Overview of Guidance on Survey for Subsurface Radiological Contaminants

Subsurface Hot Spots

Carl Gogolak

SC&A, Inc.
2200 Wilson Blvd., Suite 300
Arlington, VA 22201

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What Is a Subsurface "Hot Spot"?

- Should there be an elevated measurement comparison for the subsurface?
- Since scanning is not possible, every radionuclide in the subsurface is "hard-to-detect"
- How many and at what depths should subsurface subsamples be analyzed?
- Can the core be scanned?

Complexities of Subsurface Sampling

- Number and location of soil core samples
  - For each location, the number and depth of soil subsamples within each soil core must also be specified
  - Cross contamination among vertical layers must be avoided
  - In case of boring tool refusal, an alternative should be specified

MARSSIM Elevated Areas

- MARSSIM does not directly address the issue of "hard-to-detect" radionuclides
  - MARSSIM considers that elevated areas the size of the space between discrete sampling locations will be found with essentially 100% probability as calculated using ELLIPGRID
  - An elevated area that is smaller will have a higher risk of being missed by the sampling grid. Again, the probability of detection can be calculated by ELLIPGRID. The data quality objectives process will determine the risk that is deemed acceptable

Derived Concentration Guideline Levels (DCGLs)

- Guidance will be needed that distinguishes between a surface DCGLw (wide area) and a subsurface DCGLv (volumetric)
  - Different classes of survey units may apply to the surface of the excavation vs. that of the subsurface survey units

Pathways for Subsurface Residual Radioactivity

- Is the dose due to an intruder scenario or building foundation limiting?
- Is the groundwater pathway limiting?
- Is the DCGLv primarily dependent on inventory across a site? ...across a survey unit?

Derived Concentration Guideline Levels

- Multiple DCGLs may be needed depending upon the radionuclides present, applicable exposure scenarios, and actual site conditions
  - It may be beneficial to develop separate DCGLs for cases such as deep subsurface residual radioactivity because of the importance of the groundwater pathway
  - Using multiple DCGLs may be more straightforward where different sources are present (e.g., residual radioactivity at the surface vs. residual radioactivity associated with buried material or from deep subsurface spills or leaks that may contain mixtures of radionuclides)

Derived Concentration Guideline Levels

- NUREG-1757, Volume 2, Revision 2, Appendix G, notes that the class of the side walls may be different (Class 1, 2, or 3) depending on slope
- Typically, DCGLs are developed for layers (depth below ground surface and thickness) and apply to the final configuration/distribution after soil is placed back in the hole, or can apply to “as-is” residual radioactivity below excavation (or to the side of the excavation)

