composite or discrete samples are to be collected. A minimum of 7 discrete or composite samples shall be analyzed using XRF for metals and gas chromatography for individual Aroclors (PCBs) from each SMA. The results from these analyses shall be used to confirm that soil exceeding site-specific RBCs has been removed. If the 95 % UCL of the results collected for individual Aroclors (PCBs) or other COCs exceeds the RBCs as per PADEP ACT 2 guidelines, than the Contractor shall remove an additional 0.5 feet of soil from the sectors with the highest reported values and then recalculate the 95% UCL until the SMA as a whole does not exceed the RBCs. For additional detail concerning the development of the 95 % UCL and establishing when and if off-site analyses might be required please see Section 3.1.8.

3.1.8 Limits of Uncertainty to Support Project Decisions

Establishing limits of uncertainty for the purpose of decision-making can include many types of evaluations and data. In the following section the major types of project decision envisioned will be discussed and potential methods for establishing acceptable limits of uncertainty proposed. The range of methods for establishing limits for uncertainty management range from the use of classical statistical methods through the use of analyst observations or other practical considerations that suggest additional QC sample analyses or other action is required before a decision can be made.

As the project proceeds, investigative data and QC data should be analyzed on an on-going basis such that decision criteria for the project can be adjusted as a more robust comparison data set is assembled. Duplicate (collocated), replicate (well-homogenized splits), matrix spikes, other field-laboratory QC, and analysts observations can play a role in setting up and adjusting uncertainty limits for decision making. Poor replicate agreement can be an indicator of inadequate sample homogenization prior to splitting the sample, or inadequate sample support (i.e. size, shape, and orientation) used during sample preparation procedures prior to instrumental analysis, or poor analytical precision. Matrix spike results and analysts observations can indicate that analytical interferences are present and alternative methods are required. Poor duplicate (collocated) agreement can indicate a high degree of matrix heterogeneity. The distance between the collocated samples provides an indication of the scale of the heterogeneity. For instance, extreme heterogeneity (concentrations ranging from 100 ppm to 50,000 ppm over a distance of 2 feet) has been observed at some sites where nuggets of pure product are common. Composite sampling can be used to limit the impact of these types of heterogeneities and could play a significant role in the sampling design selected during the confirmation and final waste classification prior to disposal portions of this project.

There is a wide range of information that may need to be considered when deciding on limits of uncertainty to guide decision-making and resolve apparent data problems. Decisions about what actions are scientifically appropriate are totally dependent on how the data will be used to make decisions and the "scale" of those decisions (i.e., the decision support). For example, decisions about a remedial design that will surgically remove individual hotspots will require a much finer scale of characterization than will decisions about a design that relies on institutional controls. Likewise, remedial design for a solvent flushing project to treat subsurface DNAPL contamination can require characterization on a finer scale than will the remedial design of a thermal treatment project to treat the same problem. The following table lists some of the potential uncertainty management issues and type of responses that could be appropriate.

