

Comments on Methods to Conduct Soil Survey and to Develop Soil Standards

TO: NYS Dept. of Health Services at: ceheduc@health.state.ny.us

FROM: David Bouldin, Murray McBride, and Ellen Harrison, Cornell Dept. of Crop and Soil Sciences; Anthony Hay, Cornell Dept. of Microbiology; Tammo Steenhuis and Brian Richards, Cornell Dept. of Biological and Environmental Engineering

DATE: June 18, 2004

Re: Comments on the Proposed Soil Survey Method

Thank you for the opportunity to comment on the proposed soil survey method to be used in developing soil standards for Brownfield clean ups. We will provide further comments on the fact sheets at a later time.

These comments represent the thinking of the Cornell faculty listed above. Our expertise and experience includes soil science, hydrology, toxicology and risk assessment that we hope will be useful to your deliberations. We recognize the tremendous challenge which you face and would welcome the opportunity to talk with you further if that would be useful. We would be willing to meet with you in Albany to discuss things such as the data we have on NYS soils, the quantification of plant uptake, likely pathways of highest risk for various contaminants, and calculation of groundwater impacts – all of which we have studied in detail.

Please contact Ellen Harrison, Cornell Waste Management Institute, 100 Rice Hall, Ithaca 14853 (607 255-8576; EZH1@cornell.edu) if you would like to follow up on these comments.

You are to be commended for proposing a rigorous approach to developing the rural soil values. We believe that the use of background values as the default clean up concentrations is a sound approach. It is realistic and achievable and should provide reasonable protection.

As you recognize, it is critical that background values be realistic and representative. One concern we discuss below is that natural, uncontaminated background levels of inorganic elements will vary within the state due to differences in geologic parent materials. A second concern is the likely inclusion of contaminated soils in the survey of “background” which would then cause a falsely high concentration to be taken as acceptable background. Thus extreme care is needed to ensure that selected sampling sites are not contaminated.

Having reviewed the materials on the WWW site (<http://www.dec.state.ny.us/website/der/superfund/soil.html>), we offer the following comments that we hope may help to make the soil survey more useful. By surface mail

we are sending a copy of these comments as well as a copy of the body of the thesis referred to below.

Soil Survey

We enclose a copy of the body of the PhD thesis of Malik Al-Wardy, “Elemental Distribution in the Surface and Sub-Surface Soils of Central and Western New York,” that was awarded by the Dept. of Crop and Soil Science in 2002. The research involved analysis of many soil samples from Central and Western NYS. The data in the thesis may be useful to you in assessing soil background levels for inorganic elements. One important (but not surprising) finding is that the main source of variation for a number of inorganic elements is parent material. Thus a geologic map is an important predictor of the concentration of many of the inorganic elements in NYS soils.

Parent Material and Inorganic Contaminants: Recognizing that parent material is key to the concentration of inorganic elements in background soils, we recommend that rather than a geographically random selection of non-urban sampling locations in 5 regions, that the sampling regions be defined by the underlying parent material. There are not a large number of different parent materials in NYS, so it might be possible to obtain data according to regions defined by parent material. GIS data for the purpose of identifying geologic parent materials likely exists.

It is important for the survey to recognize and document the differences in the naturally occurring concentration of inorganic elements in different regions of the state. Otherwise unrealistic clean-up goals are likely to be imposed in some areas and in other areas, a level of contamination may be tolerated that is not warranted. Thus, for example, if one region of the state has relatively high arsenic due to the bedrock in that area, it is conceivable that the “background” soil level selected from statewide data would be lower than background arsenic in uncontaminated soils in that region. This would lead to a situation in which soils would need to be imported to reach a “background” level that is lower than background in the vicinity. Conversely, to continue with the example, if samples with high naturally occurring arsenic are included in developing the background soil concentrations, in areas of the state where arsenic is not elevated in parent materials the “background” value would be higher than background in the vicinity.

It appears from the research literature that a particular element may be less bioavailable or leachable when it is naturally occurring rather than when it is present as an added contaminant. This would result from different chemical forms, species and compounds. Thus it would not be protective to use high background concentration values that represent naturally occurring levels and apply those values to areas of the state where natural background is low and any elevated levels are the result of site contamination. This speaks to the need for regionally specific background values based on naturally occurring patterns.

Sample parameters. There are several additional parameters which we believe should be included in the analysis since they are important parameters for predicting uptake and leaching. These include:

- pH – which is highly correlated to uptake, leachability and availability
- Total Sulfur – which is related to the potential for acidification and hence to leachability and uptake
- Cation Exchange Capacity (CEC) – related to uptake
- Total Organic Carbon – related to CEC and retention and binding of chemicals in the soil.

We also believe it would be reasonable to eliminate some constituents like calcium, iron or aluminum since they do not represent a significant risk to human and environmental health.

Sample location is critical. Above we discussed sample location from the point of view of underlying geologic materials. It is not clear from the document on the WWW what the intent is in regard to the level of contamination of potential sample locations. It appears from the criteria listed that the intent is to avoid grossly contaminated sites. However, the currently proposed setback from roads and industrial facilities is not sufficient to exclude significantly contaminated areas.

Distance from road – 20 paces is not enough distance from well traveled roads to avoid contamination. A quarter mile is more appropriate for avoiding road-borne contaminants along major roads. It does not seem appropriate to subject future occupants of Brownfield sites to the level of contamination expected adjacent to highly trafficked roads.

Distance from industrial facilities – the proposed distance is not sufficient for the downwind direction. A downstream plume may be more than half mile. In fact, a hot spot where air circulation brings contaminants down to earth may be that far away depending on stack heights and air movement. It might be possible to use GIS to locate permitted air pollution sources and map presumed plumes based on wind direction or to stay at least a mile from sources. It does not seem appropriate to subject future occupants of Brownfield sites to the level of contamination expected in the plume of an industrial facility.

The criteria also seem to potentially exclude pristine sites. In generating a data base for background soils, it would seem reasonable to include relatively pristine woodland sites, for example.

Analytic methods

The EPA analytic methods often do not specify detectors, and this can be key to results. Methods may just specify sample preparation. As an example, the cadmium data in the thesis provided to you and in fact in many peer reviewed publications are questionable. When ICP is used as the detector, interference occurs with iron, aluminum and arsenic and may give unrealistically high readings for cadmium. This would lead to a “background” cadmium concentration that is higher than true soil cadmium concentrations. Flameless AA is a more appropriate detector for cadmium and is what was used by Holmgren et al in their characterization of US soils. The cadmium values in their study are 1-2 orders of magnitude less than those typical of ICP studies. Thus we

recommend specifying flameless AA for cadmium measurement. We would be happy to discuss other analytic constraints with you.

How Soil Survey will be used. Having good numbers for the concentration of various soil contaminants and constituents is a first step. Then the question is how they will be used to develop standards for clean up. The documents provided do not make clear how the ecologic and the human health concentration values will be used together or separately.

Will the state be divided into regions? (The state of Maryland apparently divides their state into several regions for the purpose of defining background soil values.) Will the average value for concentrations detected become the background clean up value? The median (in which case half of the “background” soils in the state or region would be cleaner)? The 95th percentile? If the 95th percentile or some other high end value is used, it is particularly important not to include contaminated site data in the survey. Otherwise the “background” value may really represent a contaminated site.

Definition of “background”

It would seem reasonable to use the 95th percentile values from surveys of uncontaminated rural soils as the background soil number. However, as pointed out above, the concentration of inorganic elements in NYS soils will depend greatly on the parent material from which the soil is derived. It is quite possible that the 95th percentile from a statewide survey for a particular element would be close to the average in another region. It might be preferable to have different background soil standards for different geologic regions and within those regions to use the 95th percentile. However, if areas sampled include some that are contaminated (which would be likely if the current scenario for selecting sample locations is used as discussed above), then use of the 95th percentile could mean that relatively contaminated soil concentrations that may represent a significant risk are deemed “background.” Thus either more stringent criteria should be applied to preclude sampling from contaminated sites or else the median value and not an upper value percentile should be selected as the background concentration.

TO: NYS Dept. of Health Services at ceheduc@health.state.ny.us

CC: Jim Herrington, DEC; Kevin Gleason, DOH

FROM: David Bouldin, Murray McBride, and Ellen Harrison, Cornell Dept. of Crop and Soil Sciences; Anthony Hay, Cornell Dept. of Microbiology; Tammo Steenhuis and Brian Richards, Cornell Dept. of Biological and Environmental Engineering

DATE: June 21, 2004

Re: Comments on the proposed methods to develop Soil Clean Up Objectives

Thank you for the opportunity to comment on the proposed approaches to developing soil standards for Brownfield clean ups.

These comments represent the thinking of the Cornell faculty listed above. Our expertise and experience includes soil science, hydrology, toxicology and risk assessment that we hope will be useful to your deliberations. We recognize the tremendous challenge which you face and would welcome the opportunity to talk with you further if that would be useful. We would be willing to meet with you in Albany to discuss things such as the data we have on NYS soils, the quantification of plant uptake, likely pathways of highest risk for various contaminants, and calculation of groundwater impacts – all of which we have studied in detail.

Please contact Ellen Harrison, Cornell Waste Management Institute, 100 Rice Hall, Ithaca 14853 (607 255-8576; EZH1@cornell.edu) if you would like to follow up on these comments.

Having reviewed the materials on the WWW site, we offer the following comments.

RISK Assessment Issues from the Fact Sheets

General

The development of generic standards that apply to all sites is a tremendous challenge since site specific attributes such as soil characteristics (pH, organic matter content, etc.) and site characteristics (slope and runoff potential, depth to groundwater) have a great impact on the risks posed by particular contaminants. Recognizing the challenge of doing such generic standards, we offer the following comments.

Agricultural endpoint. It is highly appropriate to include the home garden pathway in the risk analysis. Residential gardening is practiced by many. Once remediated, there is no reason to think that residential occupants of remediated brownfield sites would be any less likely to garden than others.

It does not appear that agricultural use and productivity is among the endpoints under consideration. It would seem that unrestricted use should include agriculture (both growing crops and also pasture) as a potential land use. If so, there are some additional pathways of exposure to consider. One is the potential for some contaminants to be present at concentrations that are phytotoxic, thus compromising the productivity of the soil. Copper, nickel and zinc are such contaminants. For these metals when they are in soils, risk assessments generally find that phytotoxicity is a limiting risk pathway. Another pathway of concern if agriculture is practiced on these sites is the potential for some contaminants to accumulate in animal products consumed by humans. This is particularly true for some organic chemical contaminants that are lipophilic. While direct root uptake by plants is often low for such contaminants, uptake by leaves as a result of air transfer has been shown for some. More directly, however, grazing animals eat a significant quantity of soil (varying greatly depending on pasture conditions, but as high as 18% of diet dry weight has been documented). If agricultural use is to be protected by these soil standards, then the methods need to address these risks.

Focus. There are many chemicals and many potential exposure pathways which makes this a very complex task. However, many of these chemicals and pathways have been assessed by others and there is a substantial literature on some of them. We suggest that it might be helpful to convene an expert panel to help focus your effort and to identify particular pathways that are likely to present the greatest risk (and hence most restrictive standards) for specific chemicals. For example, there has been work that would lead us to conclude that for cadmium, the pathway that is likely to be the most restrictive is the home gardener due plant uptake into vegetables (particularly lettuce), while for zinc it is likely to be phytotoxicity. A consensus of experts on the pathway(s) of greatest risk for the chemicals listed (or for a class of chemicals) might help limit the necessary work. We would be willing to offer our assistance in such an effort if that is useful.

Multiple routes of exposure. Exposure to a particular chemical as a result of the brownfield site is likely to be only one source of exposure. The approach of taking background exposure into account as proposed is important and should be maintained. If each source of exposure is assessed independently as though it were the only source, then the cumulative exposure experienced could be many times greater than that deemed to be an acceptable risk.

Runoff. It does not appear that runoff is included as a pathway of exposure. Particularly for fish and aquatic organisms, which can be highly sensitive to some pollutants, this may be the major risk pathway. Some assessment of the risk posed by runoff from contaminated sites should be included. An important assumption in developing such a risk assessment is the expected dilution (i.e. What fraction of the watershed does the site comprise? Or conversely, what size stream is being protected?). Such a decision is clearly a policy choice, but whatever choice is made should be transparent.

Groundwater. The proposed model relies on out-dated concepts of homogeneous flow and does not account for preferential flow. It includes a “correction factor” of 100 which does not appear to be justified. Caution in the use of such an arbitrary correction factor was recognized in TAGM 4046.

The rationale for the 100 fold correction factor is that the following mechanisms during transport may prevent all of the contaminants in the contaminated soils from impacting the ground water. 1. volatility, 2. sorption and desorption. 3. leaching and diffusion; 4 transformation and degradation 5: change in concentration due to mixing and dilution when entering the ground water.

Although the statement is true in general there are some problems used in the present context. First, the equation already includes the (2) sorption and desorption processes and describes (3) leaching as transport. This leaves us to consider how mechanisms 1, 4 and 5 affect the leaching.

1 Volatility. Not all compounds are volatile. Moreover if the chemicals are incorporated, volatilization is small. Thus volatility will only reduce the concentration of chemicals that are volatile and not incorporated into soils.

4. Transformation and degradation. Degradation is highly variable among the compounds being considered. Some compounds transform in much more toxic daughter products, others degrade into less toxic, and some chemicals like DDT hardly degrade. So this assumption is not conservative.

5. Dilution and mixing in ground water. This is only conservative if the site is relatively small. If the site is large there will be very little dilution at the downstream end.

Consequently if we have a compound that is non-volatile with a low degradation rate and applied over a large area on a coarse sandy soil with shallow groundwater (leading to preferential flow during a large storm), we might expect the equation to be valid for describing the concentration in the soil and in the ground water without the application of any correction factor. Multiplying the soil concentration by a factor of 100 is irresponsible for this chemical in this context.

It makes sense to make different calculations for groundwater risk for upland (generally glacial till or bedrock) versus outwash aquifers. Thus the magnitude of any multiplication factor can be estimated based on the degradation rate of the chemical, recharge rate and travel time to the groundwater. If groundwater is the most restrictive pathway having a slightly more complicated equation might be warranted. For outwash aquifers there would probably be little correction while at distance on uplands it might be larger. Cornell faculty are more than willing to help with the development of the formulation of such an equation and correction factors if the agency deems it useful.

Partitioning of Organic Chemicals. We suggest the use of the EPA-sponsored tool, EPI Suite, for estimation for organic partitioning. This tool is free and accessible at: <http://www.epa.gov/opptintr/exposure/docs/episuite.htm>. It makes use of several models and known information about specific chemicals to calculate the predicted environmental fate. It would be far easier and provide better results than simply using Koc values.

Plant uptake

Measured plant uptake values are highly variable for many reasons including different soils (pH has a large impact for some contaminants), different environmental and climatic conditions (which may vary from year to year as well as from location to location) and different crops (there are very large differences among crops and even among varieties of the same crop plant!). This graph shows the results of field experiments with Cd loading on the X axis and Cd uptake on the Y. Note the tremendous range of uptake coefficients measured in real field experiments. This results from soil differences (pH is a major determinant of Cd uptake), environmental and climatic differences and differences in crops. If a broader array of crops were included, the range might be even larger.

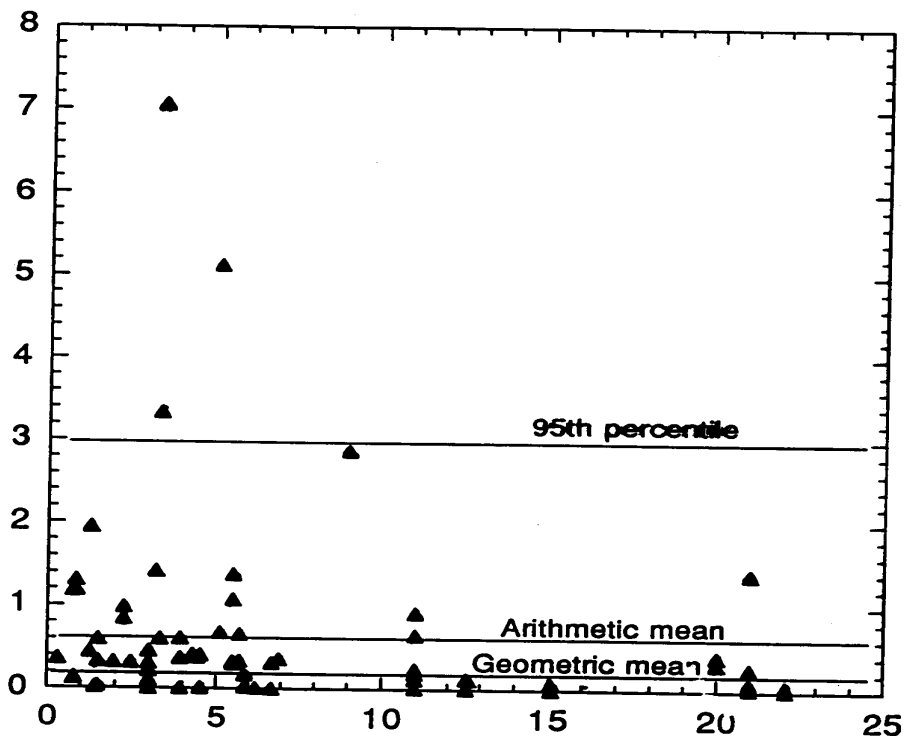


Figure 1: Cadmium uptake into leafy vegetables.

The ORNL report is not appropriate for use in the analysis of risks posed by uptake of contaminants into food crops since it addresses the average values for a limited range of plants. In performing a risk assessment for residential clean up, it would seem advisable to use data from crops that might be expected to be grown in a home garden and to use data that represent a relatively high uptake since a garden might well be situated on a relatively “risky” soil (in the case of cadmium this would be soils with low pH). Using average US or international values would not be protective of people gardening in many of the areas of NYS, where acid soils are common.

Fortunately, there are relatively few contaminants for which plant uptake is likely to be a major pathway of exposure. Cadmium and chromate are the two inorganic elements for which risk to humans through plant uptake should be assessed. If agricultural use by grazing animals is included, then molybdenum is an important contaminant to assess. If agricultural productivity of soils and phytotoxicity is included, then zinc and copper should be assessed. .

Diet. What people eat is an important component of assessing risks from garden use of the site. Home gardeners tend to be higher consumers of vegetables than the general population and that must be taken into consideration. It would seem reasonable to assess the risks based on the diet of a vegetarian home gardener.

Use of safety factors. It is sometimes suggested that risk assessments become overly conservative when safety factors are used, especially when several terms in the risk

assessment algorithm incorporate a safety factor. However, it is important to remember that safety factors are not arbitrarily thrown into the equations, but are rather included when there are specific uncertainties that need to be compensated for (such as a lack of data). The use of uncertainty factors has declined as usable data have increased (see Examination of EPA Risk Assessment Principles and Practices, 2004, section 4.3.3, accessed at <<http://www.epa.gov/osa/ratf-final.pdf> >). They are a valid and important component of risk assessment when data are missing.

It has also been suggested by some that risk assessments are overly conservative when default values such as the 95th percentile are used in more than one component of the risk calculation. However, the particular risk algorithm calculations determine how strongly such defaults influence the final calculation. It is not as simple as multiplying them together. Rather it depends greatly on the sensitivity of the calculation to the particular inputs being considered. This point is well explained in section 2.1.6 of the above referenced EPA document.

It would not seem consistent with reasonable protection to use mean or median values for parameters in the risk assessment process since this would not be protective in many situations. Rather use of data from the upper ends of the distributions makes sense. These data points represent real situations and people.