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In reply, please refer to:
File: 2019-387 RB

August 19, 2019

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USEPA REGION 9
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Ned Black, PhD
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Subject: Update to 2011 HDOH Memo Regarding Representative Sample Data

Dear Dr Stralka and Dr Black,

This letter addresses questions you raised in a meeting with staff from the Hawaii Department of Health (HDOH), Hazard Evaluation and Emergency Response (HEER) Office earlier this year regarding the acceptance of discrete soil and sediment sample data at contaminated sites in Hawaii. I was unfortunately unable to attend that meeting.

You asked if HDOH accepts discrete soil and sediment sample data for final decision making as part of a human health or ecological risk assessment. A detailed discussion of this issue is provided in Attachment 1. The short answer is "Yes." This is caveated, however, with a condition that individual, discrete samples be collected, processed and tested in accordance with Gy's sampling theory. The total mass and number of samples collected must also meet sampling theory requirements for "infinite particle" media such as soil and sediment. This typically requires the collection and testing of 1-2 kilograms of soil from at least 50 points within a targeted area. Independent, replicate sets of discrete sample data (minimum two) must be collected and tested to demonstrate total sampling precision and the reproducibility of an estimated exposure point (area) concentration. I am unaware of any discrete sample data project in Hawaii that fully meets these conditions.

We left this question open in a June 27, 2011, HDOH technical memorandum that I prepared following a meeting between our staff earlier that year (Attachment 2). In that meeting, we discussed and I think in general agreed on the high potential for error in determining the extent of contamination based on testing of small, individual masses of soil and sediment from "discrete" points. This is due to the inherent, heterogenous nature of contaminants in soil and sediment and the randomness of the concentration reported for a sample collected at a single point. We demonstrated the range of possible error in the use of discrete sample data to estimate

the extent of contamination in a field study of that we carried out in 2014 (see Attachment 1). The results were alarming but not necessarily surprising, given the common recognized disparity between "co-located" discrete samples collected as part of a site investigation.

The potential for significant error associated with estimation of an exposure point concentration based on a single set of discrete sample data was less well understood, since replicate sets of samples are rarely if ever collected to test data reproducibility. Our 2014 field study demonstrated, however, that the error can indeed be very large and that 95% UCLs based on replicate sets of discrete sample data collected from the same exposure area can vary significantly. This occurs in part because the mass of soil tested and/or the number of points considered in the sample data are inadequate to represent the targeted area and volume of soil.

These types of potential errors in the use of discrete sample data to characterize sites and assess risk motivated our office to begin transitioning to the use of "Decision Unit" and "Multi Increment Sample" investigation methods in 2004 and fully implement the use of "DU-MIS" methods in 2009. The science is very clear - DU-MIS sampling methods are far more reliable and efficient for final decision making than discrete sampling methods. This includes both initial site characterization and assessment of risk. The only question in the case of the latter is whether the degree of hidden error inherent in discrete sample data is tolerable in comparison to safety margins built into toxicity factors and estimates of exposure. This would be a useful topic to explore and discuss in more detail for both soil and sediment investigations.

We would be glad to discuss these issues with you and your group in more detail. Please feel free to contact me at your convenience. Perhaps we could begin by reviewing examples of projects where you feel that discrete sample data were adequate for final decision making to initiate discussions? I would be glad to set up a meeting at our office during your next visit to Hawaii. Please contact me at your convenience (roger.brewer@doh.hawaii.gov).

Sincerely,

Roger C Brewer

Roger C. Brewer, PhD
Senior Environmental Scientist

Cc: Keith Kawaoka, Fenix Grange, Maria Reyes (HDOH); Angeles Herrera, John Chesnutt (USEPA 9), Aaron Poentis, Jan Kotoshirodo, Janice Fukumoto (Navy)

Attachment 1: Discrete Sample Data Reliability (August 19, 2019)

Attachment 2: Multi-Increment versus Discrete Soil Samples (HDOH June 27, 2011)

Attachment 1

Discrete Sample Data Reliability

(HDOH August 19, 2019)

Discrete Sample Data Reliability for Use in Site Characterization and Risk Assessment

2011 Technical Memorandum

In the 2011 meeting between USEPA and HDOH staff documented in the 2011 memorandum (Attachment 2), we discussed concerns regarding the reliability of discrete sample data to estimate the lateral and vertical extent of contamination above potential levels of concern as well as the use of the data in human health and ecological risk assessments.