UNCERTAINTY MANAGEMENT ISSUES AND POTENTIAL RESPONSES

Problem	How to Identify	Resolution
Matrix heterogeneity	Compare the results of samples collected at known distances from each other (collocated duplicates)	After determining the scale over which it is important to understand the impact of heterogeneity, increase the sampling density in those areas where incorrect decisions would be risky from a protectiveness or economic aspect
Inadequate sample preparation/ homogenization	Compare the precision of replicate sample prep + analysis on raw aliquots from a single sample jar to the precision of replicate analyses performed on a single prep'd sample aliquot (replicate analyses on a single extract or digest)	Improve the consistency of sample preparation procedures, or select a procedure more appropriate to the matrix. Increasing sample size or the use of compositing might also need to be considered.
High analytical variability	Analytical QC sample results are outside required performance criteria or interferences are suggested by analysts observations	Apply additional sample cleanup steps or use an alternative peak to perform the analyte quantitations. For example, use an alternative spectral line for quantitation of arsenic when lead concentrations are high. In the case of PCBs use a dual column method with reverse elution order to verify the quantitation
Detection limits are elevated due to the presence of interferences.	Non-detections are above the action level for the site resulting in the calculation of artificial risk	Same as above or selection of an alternative method that is more analyte specific. For example, use of a mass spectrometry for PCBs when present in the parts per million range
Detection frequencies are insufficient or the distribution of results so erratic that the population characteristics cannot be adequately defined for comparison purposes	If detection frequencies are less than 50 percent or data distributions can not be established as either normal or lognormal use of a UCL for determination of attainment may not be possible.	Block or stratify the data into different populations that could be more amenable to statistical analysis. Collect more data based on a geostatistical or tighter grid design to better characterize the population of interest. Composite sampling should also be considered to limit any nugget effects.
Results are very close to the action level making decision making difficult	Based on the project limits of uncertainty the results fall in the category of too close to call	Decide that the result should be considered dirty, take a conservative approach, or collect additional confirmation results using an alternative method. Alternatively collect sufficient data such that the true mean can be estimated more accurately and a decision made with the level of significance and confidence required by the project.

For these reasons the analysis of the 9 or more samples using both the field-based and fixed lab confirmation methods, as is often the case for most demonstrations of methods applicability is, rarely adequate. A focused quality control program, which evaluates decision uncertainties on a real-time basis, must also be used to refine decision criteria and the limits on uncertainty that can be tolerated as a project progresses.

When using a dynamic work plan and field-based measurement technologies it is imperative that the project team track and adjust decision uncertainty limits as more is learned about the site. It might also be necessary to establish a range in concentrations or decision uncertainty limits where the need for additional sampling and analyses is triggered. The need for additional data is also usually driven by the nature of the proposed remedy and cost of a particular cleanup action. If a remedy is very expensive, it may warrant the collection of more samples rather then just making a conservative decision to send soil for off-site treatment or decide that the location is dirty. For example, if results indicate that the concentration for a particular COC in a soil pile is right at the level of concentration mandated by a Land Disposal Restriction (LDR) it might benefit the project team to collect additional samples to confirm the decision before manifesting the waste. On the other hand, if the concentration reported is substantially below or above the LDR and duplicate variability is low, additional sampling may not be warranted. Establishing these types of uncertainty limits and related quality assurance requirements for decision-making purposes and providing clear guidance concerning the resulting actions is crucial to projects using the Triad.

The Contractor shall collect soil samples and perform chemical analysis in such a manner that the resulting data meet and support data use requirements. The Contractor shall develop and implement a Chemical Data Acquisition Plan to ensure that data are of sufficient quality to support project decisions. Measurement objectives shall be defined and presented for each chemical parameter and its accompanying measurement method used for the project.

Some of the potential decisions that will be required during implementation of the dynamic work plan for the site are listed below. Also provided are several recommendations concerning how limits of uncertainty might be established and the need for additional analyses (investigative and QC) identified on a real-time basis and decision criteria revised. Suggestions provided are meant as guidelines only and do not represent any type of formal guidance. The actual methods used in the field to develop limits of uncertainty to support decision-making will need to be developed by the contractor and approved by PADEP and other project stakeholders before use and on a real-time basis as more is learned about the site. Some of the decisions, methods for establishing limits of uncertainty, and other elements that can be used to support decision making are provided below in chronological order in which they are likely to occur for each SMA:

- **Development of Preliminary Decision Logic Based on the Results of a Demonstration of Methods Applicability (WE 1.1).** Once the data is available from the methods applicability Study described earlier in this SOW it will be possible to begin the process of refining decision criteria for many of the activities described in this section. Setting the appropriate initial field decision (i.e., action) levels should include comparison using regression analyses between the field-based and fixed lab analyses. Reasonable correlation must be observed otherwise alternative methods or serious method modifications should be identified and tested to determine an alternate method for evaluating contaminant distributions at the site. Regression analyses should also be used to compare fixed lab TCLP results and field-based total metals results. Correlation factors of this type will be important come time for excavation and stockpiling of soil prior to final characterization using TCLP before disposal. Results obtained from the methods applicability study for this purpose will likely be insufficient, so the project team should pay special attention to roll in the initial results from the additional characterization effort, in which twenty percent of the samples are slated for TCLP and field analyses. As mentioned previously care should be taken that sample sent for TCLP are sufficiently high (above the twenty times rule) before they are sent off for TCLP analysis. Similarly the project team should consistently roll results into a relational database such that the correlation between fixed lab and field-based lab results can be tracked and the need for revision of the field based decisions for all other activities get revised as more is learned on a real-time basis.
- **Assuring the sufficiency of soil data (WE 1.4)**. A significant source of uncertainty related to project decision-making can come from the spatial variability of soil sample results. Past analyses at the site indicate the presence of significant hot spots that can drastically impact disposal costs. Because of the availability of a mobile laboratory at the Site, the project team will have the flexibility to collect additional samples to characterize any given sector or SMA. PADEP recommends that if the concentration for total PCBs is above 50 mg/kg or the concentration of mercury exceeds the total metals concentration expected to result in an exceedence of the TCLP criteria for mercury (see WE 1.1) that the Contractor subdivide the grid sector into smaller sectors and collect additional samples to provide characterization at a finer spatial scale. Ten by ten foot grids, as discussed earlier in this document should then be used to chase the hot spots and minimize wastes requiring additional characterization. Initial site planning efforts indicate that the field-lab sample throughput capability will be greater than is necessary to support the 50 by 50 foot grid-sampling scheme, which will allow the Contractor greater flexibility in collecting additional samples when the data evaluation process indicates it is necessary to limit the need to dispose of wastes containing higher concentrations of PCBs and mercury. The cost of analysis will need to be weighed against disposal requirements once they are better defined to decide when and how to collect additional samples. It is recommended that a tool such as Ingersoll's uncertainty calculator be used to track when site heterogeneity is sufficiently high to warrant additional sampling (Ingersoll, 2001) and to identify primary sources of uncertainty (i.e. sampling versus analytical). Additional sampling protocols such as the use of composite samples instead of discrete samples may also need to be considered if site spatial variability is found to be too high to support the currently proposed sampling and analysis plan.
- **Estimating the volume and location of soil within the site boundary that contains COCs at or above the site-specific RBCs (WE 1.5), identifying the need for the removal of contaminated soil.** Defining the limits of uncertainty for supporting decision-making during this effort will be relatively straightforward. The contractor, in accordance with PADEP Act II guidelines will identify when and if either historical or field-based measurement results indicate a particular grid sector exceeds the RBCs provided in Table 1. If the available results for a grid sector are above the RBC then the material must be slated for removal. If the results are well below the RBC than the material can be left in place. If the contractor discovers that some analytical bias is evidenced from the results collected using the field-based methods then it may be necessary to identify a region where results are to close to the action level to make a clear call

and that either confirmation samples or additional data needs to be collected to better define the need for removal of the material. I most cases this will be an issue when reported concentration are near but below the action level, but It could also be the case sometimes when results are near the action level and the presence of an interference is indicated by the analyst. In real life these types of situations rarely occur, but when they do the results should be communicated and a decision made concerning the most appropriate action between PADEP and the Contractor. The collection of additional data, or the analysis of confirmation data using and alternative method, or both need to be considered.

- **Initial waste segregation prior to excavation to limit disposal costs**. Samples analyzed for the presence of PCBs and mercury may vary greatly at the Site based on a review of existing results. These two chemical constituents have the greatest impact on disposal costs. However, other metals that can result in a waste being classified as Hazardous under RCRA may also impact disposal costs. Values recorded near the upper threshold limit as stipulated in Federal LDRs are of particular concern for total PCBs and mercury. When concentrations for PCBs and mercury approach 499 mg/kg and 260 mg/kg respectively, additional sampling and analysis may be required. Additional sampling and analysis is also recommended by PADEP when results are near or above either of the above mentioned LDRs, or near or above 50 mg/kg total PCBs, or near and above the level for mercury estimated during the methods applicability study that would result in the waste being characterized as Hazardous under RCRA for mercury.

