Soil Treatability Study

Energy Technology Engineering Center • U.S. Department of Energy

Identification of Uncertainties Regarding Selection of Soil Remediation Technologies at ETEC
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Purpose

The purpose of this memorandum is to discuss the concept of uncertainty and how it affects decision making for soil remediation at the ETEC site, document the approach for identifying sources of uncertainty related to soil remediation at the ETEC site, present the sources of uncertainty that have been identified through that process, and finally present a list of potential studies that could be performed to address those sources of uncertainty identified for selection of soil remediation technologies at the ETEC site.

Background

Previously, the STIG was presented with a series of tables that reflect the study boundaries and objectives, the technologies for soil remediation that have been eliminated and why, and the technologies that are being considered for possible remediation of ETEC soils. The study boundaries are shown in Table 1. The study objectives are shown in Table 2. The study boundaries have been crafted for general consistency with the requirements of the AOC.

Table 1. Study Boundaries

	Study Boundary
1	The goal of the chosen soil remediation alternatives will be to meet the established cleanup levels or reduce the contaminant concentrations/volume of soil to be excavated.
2	There will be no "leave in place" or on site burial/landfilling of contaminated soils.
3	Remediation alternatives will be in place by 2017.
4	Incineration (burning that forms an ash) will not be used as a remediation alternative.
5	Remediation alternatives will not exacerbate existing contamination issues or create new contamination problems.
6	Treatability studies being conducted for groundwater and unweathered bedrock are ongoing and will not be duplicated.
7	Plants that are not native or not naturalized to SSFL will not be considered as part of phytoremediation technologies. (native plants will be considered first as applicable)

Table 2. Study Objectives

	Study Objectives
1	Dig and haul/excavation will be minimized as much as possible.
2	Remediation alternatives will be designed to consider the wild fires, native vegetation, and natural environment as much as possible.
3	Land and site disturbance will be minimized as much as possible.
4	Green and innovative/cutting edge technologies will be assessed as much as possible.

The overall treatment strategies are shown in Table 3. The following table presents the treatment strategies in their active and passive phases, where applicable, and how the two phases will most likely be paired.

Table 3. Treatment Strategies

Active Treatment Technology (Step 1)	In-Situ Thermal (Less than 200°C)	Ex-Situ** Thermal (Greater than 200°C)	In-Situ Bio-remediation	Phyto-remediation	In-Situ Nano	Ex-Situ** Soil Washing
Potential Passive Treatment Technology (Potential Step 2)	Phyto-remediation	Engineered Barrier*	Phyto-remediation	Phyto-remediation	Phyto/Bio-remediation	Engineered Barrier*

*Only in cases where recontamination is possible
**On-site with no off-site haulage

The Concept of Uncertainty

An uncertainty is basically an unanswered question or a question with multiple possible answers. A question like “Will a specified plant remove a specified contaminant from the soil?” is an expression of the uncertainty that one may have about using a plant to remove a contaminant from soil. Identifying sources of uncertainty is important because uncertainty affects decision making. For example, the decision to use a specified plant to “remediate” a contaminated section of soil is based on having a fairly high degree of certainty (low degree of uncertainty) about the viability of that remediation approach. It does not make sense to choose a remediation approach if one is certain it will not perform. Therefore, the uncertainty related to that plant needs to be resolved prior to making the decision. Or, one can choose to decide against using that plant because there is too much unresolved uncertainty. Resolving uncertainty requires research, and research can take on a variety of activities. For example, modeling of phenomena, laboratory studies, field studies, and literature studies constitute research approaches that can be used to resolve (and identify sources of) uncertainty..

Approach for Identifying Uncertainties

Here, the approach taken to identify the sources of uncertainty related to selection of soil remediation technologies at the ETEC site involved, as a first step, examining each of the possible treatment technologies shown in Table 3 and identify questions that would need to be answered before a decision to use a particular technology was made. The second step was to look at each of the contaminants and identify any questions about a particular contaminant that would need to be answered before a decision to use a particular technology was made. Finally, each of the clearly contaminated areas (CCA) likely to need remediation was examined to identify site-specific questions that would have to be answered before a decision to use a particular technology was made. These three perspectives were explored in an effort to develop a complete picture of the uncertainty related to selection of soil remediation technologies at ETEC.

To further explore the technology specific uncertainty, the issues of feasibility, applicability, and optimization were addressed. For example, are there questions regarding the feasibility of a technology or are there questions about the applicability of a technology. Or, is the uncertainty specific to a given technology more about optimization of the technology for the ETEC site. By asking these further questions, additional sources of uncertainty were identified.

Similarly, to further explore the contaminant specific uncertainty, the issues of chemical form and physical form were addressed. For example, are there unanswered questions regarding the chemical form or physical form of a contaminant. Or, are there other sources of uncertainty specific to a given contaminant that need to be addressed.

The same type of thinking was applied when discussing specific uncertainty for clearly contaminated areas likely to need remediation and included asking if there are any uncertainties relative to these areas, namely in their positioning relative to groundwater and their terrain, that need to be addressed before a decision can be made.