There was general agreement on the potential for error in the use of discrete sample data for general, site characterization purposes. We tentatively concurred with the continued use of discrete sample data to estimate mean, exposure area concentrations in risk assessments pending further research but we questioned the adequacy of small numbers of samples, for example eight or ten, purported in USEPA guidance to be adequate to represent large areas of contaminated soil.

Post-2011 Research and Experience

Our office carried out a detailed field study of discrete sample data variability in soil in 2015 (HDOH 2015; Brewer et al. 2017a,b). The results of that study as well as with additional experience at sites in Hawaii and discussions with international sampling experts are clear – Data provided by laboratories for a discrete soil sample are not reliably representative of the sample provided, and the sample provided is not reliably representative of the immediate area where it was collected. The only question is the degree of potential error in the data and in final, decision making.

Site Characterization

Our field study suggested that the concentration of a contaminant in soil can randomly vary around a single point by a factor of two under relatively ideal circumstances (e.g., arsenic-contaminated wastewater released to fine-grained soils) and as much as several orders of magnitude under scenarios where tiny "nuggets" of the contaminant are present in the soil (e.g., nuggets of PCB-infused tar from waste dielectric oils). The inherent randomness of discrete sample data is predicted in sampling theory for "infinite particulate media" such as soil and sediment and has been known by the mining and agriculture industries for decades. This phenomenon has only been recently "discovered" by the environmental industry, however. This is in large part due to the fact that the repercussions of erroneous data – failed mining ventures and failed crops in the former, are less obvious in assessments of chronic health risk.

Even so, the unreliability of discrete sample data in environmental work is well known to field workers, where completion of a site investigation can take years only for later data to indicate that the extent and mass of contamination present was much greater than initially thought. This has obvious implications on the continued acceptance of discrete sample data by regulatory agencies to assess the final adequacy of remedial actions.

Risk Assessment

The HDOH field study documented similar concerns with the use of a single set of discrete sample data to estimate the true mean for a targeted exposure area of contaminated soil and

subsequent assessment of risk. In one case (Study Site A – Arsenic), the 95% UCL estimated for random sets of 10, discrete samples collected from the area was consistently *higher* than the more reliable mean estimated by triplicate Multi Increment samples collected from the same area. While this might be used to support a conclusion that a 95% UCL based on discrete sample data is "conservative," it has obvious, negative implications for people concerned about potential impacts to their health as well as for parties required to remediate properties that in reality do not pose a significant risk to human health or the environment.

In the second case (Study Site B – Lead), the 95% UCL predicted from random sets of 10, discrete samples collected from the area fell both below and above the "true" mean concentration of lead in the soil based on DU-MIS data. This highlights the fact that a 95% UCL calculated from a single set of discrete samples is, like data for single points, *random within a largely unknown range of possibilities.*

The randomness and unreliability of 95% UCLs based on discrete sample data was particularly highlighted at the third study site (Study Site C – PCBs), where 95% UCLs based on random, 10-sample data sets varied from as low as 4 mg/kg to over 1,000,000 mg/kg. Such error in the estimation of the mean contaminant concentration for a targeted exposure area could only be reliably identified by the collection and comparison of independent, replicate sets of discrete sample data.

Collection of Representative Sample Data

As I discussed in a February 2019 webinar and again in July 2019 (links posted to the HEER Office webinar webpage), risk assessors "almost got it right" in the 1990s. Risk is of course based on the "mean" or "true" concentration of a contaminant within a designated, exposure area, rather than concentrations reported for individual, small masses of soil within the targeted area. These are referred to as "Exposure Area Decision Units" in Section 3 and Section 4 of the HDOH TGM.

The true mean can only be determined by testing of the entire volume of soil in the exposure area. This is of course not feasible. The mean is instead estimated by collecting and testing soil from a number of points within the exposure area. On this point we still agree.

The objective from an analytical standpoint is to estimate the concentration of the targeted contaminant in the total mass of soil collected. Data for individual points have no meaning in terms of assessing risk. The individual points do not reflect the mean for the exposure area, nor does the mass tested by the laboratory, typically one or ten grams, reflect the default mass of soil assumed to be ingested by young children (200 mg/day) or adults (100 mg/day). The concentration of a contaminant reported by a laboratory will vary with respect to the mass of the soil subsample specifically tested by the laboratory. The range of contaminant concentrations reported therefore also has no meaning in terms of risk.

The use of statistical tests to estimate the mean concentration of a contaminant based on a single set of discrete sample data could in theory provide an acceptably accurate answer, with the limitations noted above. The number of points included and the total mass of soil represented by

the data would also need to meet minimum requirements under sampling theory for testing of "infinite particle media." This is discussed in Section 4 of the HEER TGM.

It makes far more sense and allows for far better data precision to simply combine the individual masses of soil collected within a targeted exposure into a single sample, have the laboratory properly process the sample, collect a representative subsample for analysis and report a single concentration. This is the essence of "Decision Unit" and "Multi Increment Sample" investigation methods, which could be more properly described as "Risk Based Site Characterization." Sampling theory and decades of research by field workers and statisticians in the mining and agriculture industries tells us that for typical, environmental investigations, a sample must be collected from a minimum of 50 points or "increments" (to address distributional heterogeneity) and have a minimum mass of 1-2 kilograms (to address compositional heterogeneity). The total precision of the resulting data is assessed through the collection and testing of independent, replicate samples, as discussed in Section 4 of our TGM. In some cases, the collection of a smaller sample from fewer points might yield accurate data, but this would need to be demonstrated on a site-specific basis. Larger samples comprised of more than 50 increments and having a greater, bulk mass might be required in other instances, as seems to routinely be the case for PCBs and soil contaminated with small fragments of lead.

Environmental professionals well experienced in discrete sampling methods but new to sampling theory and DU-MIS methods typically reach a "compromise" point where they conclude that DU-MIS investigation methods are appropriate for some situations and discrete sample investigation methods are appropriate for others. This is usually due to a premature assumption that discrete samples are required to determine the initial extent of contamination. As demonstrated in our field study as well as in thirty years of "failed" confirmation samples, however, discrete sample data are highly prone to "false negatives," that is, underestimation of the actual extent of contamination present. The extent of contamination is far more reliably determined through the designation of well-placed Decision Units and the collection of Multi Increment samples from each DU. We dedicated an entire webinar to this topic in our 2017, six-part training series on DU-MIS investigation methods (recordings posted to HEER YouTube channel).

Risk assessors sometimes retort that they want to know the "range" of contaminant concentrations in soil collected from individual points as part of their decision making. As discussed in our training workshops and publications, however, the concentration reported for a contaminant in soil is entirely dependent on the mass of soil actually extracted by the laboratory. Greater variability and higher concentrations will be reported for smaller and smaller subsamples. At some scale, the "maximum" concentration of a contaminant in soil, if present, will always be "100%" (Brewer et al. 2017b). The concentration of a contaminant reported for a random subsample collected from a single, random, discrete field sample in turn has no bearing whatsoever on risk. It is a random artifact of the mass of soil tested.

Sediment Research

The majority of past research by our office and other entities have focused on improved sampling methods for soil, but it is rational to assume that similar concerns apply to sediment. The only question is again the relative degree of error in the data and in decision making.

Informal studies in Hawaii and discussions with sediment experts in the US and other countries suggests that data for co-located, discrete samples in sediment that was contaminated prior to being deposited are unlikely to vary to the extreme observed at the HDOH PCB study site but could easily vary by an order of magnitude under some scenarios. This seems to be particularly true for PCBs, similar to our findings for soil.

A detailed field study of discrete sample data variability similar in scope to the soil study carried out in 2015 by HDOH is sorely needed. We propose that such a study be jointly carried out with staff from USEPA Region 9 and other government agencies or research institutions to better understand the reliability of discrete sample data for characterization and assessment of contaminated sediment. The HDOH TGM provides a few examples of DU-MIS investigation methods for sediment but more field research in sample collection methods is also needed. The study could explore more efficient ways to collect representative sediment samples in different aquatic environments, including for example the recent advent of "mini Vibracore" sampling tools.

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Attachment 2

Use of Multi-Increment versus Discrete Soil Samples in DoD sites in Hawaii (HDOH June 27, 2011)

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In reply, please refer to:
File:
2011-390 MR

July 15, 2011

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Facility/Site: **Department of Defense (DoD) Sites in Hawaii**

Subject: **Use of Multi-Increment versus Discrete Soil Samples in DoD sites in Hawaii**

Dear Ms. Fukumoto:

In recent years, the multi-increment sampling method has been developed to provide another tool to help in environmental investigations. There still seems to be a lot of questions on when and where multi-increment sampling is appropriate to use. Attached is a memorandum from Dr. Roger Brewer summarizing the key points and recommendations on the use of multi-increment versus discrete sampling methods in investigations of DoD sites in Hawaii. In addition to the HDOH Technical Guidance Manual, these recommendations, resulting from the May 18, 2011 meeting with NAVFAC-HI, NAVFAC-PAC, USEPA Region IX, and HDOH, serve as HDOH guidance on how sites are to be investigated using multi-increment samples. Please advise your contractors and other Navy reviewers who need to know how multi-increment sampling is done, of this guidance.

Should there be any questions, please do not hesitate to contact me at 586-7576. Thank you very much for your time and consideration in this matter.

Sincerely,

Ma. Eloisa Q. Reyes

Maria Eloisa Q. Reyes, Ph.D.
Remedial Project Manager
Hazard Evaluation and Emergency Response Office

Attachment

c: John Chesnutt, U.S. EPA Region 9
Christopher Lichens, U.S. EPA Region 9
Daniel Stralka, U.S. EPA Region 9
Ned Black, U.S. EPA Region 9
Rich Howard, TechLaw, Inc.

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In reply, please refer to:
File: EHA/HEER Office

TO: Fenix Grange, Steven Mow and Maria Reyes
Site Discovery, Assessment and Remediation Section
HEER Office

2011-344-RB

FROM: Roger Brewer RCB
Environmental Hazard Evaluation
HEER Office

DATE: June 27, 2011

SUBJECT: Use of Multi-Increment versus Discrete Soil Samples at Department of Defense (DoD) Sites in Hawai'i

This memo summarizes key points and recommendations on the use of multi-increment (MI) samples (MIS) versus discrete soil samples at DoD sites in Hawai'i, following our May 18, 2011, meeting at Pearl Harbor Navy Base with Janice Fukumoto of NAVFAC and Dan Stralka (human health risk assessor), Ned Black (eco risk assessor), John Chestnut (Federal Facilities manager), Chris Lichens (project manager) of USEPA Region IX. The meeting focused on the use of MIS vs discrete samples for risk assessment purposes as well as the use of MIS vs discrete soil samples for site investigation purposes. This memo reflects similar comments regarding the use of discrete soil samples by USEPA contactors for investigation of a former pesticide mixing site within Pearl Harbor Naval Reservation (HDOH 2011a).

The discussion focused on two main points:

A. Use of the 95% UCL of soil data in human health, risk assessments at DoD sites, and
B. Use of data for a small number of discrete soil samples (e.g., <8) for final decision making purposes during the site investigation stage of a project.

HDOH and USEPA Region IX staff agreed on the first point and further agreed that either discrete or MI samples can be used to accomplish this goal during the Risk Assessment stage of a project. USEPA staff pointed out that the concept of Exposure Area Decision Units (DUs) described in the HEER office *Technical Guidance Manual* (TGM) is identical to the concept of exposure areas described in USEPA risk assessment guidance. Both HDOH and USEPA staff emphasized that an adequate number of discrete soil samples must be collected to calculate a viable 95% UCL. USEPA staff pointed out that a minimum of eight samples is required and usually more, depending on the number and variability of discrete sample data points. HDOH staff suggested that MI samples generally provide higher quality data, given the large number of sample ("increment") points incorporated into the final data and enhanced coverage of the targeted DU.

HDOH and USEPA staff disagreed on the use of a small number of discrete soil samples (e.g., less than eight) to initially screen a site for potential soil contamination concerns during the Site Investigation stage of a project. USEPA staff suggested that the maximum concentration of targeted contaminants reported for a small number of samples could be compared to risk-based screening (action) levels and combined with general knowledge of the site history to determine the need for additional actions. HDOH staff pointed out that, based on their experience with both discrete and MI sample data, this approach is prone to "false negatives" and the risk of declaring a contaminated site to be clean. HDOH staff insisted that high quality data be collected for final, decision making purposes in both the Site Investigation and Risk Assessment stages of a project, regardless of whether discrete or MI samples are used. Additional discussion of this issue is provided below.

Use of Discrete vs MI Soil Sample Data in Risk Assessments

USEPA and HEER staff concurred that either discrete or MI soil samples can be used to characterize targeted Exposure Area DUs as part of a risk assessment. This is also discussed in the HEER office Technical Guidance Manual (TGM; HDOH 2009). USEPA staff noted that the concept of a "Decision Units (DU)" to specify a targeted exposure area in the field is consistent with USEPA risk assessment guidance. The targeted Exposure Area DU should be designated at the beginning of the investigation and either discrete or MI samples then collected to characterize the DU.

If discrete soil sample data are used then a 95% UCL be calculated for estimation of Exposure Area ("Point") Concentrations (EAC). This is done in part because the number of available, discrete sample data points is often inadequate to calculate a reliable Exposure Area Concentration based only on the arithmetic mean. Use of the 95% UCL is intended to help address this issue and estimate a more conservative but still reasonable EAC.

If the maximum-reported concentration exceeds the calculated 95% UCL calculated for the DU, the maximum concentration should not be used for final, decision making purposes. Additional discrete samples (or alternative MI samples) should instead be collected to improve the quality of the data and provide a more representative estimate of the 95% UCL. Although this is rarely done for risk assessments, USEPA staff suggested that is it adequate for initial, Site Investigation purposes. As discussed in the following section, this conflicts with guidance in the HEER office TGM and is not recommended for use in either risk assessments or site investigations.

USEPA staff also recommended that a 95% UCL be calculated for estimation of the Exposure Area Concentration if an MIS approach is used to characterize a DU for risk assessment purposes. This is conservative but reasonable for DoD sites. As discussed in our Technical Guidance Manual, this will require the collect of at least three, replicate MI samples in the targeted DU. USEPA staff agreed that replicate samples do not need to be collected in *every* DU to be evaluated in the risk assessment. Statistical evaluation of replicate data for a DU can be applied to other DUs where replicate samples were not collected, provided that the DUs have a similar contaminant history. This is also discussed in our TGM. In some cases it may be prudent to increase the number or increments included in an MI sample and/or increase the number of replicates collected in order to improve the calculation of a 95% UCL.

Use of MIS vs Discrete Soil Samples in Site Investigations

Both USEPA and HEER staff also agreed that either discrete or MI soil samples can be used during the Site Investigation stage of a project. In either case, however, **Decision Units must be designated to specifically denote the area (and volume) of the soil that the samples are intended to represent as part of the initial stage of a Site Investigation.** This is generally not done as part of traditional, discrete sampling approaches.

Much of the discussion with USEPA staff centered on the use of a small number of discrete samples during the Site Investigation stage of a project and use of the data to determine whether or not the project should continue on to the Remedial Investigation stage. Although this was common practice in the past, **the absence of well-thought-out DUs and reliance on a small number of discrete sample points for final, decision making purposes at the Site Investigation stage of a project can lead to multiple problems** (see attached figure; HDOH 2011b), including:

1. Risk of "false negatives" and erroneous declaration of contaminated sites to be clean;
2. Underestimation of the lateral and vertical extent of contaminated soil surrounding significant spill areas;
3. Confusion over sample-size "hot spots" in areas that are otherwise not significantly contaminated ("false positives");
4. Underestimation of contaminant mass for evaluation of soil treatment options.

These problems occur due to the inherent heterogeneity of contaminant concentrations in soil at the scale of a discrete sample or more specifically the discrete sample aliquot actually analyzed by the laboratory (typically one to thirty grams). Attempting to do so opens the potential for "false negatives" ("A" in attached figure) and the erroneous determination of "clean" boundaries within areas of otherwise contaminated soil (i.e., mean fails screening level but individual sample points may fall below this level; see HDOH 2011b).

Focusing on individual, discrete soil samples can also lead to confusion over "false positives" and outlier "hot spots" ("B" in attached figure) within an otherwise area of clean soil (i.e., mean passes screening level but individual sample points may exceed this level). These problems are expressed in the field by the need for multiple, over-excavations of contaminated soil that had initially been identified based on discrete samples data or misguided attempts to excavate isolated, sample-size "hot spots" of contaminated soil in otherwise clean areas (see HDOH 2009, 2011b).

If discrete samples are to be used during the Site Investigation stage of a project, then an adequate number of samples should be collected from designated DUs to calculate a representative, 95% UCL for all targeted contaminants. The 95% UCL should then be used for final, decision making purposes, including the need to carry the advance the DU into the Remedial Investigation stage of the project. If the maximum-reported concentration exceeds the calculated 95% UCL calculated for the DU, then additional discrete samples should be collected until such time that a viable, 95% UCL can be calculated. Use of the maximum-reported concentration of a contaminant from a small number of discrete samples to screen the site is not acceptable. Subsampling of discrete soil samples to be used to calculate a 95% UCL for risk assessment purposes is not necessary, however, although this may decrease inter-sample variability and help generate a more representative UCL.

In some cases it may be necessary to make preliminary decisions for site investigation, risk assessment and/or remedial actions based on a small number of discrete soil samples (e.g., sites with existing, discrete soil data). **In order to ensure that the potential errors outlined above are adequately addressed, recommendations based on discrete sample data should be confirmed by the collection of followup, Multi-Increment (MI) samples in accordance with HEER office guidance** (HEER 2009, 2011b).

As an alternative, and as recommended in our TGM, an MI sample can be collected and used to characterize targeted DUs at the beginning of a site investigation (HDOH 2009). MIS-investigation approaches help to minimize these types of problems by first designating a specific area/volume of soil that the soil sample(s) is intended to represent and then ensuring that an adequate number of sampling points, or "increments," are collected within that area to estimate a representative mean. Multi-increment samples by definition require that a relatively large number of sample points ("increments") be incorporated into the sample in order to provide a better estimation of mean contaminant concentrations up front. The collection of replicate samples within the same DU (or similar DUs) is intended to help verify that the data reported for targeted contaminants is indeed representative of the true mean. If the replicate data are adequately similar (e.g., Relative Percent Difference +/- 35%) then adjustment of data for individual DUs (e.g., calculation of 95% UCLs) isn't strictly necessary.

<u>Subsurface Investigations</u>

Decision Units must be designated for subsurface investigations. This would ideally involve the designation and characterization of individual, subsurface DU layers, with thirty or more increments collected from each layers. **This will require the installation of thirty or more borings for typical, tabular-shaped DUs (i.e., vs DUs that are thicker than they are wide or long).** If this is not practical, for example due to access or budget constraints, then the limitations of the data should be discussed in the investigation report. As discussed in the HEER office TGM, increments are collected and combined from subsurface DU layers in the same manner as done for surface soils. The mass of increments collected from individual cores may require subsampling in the field in order to reduce the final, bulk MI sample to a manageable size (see HDOH 2009, 2011b). This approach can also be used for the investigation of subsurface soils contaminated with volatile chemicals (HDOH 2011c).

For screening level purposes, it may be useful or even necessary to designate targeted layers *within individual borings* as Decision Units. This is commonly done to initially estimate the lateral and/or vertical extent subsurface contamination. As discussed in the HEER office TGM, the *entire core* from the targeted DU layer should be submitted to the lab for subsampling and analysis. In essence this is a "discrete" sample since the core is not subsampled prior to submittal to the lab for processing and analysis. If the cores are too long or otherwise too bulky then they should be subsampled in the field (refer to HEER office TGM). The reduced confidence in the resulting data should be noted and taken into consideration along with the history of the targeted area and the potential for significant contamination to be present. As discussed above, **preliminary decisions based on based on limited discrete sample data should be confirmed by the collection of followup, Multi-Increment (MI) samples and/or additional, more focused borings in areas of particular concern.** Examples include the collection of MI confirmation samples from sidewalls and floors of excavation initially established based on discrete sample data from borings.

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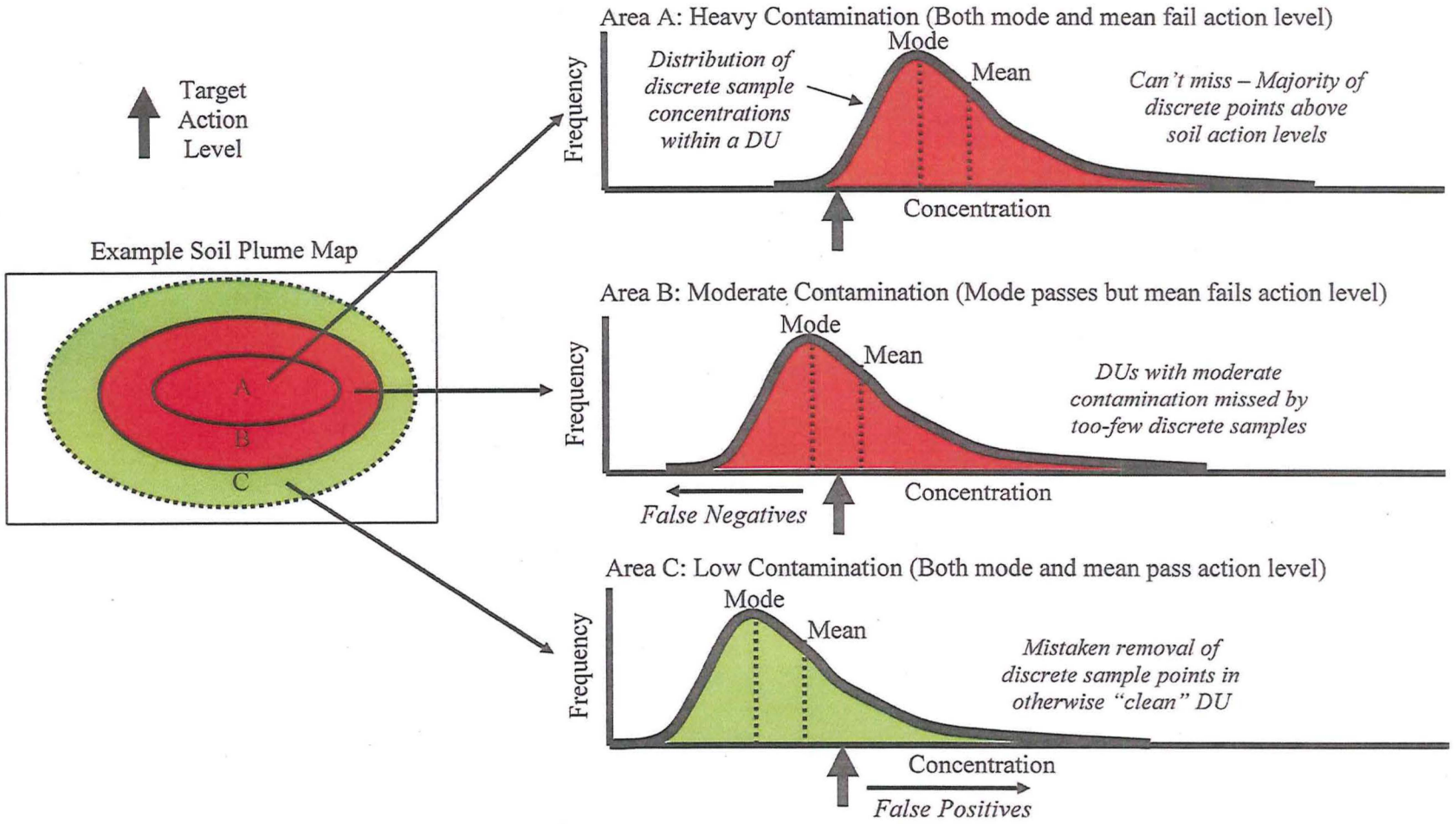

Figure 1 (see also HDOH 2011). Effect of contaminant heterogeneity at the scale of a discrete laboratory subsample on decision making when using a non-representative number of discrete samples or MI increment points. Initial samples likely to fall around the mode. A minimum of thirty to fifty sampling points (discrete or MI) is required to adequately capture the heterogeneity of contaminant distribution within the DU and estimate a representative contaminant mean (and mass). A small number of discrete samples will identify areas of heavy contamination in Scenario A but could underestimate mean concentration and total mass, leading to failed *in situ* remediation. False negatives in Scenario B can lead to an underestimation of contamination extent and failed excavations or *in situ* treatment. False positives in Scenario C lead to unnecessary soil treatment/removal associated with discrete sample points or borings in otherwise clean DUs.