  Mercury or total PCB concentrations that exceed Federal LDRs and other respective criteria will require more costly incineration or other treatment prior to disposal. To assure that PCB or mercury contaminated soil expected to exceed these values is clearly defined it is recommended that the Contractor supplement data from the methods applicability study as more data is collected such that decision criteria can be refined and clear correlation factors developed to support segregat ion of soil into the appropriate staging areas prior to excavation. Not only should the field-based decision criteria be sound, additional sampling should be conducted as appropriate to limit soil volume for samples containing elevated levels of total PCBs, mercury, and even other metals that could potentially exceed TCLP threshold limit values (Table 2).

  As with the previous activity it is essential that the Contractor identify and develop a method for communicating with PADEP when results appear to be too close to call. Depending on the observed bias of the field-based method, the apparent heterogeneity of the site materials, and analysts observations it may be prudent to collect additional samples for analysis or to send select samples to an off-site laboratory for confirmation analysis using an alternative method. These types of decisions will need to be made based on observations and conclusions drawn in the field as the data from the demonstration of methods applicability study and other confirmation sample results are obtained and processed.

- **Pre-disposal TCLP analyses.** Prior to disposal, piles of soil will need to be characterized in accordance with disposal facility requirements. Required levels of sensitivity and logistical considerations mandate that TCLP analyses be conducted at an off-site laboratory. The limits of decision uncertainty will primarily be controlled by the heterogeneity of the soil piles. The TCLP threshold limits and QC requirements are established in EPA Method 1312 (Table 2). The use of field analysis can provide some added value during this portion of the program when composite results are reported and they exceed the TCLP threshold limit values. The Contractor should maintain sub-samples of those used to prepare the comp osites sent to the laboratory along with a map detailing their approximate location and depth within the pile. A minimum of ten samples should generally be used to prepare any one composite to limit impacts from isolated hot spots within any given pile slated for disposal. Upon receipt of the results the Contactor should consider the use of additional field based results to decide whether further segregation of the pile might provide added value by decreasing the amount of material requiring a more expensive disposal alternative. Field analyses of the discrete samples used to prepare the composite sent to the laboratory might then be used to identify portions of a particular pile that are most likely to have resulted in the observed exceedence of the TCLP criteria. To facilitate this type of segregation a griding system should be used to collect the initial composites. When possible and practical further segregation and limiting of the materials requiring more expensive disposal should be attempted. The practicality of such an exercise will obviously depend on the amount and location of more contaminated materials within a particular soil pile. When the size and nature of a soil pile appear to be less heterogeneous and segregation difficult, homogenization of the entire pile using a backhoe or other devise could also be warranted. For example if a single sample at the bottom of a pile is identified as having a much higher concentration then the surrounding soil, segregation may be impractical, but homogenization and resampling could resolve the apparent discrepancy in results.

- **Confirmation after excavation.** Confirmation sampling after excavation is another situation when the Contractor should maximize the use of the field based laboratory to add project value, save time and money. The post excavation process is inherently dynamic. According to PADEP Act II guidelines, the 95% UCL for COC results for a particular SMA must be below the RBCs for each COC before backfilling can commence. This can mean selectively removing contaminated grid sectors sequentially until the remediation goal is met. The Contractor should at the same time consider the observed variability in results generated in support of the confirmation effort to decide when and if more detailed griding is warranted or if compositing is justified to limit any nugget effects and improve coverage. Definitive decision logic and limits on the flexibility of the program should be carefully discussed with PADEP and subject to stakeholder review prior to implementation. Special attention should be paid to use visual observation to guide sampling activities. Special attention should also be paid to use of off-site confirmation testing when analysts observations indicate the potential for the presence of interferences. Real time decision making during this and most other elements of this project will be best facilitated through the use of a well design SMA data management and communication strategy. Web based applications can be a powerful tool for this purpose.
- **Protect worker and public health during the cleanup action**. This program will at least include some personal air monitoring and dust control measures to assure that releases of dust during excavation do not exceed potentially applicable guidelines. The contractor will also need to consider weather when conducting site activities. Rain or inclement winds need to be anticipated and the Site controlled adequately.