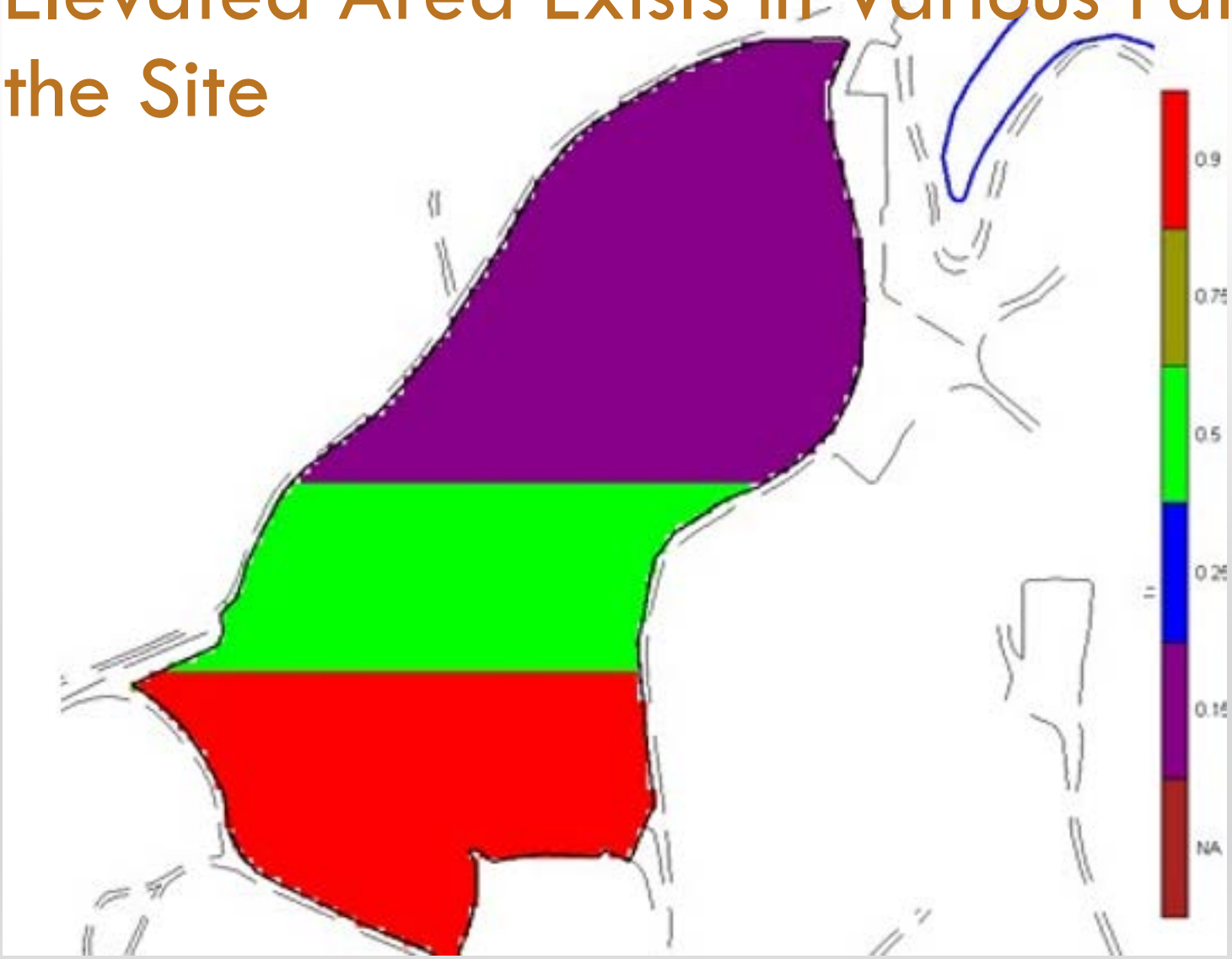
Locating Subsurface "Hot Spots"

- What is an elevated volume (size)?
- Can a layered approach be used for excavations?
- Can multiple subsurface layers or strata be considered individually and then the cumulative risk from the multiple layers or strata be assessed?

