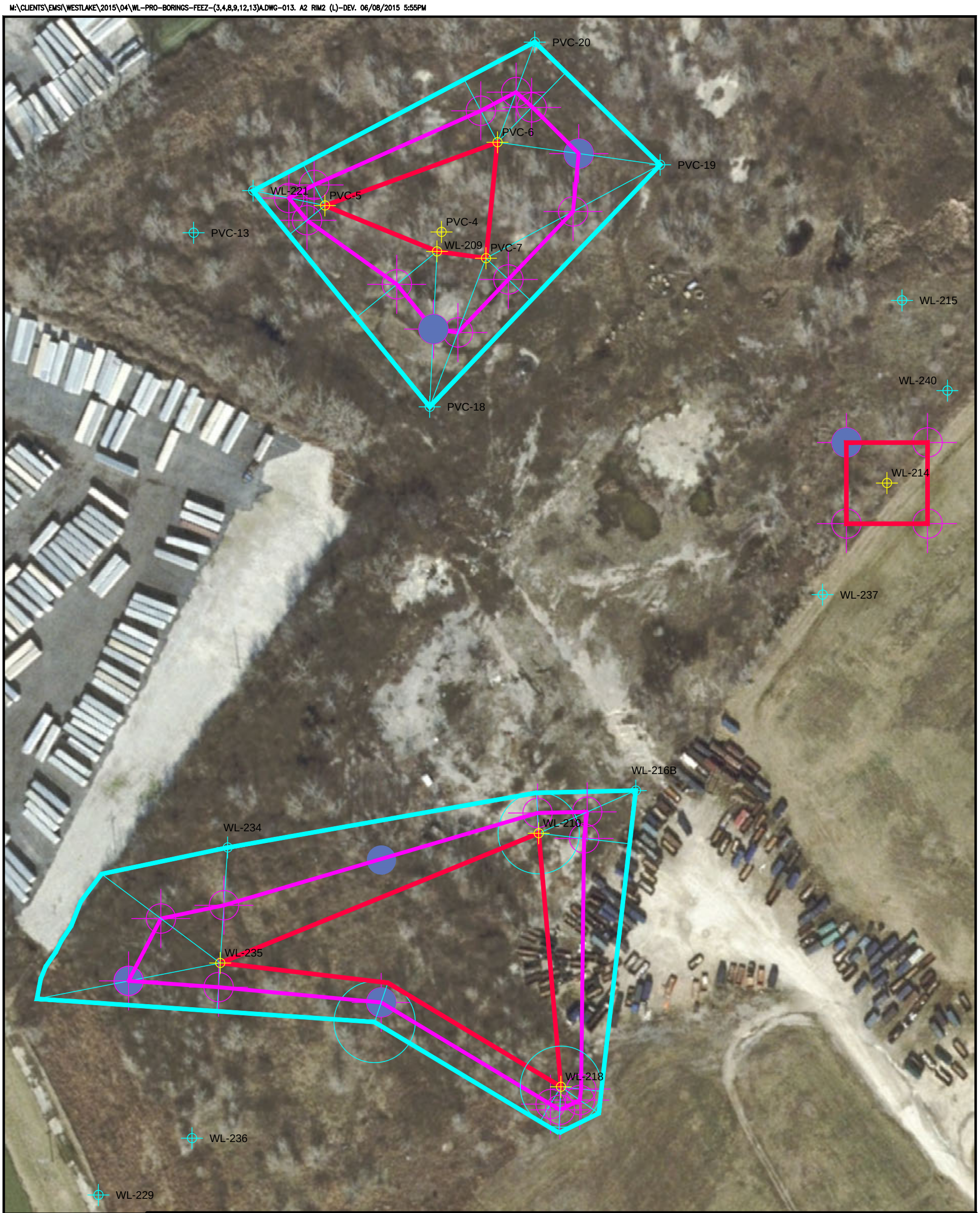

West Lake Landfill Operable Unit-1	Radiological-Impacted Material (RIM) Analysis	FEEZOR ENGINEERING, INC. Engineering for a Better World	DATE: MARCH 2010 DESIGNED BY: APPROVED BY:	DRAWING NO.:
AREA 2 - RIM 2 (Lower) Development				**013**
PROJECT NUMBER: BT-005	FILE PATH: M:\clients\EMSI\westlake\2015\04\WL-Pro-Borings-Feez-(3,4,8,9,12,13)A.dwg		REVISION / DATE	

SFS "COMPLETE RAD REMOVAL" ATERNATIVE

NON-RIM LIMIT

EXTRAPOLATED RIM LIMIT

Known RIM Limit

0 200 400 Feet

Figure B-6

Additional Area 2 Borings for Delineation of Deep RIM Occurences
SFS "Complete Rad Removal" Alternative
West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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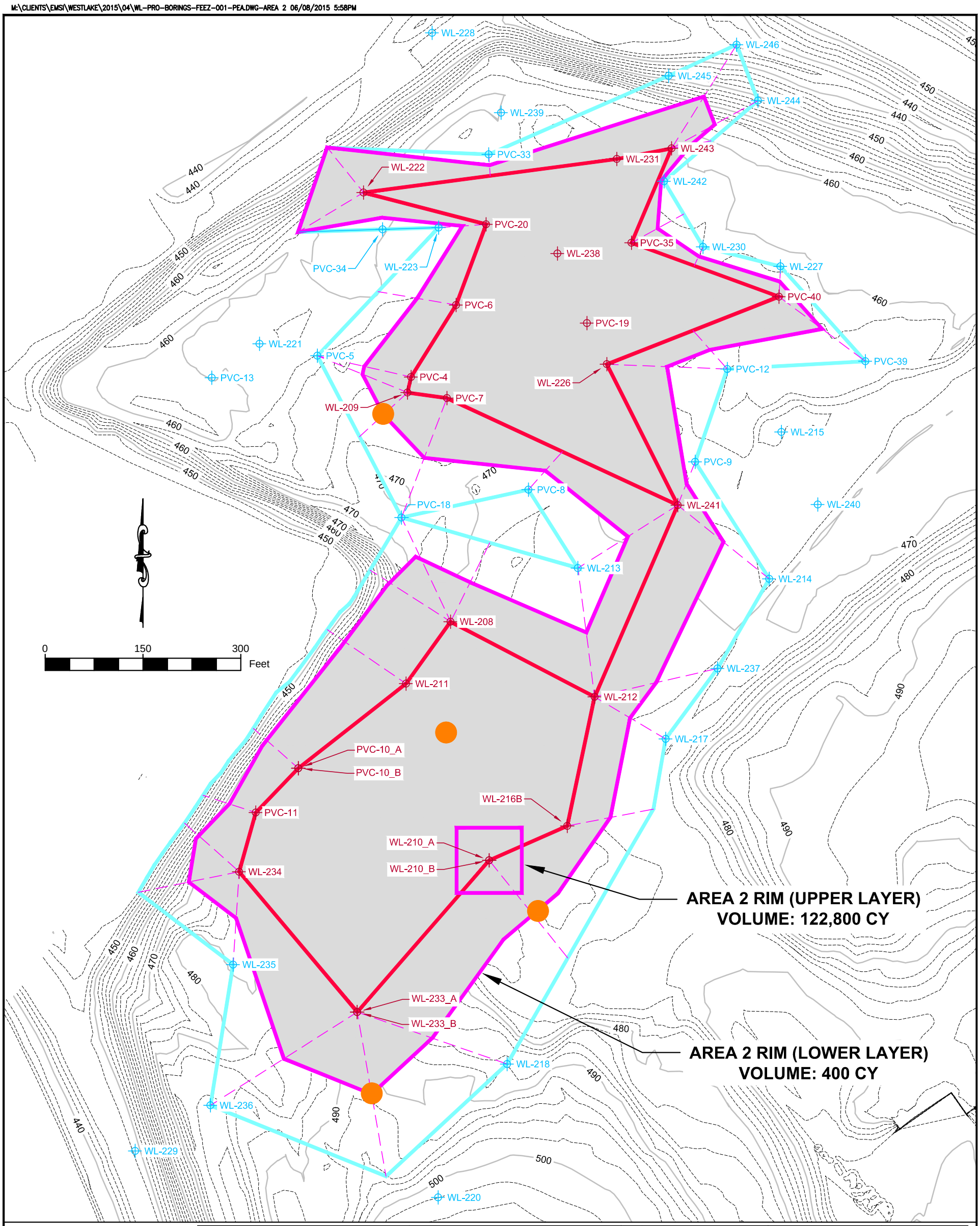

WEST LAKE LANDFILL 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	WEST LAKE LANDFILL OU-1 SFS ADDITIONAL STUDIES PARTIAL EXCAVATION	Engineering for a Better World FEEZOR ENGINEERING, INC.	SEPTEMBER 2014 DESIGNED BY: PML APPROVED BY: ---
SOIL ACTIVITIES GREATER THAN 79 pCi/g			REVISION DATE
PROJECT NUMBER: BT-006 FILE PATH:			

DRAWING NO.: **001**

LEGEND

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- BOUNDARY OF NON-ELEVATED READINGS
- INTERPOLATED LIMITS
- EPA's 79 pCi/gm PARTIAL EXCAVATION OPTION

Figure B-7

Additional Area 2 Borings for RIM Delineation
EPA's 79 pCi/g Partial Excavation Option

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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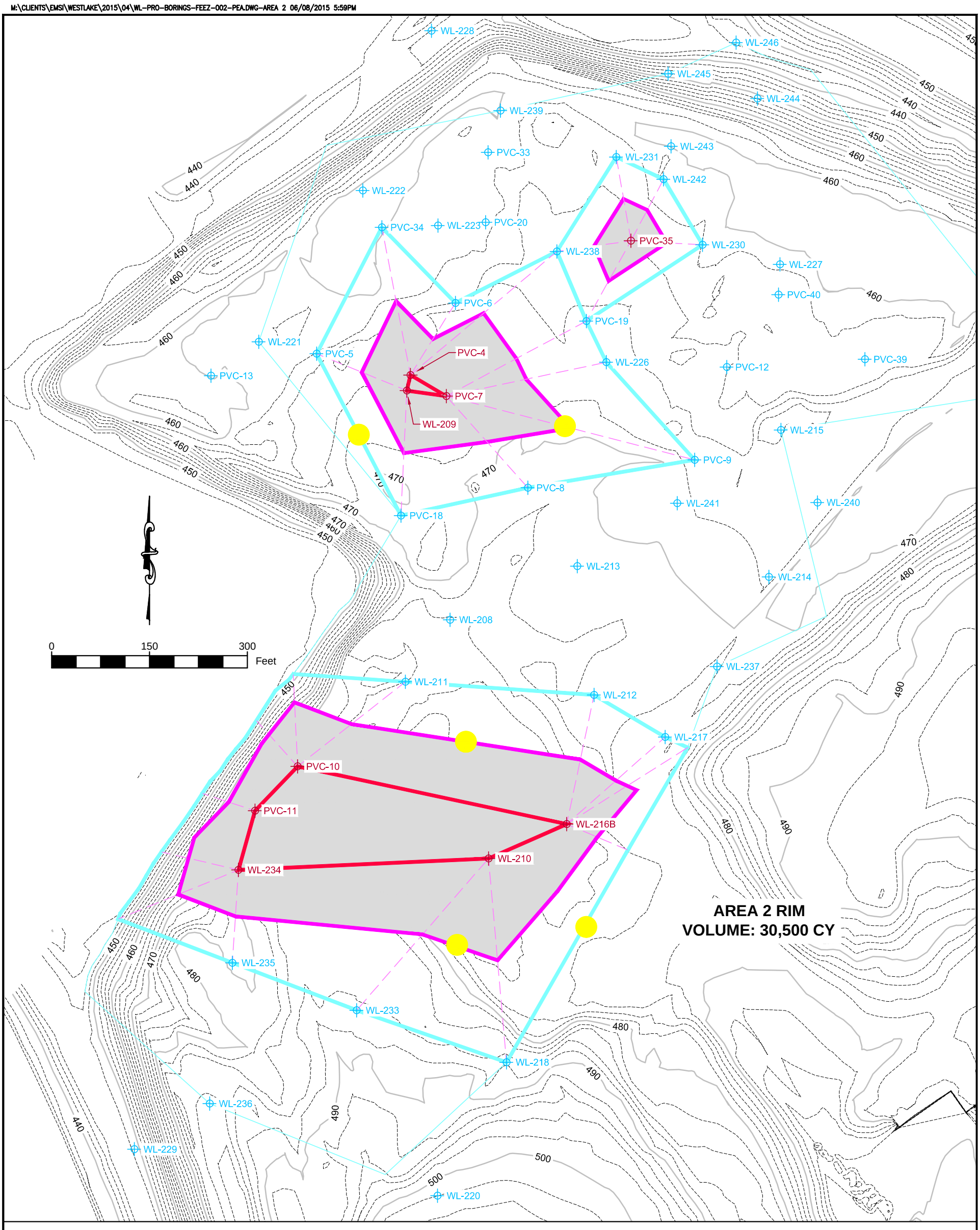

WEST LAKE LANDFILL 13570 ST. CHARLES ROCK ROAD BRIDGETON, MISSOURI 63044	WEST LAKE LANDFILL OU-1 SFS ADDITIONAL STUDIES PARTIAL EXCAVATION	Engineering for a Better World FEEZOR ENGINEERING, INC.	SEPTEMBER 2014 DESIGNED BY: PML APPROVED BY: ---
SOIL ACTIVITIES GREATER THAN 1,000 pCi/g			REVISION DATE
PROJECT NUMBER: BT-006	FILE PATH:		

DRAWING NO.: **002**

LEGEND

- 470 — 2005 TOPOGRAPHY (10' CONTOUR)
- 2005 TOPOGRAPHY (2' CONTOUR)
- BOUNDARY OF ELEVATED READINGS
- BOUNDARY OF NON-ELEVATED READINGS
- INTERPOLATED LIMITS
- EPA's 1,000 pCi/gm PARTIAL EXCAVATION OPTION

Figure B-8

Additional Area 2 Borings for RIM Delineation
EPA's 1,000 pCi/gm Partial Excavation Option

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.

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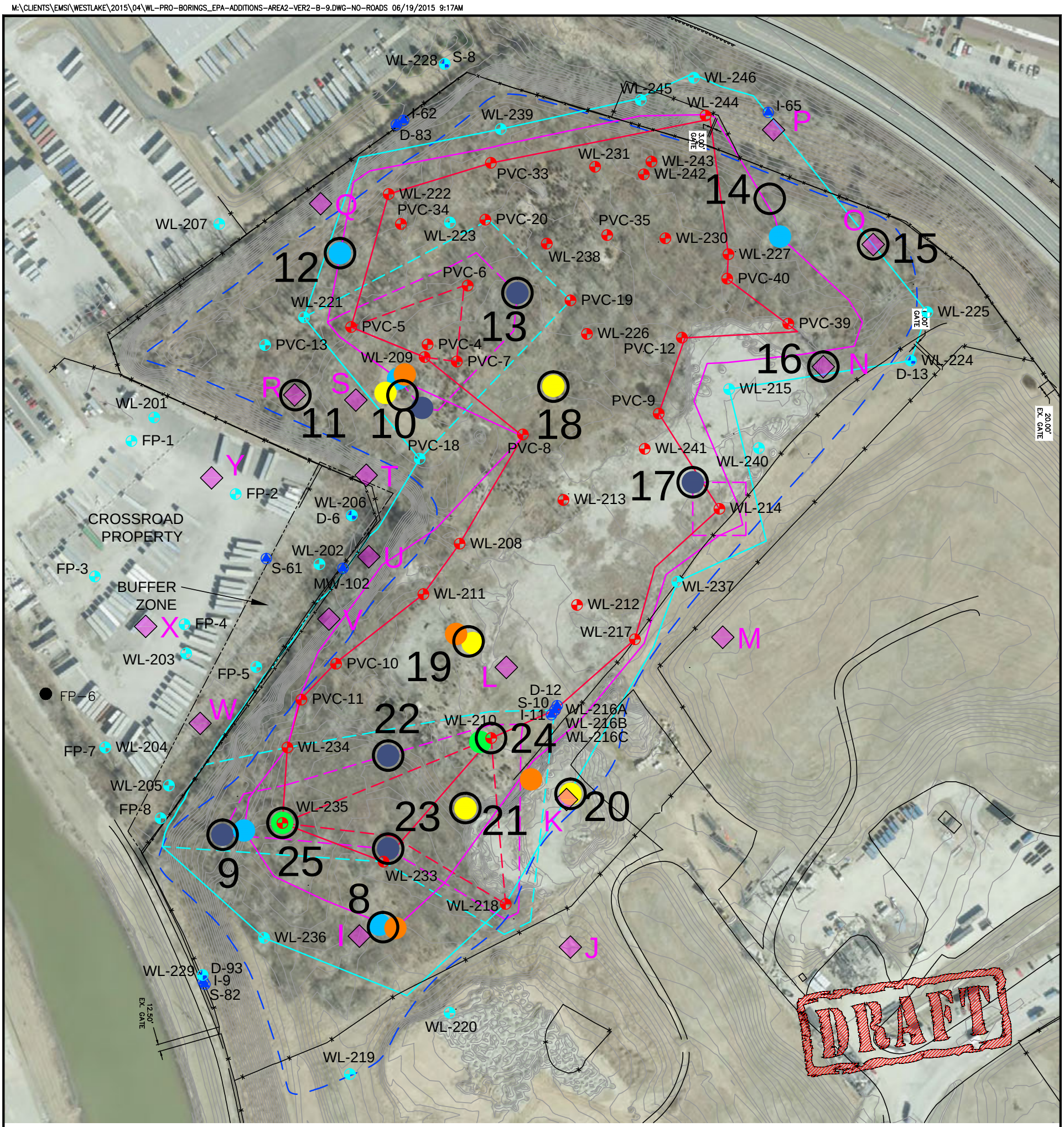

PROPOSED ADDITIONAL BORINGS

- PROPOSED ADDITIONAL EPA BORING LOCATION
- "COMPLETE RAD REMOVAL" SHALLOW
- "COMPLETE RAD REMOVAL" DEEP
- PARTIAL EXCAVATION - 1,000 pCi/gm
- PARTIAL EXCAVATION - 79 pCi/gm
- BORING FOR AREA 2 REVISED VOLUME CALCULATIONS
- 8 PROPOSED SOIL BORING LOCATION AND NUMBER

- SFS ESTIMATED MINIMUM EXTENT OF RIM (UPPER)
- SFS ESTIMATED EXTENT OF RIM (UPPER)
- SFS ESTIMATED POTENTIAL OUTER EXTENT OF RIM (UPPER)
- SFS ESTIMATED MINIMUM EXTENT OF RIM (LOWER)
- SFS ESTIMATED EXTENT OF RIM (LOWER)
- SFS ESTIMATED POTENTIAL OUTER EXTENT OF RIM (LOWER)
- AREA 2 BOUNDARY
- FENCE
- 03-20-14 TOPOGRAPHIC CONTOUR

LEGEND - EXISTING CONDITIONS

- RI BORINGS WITH ELEVATED GAMMA AND/OR RADIUM OR THORIUM ABOVE UNRESTRICTED USE LEVELS
- RI BORINGS WITHOUT ELEVATED GAMMA AND RADIUM AND THORIUM BELOW UNRESTRICTED USE LEVELS
- ALLUVIUM GROUNDWATER WELL

N

200 0 200

SCALE IN FEET

Figure B-9

Combined Rational for
Proposed Additional Borings in Area 2

West Lake Landfill OU-1

EMSI Engineering Management Support, Inc.