At a minimum, the measurement objectives stipulated for the project shall include a discussion of the following elements, which are necessary to meet project objectives. Each element described below shall be addressed as it relates to the use of field-based and fixed-laboratory analytical procedures:

- **Accuracy of Analytical Method** - Stipulate the accuracy (bias and precision) of each analytical method as applied to a given analytical instrument for a given analyte in a given matrix and the degree of accuracy required for this project. Analytical methods performance shall be documented for the same or similar matrix prior to method startup. This may require the use independent reference standards or spiked samples, method and other types of blanks, more frequent instrument calibrations than in a fixed lab environment.
- **Reporting Limits for Analytical Method** - Stipulate the detection limit for each proposed analytical method in each matrix involved at the Site and the reporting limit (practical quantitation limit) required for the project. Methods for determining analytical limits shall be addressed, and corrective action specified for situations where they cannot be achieved.

- **Precision of Analytical Method** - Stipulate the methodology used to determine the precision of each analytical method using QC samples and instrumentation checks, and the degree of precision necessary for the project. In determining the precision of the analytical method for any given analyte, the sample matrix shall be taken into account.
- **Data Comparability** - Stipulate the methodology for performing data comparisons considering specific units, equations, and data formats to be used.
- **Checks for transmittal, data reduction and reporting errors** - Any process used for data validation must be close to the origin of the data, while being independent of the data production process.
- **Qualification of primary sample results** - The basis for qualification shall be addressed, with consideration to the results of analysis of blank samples, duplicates, spiked samples and QC check samples before site decisions are made.
- **Representativeness of Data** - Include a discussion of sampling and analysis issues that may be encountered and when and what type of corrective action will be taken when uncertainty in results suggests data are not sufficient to support real-time decision-making.
- **Data Completeness** - Include a discussion of the assessment procedures and reviews to identify unusable data, usable data, and any data use restrictions. The usable data completeness objective for each individual analytical method should be agreed upon. Data sets with less than the agreed upon percent completeness shall be addressed and corrective action documented in daily quality control reports. The Contractor shall modify its procedures to achieve the percent data completeness objective and shall implement those modifications only after the Contracting Officer has approved them.

Calibration Procedures

The Contractor shall calibrate all analytical instrumentation, whether used in field-based or fixed-lab analysis, to ensure that the equipment is functioning optimally. EPA SW-846 methods 8080b (PCBs) and 6200 (XRF) methods shall be used to establish the underlying theoretical basis for refinement of field-based methods, refinement and modification of the protocols recommended in these methods will more than likely require revision to meet project requirements. Keen attention should be paid to revising sample preparation and calibration frequency requirements to adapt to the rigors of a field-based laboratory operation. Fixed laboratory analyses will also be based on EPA SW-846 basic method requirements for calibration, again with special attention being paid to the need to assure the comparability of XRF and inductively coupled argon plasma spectrometry analyses (ICAP) using EPA Method 6010. Waste analyses will be performed in accordance with EPA SW-846 method 1312. Care should be taken that calibration standards are prepared in a fashion similar to the samples when appropriate or necessary.

- The calibration procedures and instrumentation shall be consistent with the sample analysis requirements of this project and standard methods (such as SW-846).
- Preventive Maintenance - The Contractor, using qualified maintenance personnel, shall routinely perform preventive maintenance on all analytical equipment and instrumentation.

- Detailed calibration records and notes discussing problems encountered and their resolution shall be maintained and made available for inspection by the Contracting Officer on request.