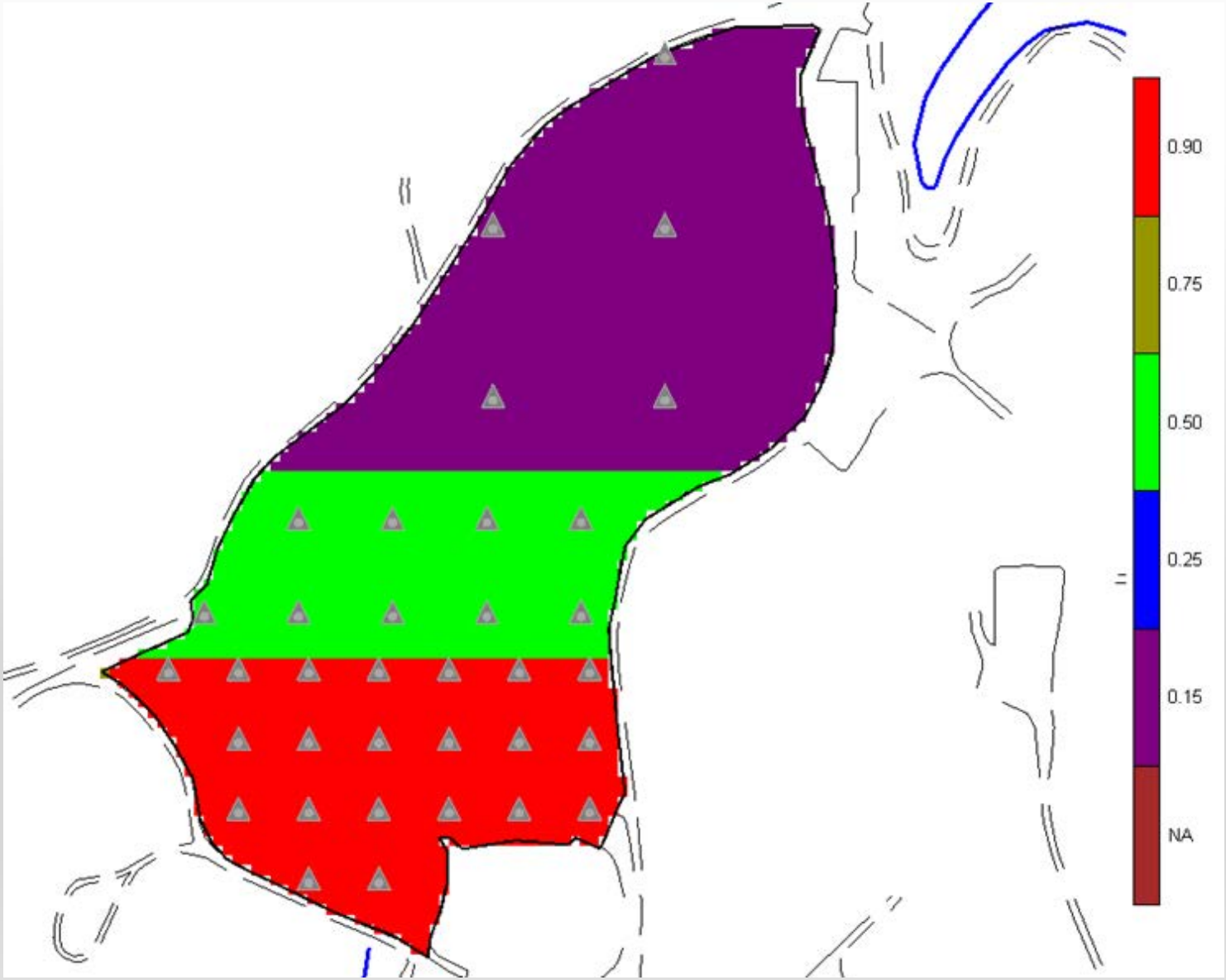
How Many Samples Are Enough?

- How much does adding sampling locations lower the decision uncertainty?
- To answer this question, there must be some measurable benefit for each additional sample taken
- In MARSSIM Scenario A, a minimum number of samples will be needed to achieve the desired Type I and Type II error rates α and β
- Once this number is reached, each additional sample results in the benefit of higher power (1-β)
- For the subsurface, a measure analogous to the power of the hypothesis test vs. sample size is desired

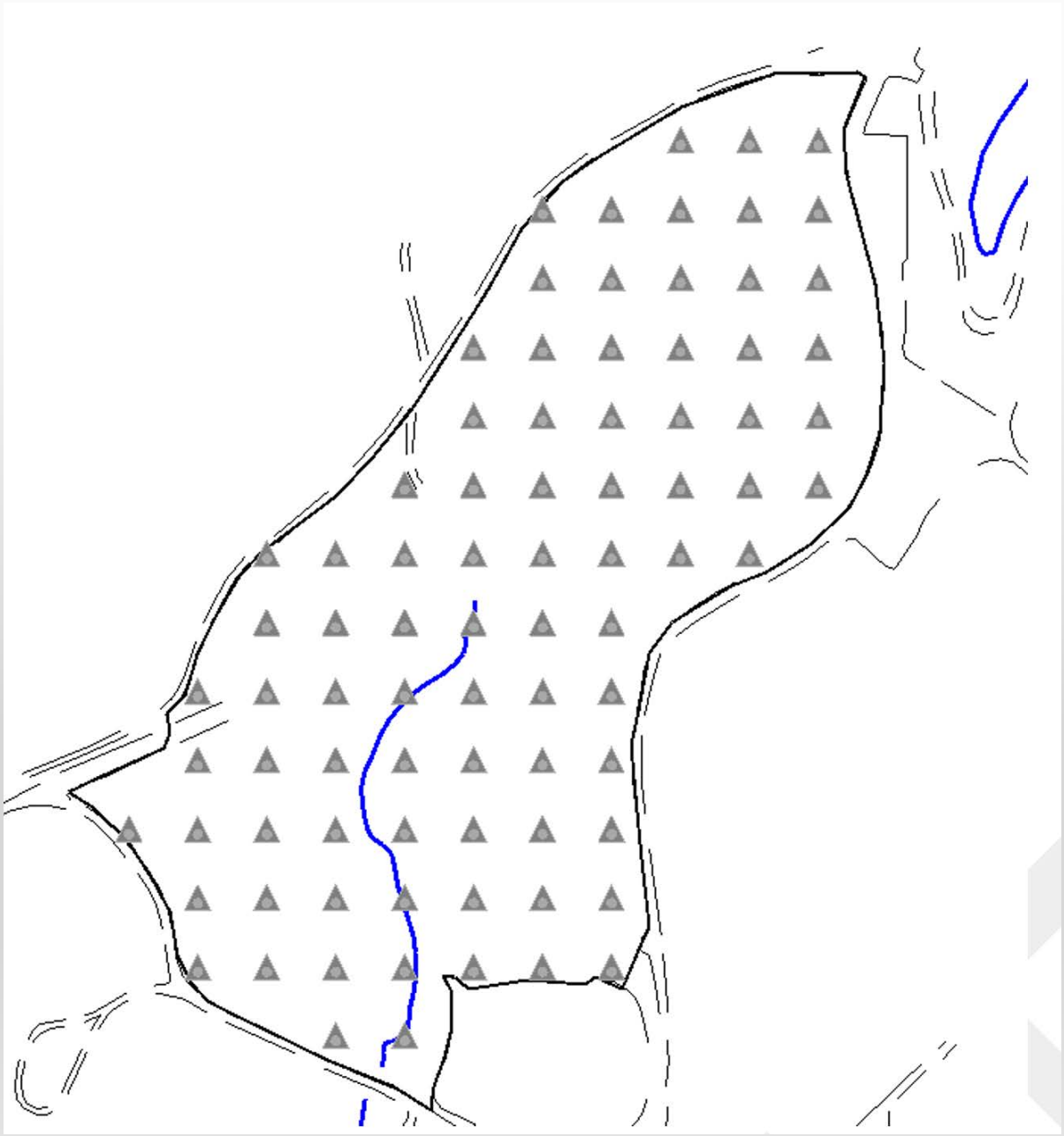
Bayesian ELLIPGRID: Likelihood of an Elevated Area Exists in Various Parts of the Site



Initial Survey Design: 37 Samples



Without Prior Probabilities: 87 Samples



Hypothesis Tests

How should a decision rule be formulated?

- Assume the survey unit does not meet release criteria unless proved otherwise (MARSSIM Scenario A) or
- Assume the survey unit meets release criteria unless proved otherwise (MARSSIM Scenario B)
  - Appendix G to NUREG-1757, Volume 2, contains examples of Scenario B for three-dimensional data
- What are the criteria for choosing between scenarios?
- If there is a wide variability in reference areas, should there be an indistinguishable-from-background test?

Other Sampling and Analysis Tools

- Are geophysical tools such as ground penetrating radar, electrical resistivity, and metal detectors useful aids in locating subsurface residual radioactivity?
- Can transect scanning (as in the UXO module in VSP) be used with such data?
- Redundant data: VSP can rank well locations by the value it contributes to the whole and eliminate those that are least useful; might this be done in reverse?

Update Existing Tools: VSP &SADA

- Geostatistics and other interpolation methods cannot find locations that exceed the largest value of the measurand unless there is some soft data that can drive higher concentrations (e.g., dry deposition data can extrapolate higher wet concentrations where the rainfall rate is higher)
- If indicator kriging is used to develop a probability distribution for the residual radioactivity, then a high percentile (e.g., 95%) may also extrapolate the data to higher concentrations; of course, this will require that the release criterion is expressed as an action level for that percentile

SC&A Contacts

SC&A, Inc.

2200 Wilson Boulevard, Suite 300

Arlington, VA 22201

(703) 893-6600

www.scainc.com

Carl Gogolak, cgogolak@associates.scainc.com

Claude Wiblin, cwiblin@scainc.com