Uncertainties Identified Relative to ETEC Soil Remediation

Tables 4, 5, and 6 show the uncertainties identified relative to ETEC soil remediation. Table 4 shows technology specific uncertainties. Table 5 shows contaminant specific uncertainties, and Table 6 shows specific uncertainties related to clearly contaminated areas.

Possible Studies to Address Uncertainty Relative to ETEC Soil Remediation

Tables 7, 8, and 9 show possible studies that could be performed to address the identified uncertainties. Table 7 shows studies that could address technology specific uncertainties. Table 8 shows studies that could address contaminant specific uncertainties, and Table 9 shows studies that could address specific uncertainties related to clearly contaminated areas.

Prioritization of Possible Studies

The next step in the process is prioritizing the suggested studies, based on a number of considerations, like which studies address the most important sources of uncertainty. To identify the most important sources of uncertainty, generic decision trees will be examined to help the DOE visualize the steps to decision making and which uncertainties will really affect those steps.

Table 4. Technology Specific Uncertainties

Technology	Feasibility	Applicability	Optimum Operation
Phytoremediation	Are plants on-site taking up contaminants?	Will the plant grow in this particular soil?	What are the ideal growing conditions for the plant?
	Will the plant remove the contaminant(s)? If yes, how much?	Will the plant grow with a particular contaminant mix?	
		Where does the contaminant reside in the plant?	
In-Situ Thermal	How hot does it have to get for PCBs, pesticides, herbicides, and dioxins to volatilize?	What is the thermal conductivity and heat capacity of the soil?	Should we use a thermal blanket or heat probes?
		How long will it take to cool the soil?	How close should we place the heat probes?
In-Situ Nanotechnology	Will the nanotechnology degrade the contaminant(s) and what are the by-products of the degradation process?	Can the nanoparticles be distributed effectively in the soil?	
		Does soil chemistry limit applicability?	
In-Situ Bioremediation (native)	What biota already exist at the site?		What can enhance the biota's ability to degrade the contaminant(s)?
	Will the biota degrade the contaminant(s) and what are the by-products of the degradation process?		
In-Situ Bioremediation (Non-native)	Will the biota degrade the contaminant? What are the by-products of the degradation process?	Can non-native biota thrive at the site?	What can enhance the biota's ability to degrade the contaminant(s)?
Ex-Situ Thermal		What is the end state of the heated soil?	What is the optimum temperature for treatment?
		What do we have to add to the treated soil before replacing it?	What is the best method for applying the heat?
Ex-Situ Soil Washing		To what extent will clays in the soil limit applicability?	What solvent should be used to treat this contaminant mix?
		To what extent will fines in the soils limit applicability?	What is the best mixing method?
Engineered Barrier	Will an impermeable engineered barrier emplaced horizontally prevent recontamination from seasonal water fluctuations?		What sort of barrier will work best for the contaminants of concern?

Table 5. Contaminant Specific Uncertainties

Contaminant	Chemical Form	Physical Form	Other
Mercury	What is the current chemical form of mercury at ETEC?	Is this contaminant partitioned to the fines?	
Dioxins		Is this contaminant partitioned to the fines?	What is the rate of natural attenuation for dioxins?
PCBs		Is this contaminant partitioned to the fines?	
PAHs		Is this contaminant partitioned to the fines?	What is the rate of natural attenuation for PAHs?
Perchlorate	What is the speciation of perchlorate at ETEC?	Is this contaminant partitioned to the fines?	What is the rate of natural attenuation for perchlorate?
Metals	What is the speciation of the metals at ETEC site?	Is this contaminant partitioned to the fines?	
Radionuclides	What is the speciation of the radionuclides at ETEC site?	Is this contaminant partitioned to the fines?	
NDMA	What is the speciation of NDMA at ETEC?	Is this contaminant partitioned to the fines?	
PCTs		Is this contaminant partitioned to the fines?	
Pesticides/Herbicides		Is this contaminant partitioned to the fines?	
SVOCs		Is this contaminant partitioned to the fines?	What is the rate of natural attenuation for SVOCs?
SVOCs		What is the fraction of SVOCs that exist in the soil vapor versus SVOCs sorbed to the soil particles?	
VOCs		What is the fraction of VOCs that exist in the soil vapor versus VOCs sorbed to the soil particles?	What is the rate of natural attenuation for VOCs?
TPHs		Is this contaminant partitioned to the fines?	What is the rate of natural attenuation for TPHs?
TPHs		What is the fraction of TPHs that exist in the soil vapor versus TPHs sorbed to the soil particles?	

Table 6. Clearly Contaminated Areas (CCA) Specific Uncertainties

CCA	Groundwater	Terrain
For each CCA	Does this CCA have a potential recontamination issue from the tritium, TCE, or perchlorate plumes?	Is this CCA on rocky steep terrain? Does the terrain preclude in-situ treatment technologies?

Table 7. Studies to Address Technology Specific Uncertainties

Technology	Feasibility	Applicability	Optimum Operation
Phytoremediation	Survey of on-site plant materials	Laboratory study of growth in soil types at ETEC	Laboratory study of plant growth enhanced by additives
	Laboratory study of contaminant uptake by on-site plants	Laboratory study of contaminant mix uptake by on-site plants	
		Laboratory study of plant accumulation (necropsies)	
In-Situ Thermal	Laboratory study or literature search of the vaporization point of PCBs, etc.	Survey or laboratory study of thermal conductivity of ETEC Soils	In-Situ thermal treatment using heating probes vs heating blanket of CCAs 10, 15, 24, 25, 31, 32 for PCBs
		Simulation of soil heating/cooling for ETEC soils	In-Situ thermal treatment using heating probes of CCAs 10, 15, 24, 25, 31, 32 for PCBs
In-Situ Nanotechnology	Laboratory study of contaminant degradation by nanoparticles	Field study of in-situ application techniques for nanoparticles at the ETEC Site	
		Survey of geochemistry of ETEC Soils	
In-Situ Bioremediation (native)	Survey of naturally occurring biota at the ETEC Site		Laboratory study of biota cultivation enhanced by additives
	Laboratory study of contaminant degradation by native biota		
In-Situ Bioremediation (Non-native)	Laboratory study of contaminant degradation of non-native biota	Laboratory study of non-native biota and soil chemistry	Laboratory study of biota cultivation enhanced by additives
Ex-Situ Thermal		Laboratory study of thermally induced soil remediation with ETEC Soils	Literature search on vaporization temperatures or laboratory study of required temperatures
		Laboratory study of processes to return the soil to normal conditions after thermal treatment	Survey of ex-situ thermal technology suppliers
Ex-Situ Soil Washing		Survey of clay content in ETEC Soils	Laboratory study of solvents and contaminants
		Survey of fines content in ETEC Soils	Survey of soil washing technology suppliers
Engineered Barrier	Literature and site data study with modeling to determine subsurface fluctuations		Study of engineered barrier types for the contaminants of concern

Table 8. Studies to Address Contaminant Specific Uncertainties

Contaminant	Chemical Form	Physical Form	Other
Mercury	Laboratory study to determine the chemical form of mercury at ETEC	Laboratory study of distribution of mercury between fines and larger particles using soils from ETEC	
Dioxins		Laboratory study of distribution of dioxins between fines and larger particles using soils from ETEC	1. Literature search on dioxin natural attenuation 2.Field study of natural degradation of dioxins at ETEC 3.Analysis of historical information from ETEC to determine degradation rate of dioxins
PCBs		Laboratory study of distribution of PCBs between fines and larger particles using soils from ETEC	
PAHs		Laboratory study of distribution of PAHs between fines and larger particles using soils from ETEC	1. Literature search on PAHs natural attenuation 2. Field study of natural degradation of PAHs at ETEC 3. Analysis of historical information from ETEC to determine degradation rate of PAHs
Perchlorate	Laboratory study to determine the speciation of perchlorate at ETEC	Laboratory study of distribution of perchlorate between fines and larger particles using soils from ETEC	1. Literature search on perchlorate natural attenuation 2. Field study of natural degradation of perchlorate at ETEC 3. Analysis of historical information from ETEC to determine degradation rate of perchlorate
Metals	Laboratory study to determine the speciation of metals at ETEC	Laboratory study of distribution of metals between fines and larger particles using soils from ETEC	
Radionuclides	Laboratory study to determine the speciation of radionuclides at ETEC	Laboratory study of distribution of radionuclides between fines and larger particles using soils from ETEC	
NDMA	Laboratory study to determine the speciation of NDMA at ETEC	Laboratory study of distribution of NDMA between fines and larger particles using soils from ETEC	
PCTs		Laboratory study of distribution of PCTs between fines and larger particles using soils from ETEC	

Contaminant	Chemical Form	Physical Form	Other
Pesticides/Herbicides		Laboratory study of distribution of pesticides/herbicides between fines and larger particles using soils from ETEC	
SVOCs		Laboratory study of distribution of SVOCs between fines and larger particles using soils from ETEC	1. Literature search on SVOC natural attenuation 2. Field study of natural degradation of SVOCs at ETEC 3. Analysis of historical information from ETEC to determine degradation rate of SVOCs
SVOCs		Historical data research or laboratory study of SVOCs that exist in the soil vapor versus SVOCs sorbed to the soil particles	
VOCs		Historical data research or laboratory study of VOCs that exist in the soil vapor versus VOCs sorbed to the soil particles	1. Literature search on VOC natural attenuation 2. Field study of natural degradation of VOCs at ETEC 3. Analysis of historical information from ETEC to determine degradation rate of VOCs
TPHs		Laboratory study of distribution of TPHs between fines and larger particles using soils from ETEC	1. Literature search on TPH natural attenuation 2. Field study of natural degradation of TPHs at ETEC 3. Analysis of historical information from ETEC to determine degradation rate of TPHs
TPHs		Historical data research or laboratory study of TPHs that exist in the soil vapor versus TPHs sorbed to the soil particles	

Table 9. Studies to Address Clearly Contaminated Areas (CCA) Specific Uncertainties

CCA	Groundwater	Terrain
For Each CCA	Question can be answered with current information. No study is needed.	Questions can be answered with current information. No study needed.

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