Quality Control Samples

The Contractor shall conduct internal quality control checks designed to establish technically sound criteria for each measurement parameter, which shall serve to accept, qualify, or reject data in a uniform and systematic manner. Internal (laboratory) and external (field) QC check samples will be analyzed at a frequency sufficient to assure the reliability of project decisions. These checks are designed to ensure accuracy and precision in the sampling procedure and the analytical methods. They include blanks, duplicates (collocated), replicate (splits) matrix spikes, reference standards and performance evaluation samples. The numbers and types of QC samples analyzed should be commensurate with decision making requirements and data distributional characteristics. The program should be designed to identify when unacceptable bias or precision limit the project teams ability to make reliable decisions in the field. A flexible and adaptive QC program designed around known site conditions is preferred. For example, random collection of field duplicates can be used to evaluate the general heterogeneity of a particular COC. However, the project QC officer and field team members should also have established guidelines for identifying when additional QC should be collected. If duplicate results are variable for PCBs or metals results using the proposed methods and results non conclusive for decision making purposes, the Contractor should consider sending a split to the fixed lab for confirmation using an alternate method. Another way in which QC results might be used to trigger corrective action could include selection alternate spectral lines or differing interelement corrections when concentrations of lead interfere with the quantitation of arsenic.

Corrective Actions

The Contractor, after notifying the PADEP Project Technical lead of any and all deviations or non-compliance events relating to chemical data quality management requirements or receipt of such notice from the project technical lead or Contracting Officer, shall immediately take corrective action. If the Contractor fails to comply promptly, the Contracting Officer may issue an order to stop all or part of the work until satisfactory corrective action has been taken. Such an order shall encompass activities of both the Contractor and its Subcontractors. The Contractor shall make no part of such time lost due to such stop orders the subject of claim for extension of time or for excess costs or damages.

- If the measurement objectives are not met, or internal or external quality control checks show significant deficiencies in the sample analysis process, the Contractor or its Subcontractor shall prepare a letter discussing the corrective action to be taken and submit it to the Contracting Officer.

- Discussion of corrective actions shall include the limits of data acceptability for each analytical parameter and sample matrix along with the possible corrective actions to be taken when these limits are exceeded.
- The Contractor shall identify personnel who are responsible for initiating and performing the corrective actions. In addition, the Contractor shall document all pertinent information regarding the problem.

Analyst Proficiency Testing

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It is imperative that field-based sampling and analyses be carried out with a high level of proficiency. Analysts are expected to handle and track soil samples, manage data, and conduct soil sample analysis and quality control procedures. The Contractor shall demonstrate meeting these requirements by developing written plans that ensure reliable and consistent data of known and documented quality are generated and that equipment operator errors are minimized.

The Contractor shall develop and present for approval, a list of analytical equipment operator proficiency requirements and set of procedures by which the analyst will be tested to demonstrate proficiency. At a minimum, the primary chemist responsible for performing on-site analysis should have a minimum of 4 years of experience directly related to the regulated analytical equipment. The project quality control (QC) officer should have at least one year of experience in conducting laboratory audits and data validation. The QC officer will be responsible for evaluating and documenting method and analyst proficiency before, during, and after each portion of the field program. When, and if, equipment or personnel must be changed during the course of the project, method and or analyst proficiency must be re-evaluated and approved by the QC officer before more analyses can be performed.

3.2 TASK 2 – DETAILED DESIGN (WE 2.0)

The Implementation Contractor(s) shall prepare the detailed design documents needed to implement Site cleanup and ready the Site for future redevelopment. At a minimum, detailed design documents shall include calculations, drawings, specifications, and a construction cost estimate. The detailed design shall describe the existing features of the Site, temporary facilities needed during construction, excavation maps, engineering and environmental controls needed during construction, final grading of the Site surface following soil excavation and backfilling, revegetation, run-on/run-off controls for the finished Site surface, and permanent engineering controls. The detailed design has been divided into four subtasks as follows: