Marriott Statistical Consulting

How the UK Land Contamination Sector Inadvertently Became the First to Move to a World Beyond p<0.05

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Why Land Contamination & Remediation needs Stats

More links at https://bit.ly/3NQcJ4V

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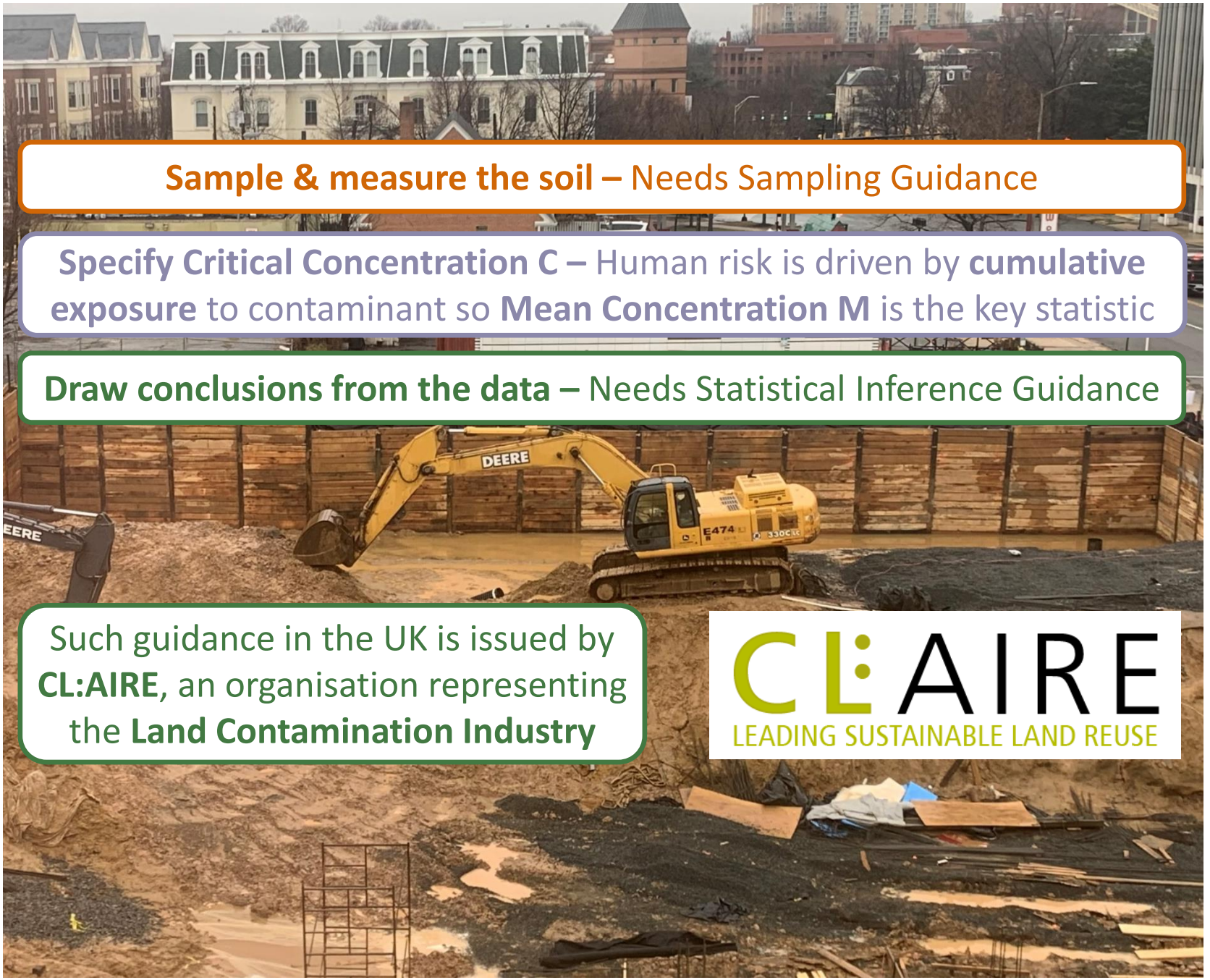


Sample & measure the soil – Needs Sampling Guidance

Specify Critical Concentration C – Human risk is driven by **cumulative exposure** to contaminant so **Mean Concentration M** is the key statistic

Draw conclusions from the data – Needs Statistical Inference Guidance

Such guidance in the UK is issued by **CL:AIRE**, an organisation representing the **Land Contamination Industry**

CL:AIRE
LEADING SUSTAINABLE LAND REUSE

More links at https://bit.ly/3NQcJ4V

CL:AIRE Stats Guidance - 2008

- The 2008 guidance was straight out of a statistics textbook on Hypothesis Testing using 1-way T-Tests.

- Given critical concentration **C,** sample size **n,** sample mean **m** & sample standard deviation **s,** test **H0** & **H1** according to status of building works -
  - Before building starts - Set **H0**: **M >= C**, **H1**: **M < C**
  - After building is finished – Set **H0**: **M <= C**, **H1**: **M > C**
  - If **p < 0.05** reject **H0** in favour of **H1**.

- In 2016, CL:AIRE asked me to rewrite this guidance due to many concerns –
  - People not using the guidance since "*it's too complicated*".
  - People jumping straight into the calculations without checking whether their sampling plan is good enough.
  - People using T-tests in a bright line fashion without thinking about it.
  - Regulators possibly making wrong decisions on grounds the guidance hasn't been followed to the letter.
  - *General sense of statistics disempowering the practitioner's expertise*.

More links at https://bit.ly/3NQcJ4V

2016 ASA P-Value Statement – Key Paragraph

"Good statistical practice, as an essential component of good scientific practice, emphasizes …

1. *… principles of good study design and conduct,*
2. *… a variety of numerical and graphical summaries of data,*
3. *… understanding of the phenomenon under study,*
4. *… interpretation of results in context,*
5. *… complete reporting and*
6. *… proper logical and quantitative understanding of what data summaries mean. …*

… No single index should substitute for scientific reasoning."

I had already recommended something like this to CL:AIRE

More links at https://bit.ly/3NQcJ4V

2019 TAS P-Value Editorial – Key Paragraphs

*"Yet the voices in the 43 papers in this issue **do not sing as one**. … To us, these are all the sounds of statistical inference in the 21st century, the sounds of **a world learning to venture beyond $p < 0.05$ …***

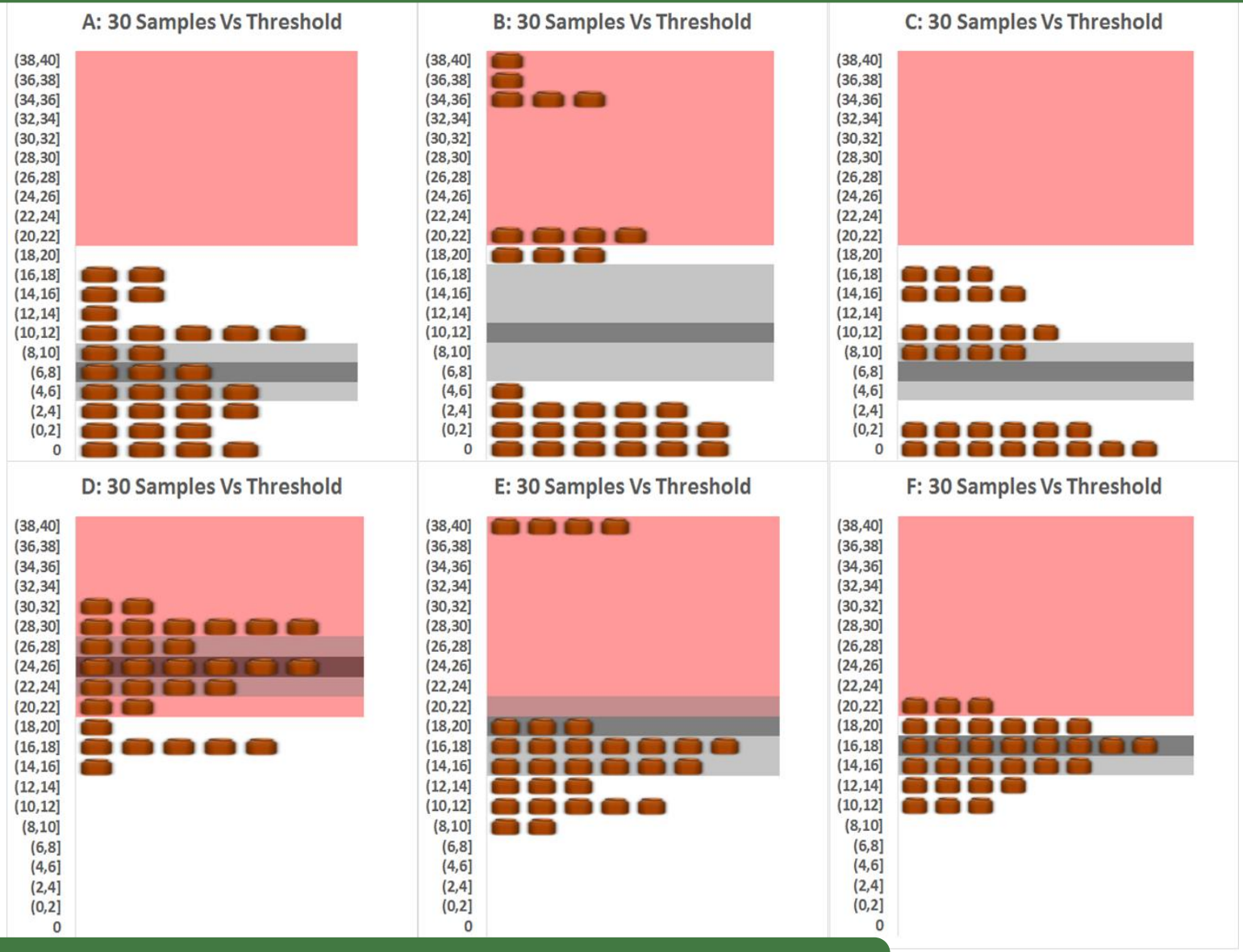
*…. Researchers will be free to communicate all their findings in all their glorious **uncertainty,** knowing their work is to be judged by **the quality and effective communication of their science**, and not by their p-values.*

As "statistical significance" is used less, statistical thinking will be used more."

Statistical Thinking is how you Navigate through Data

More links at https://bit.ly/3NQcJ4V

What I was saying to CL:AIRE in 2017



Only scenario F requires statistical inference

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Supported by

Environment Agency

NDA

RSK

SAGTA

After a long debate over the guidance's pre-requisites, the new version was published in **September 2020**

Professional Guidance:
Comparing Soil Contamination Data with a Critical Concentration

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APPENDIX A1 - "Good statistical practice, as an essential component of good scientific practice, emphasizes …

1. ***"… principles of good study design and conduct …"***
   - ❑ CSMs, Sampling Plans, Non-Detect rules, Critical Concentration, etc
2. ***"… a variety of numerical and graphical summaries of data …"***
   - ❑ Dot, Box & Spatial Plots, Summary Statistics & Confidence Intervals
3. ***"… understanding of the phenomenon under study …"***
   - ❑ Using the CSM to identify expected Data Type and results.
4. ***"… interpretation of results in context …"***
   - ❑ Do results show you need to revise your CSM or collect more samples?
5. ***"… complete reporting and …"***
   - ❑ Are you in a position to state "*I am confident that …*" for a variety of points.
6. ***"… proper logical and quantitative understanding of what data summaries mean. …"***
   - ❑ If the comparison of the confidence intervals to the critical concentrations is borderline, what is the right & wrong way to interpret what you see?

… No single index should substitute for scientific reasoning."

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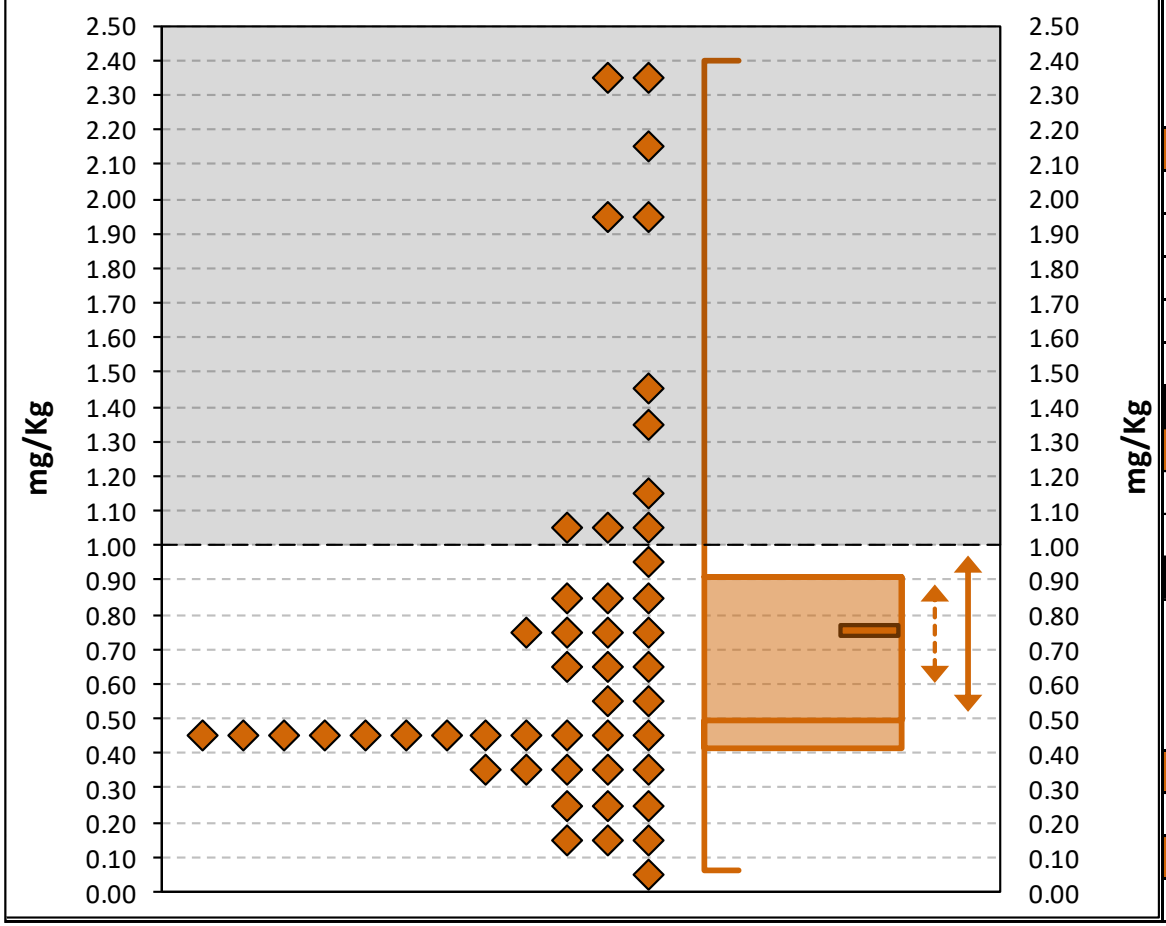
Dot, Box & Two Confidence Intervals

Dot & Box Plots, Summary Statistics & Confidence Intervals

Dataset	Log Symmetric
Units	mg/Kg



Summary Statistics Actual Values

Number of Samples	48
Maximum	2.40
Upper Quartile	0.91
Median	0.50
Lower Quartile	0.41
Minimum	0.06
Critical Concentration	1.00
Mean Concentration	0.75
Standard Deviation	0.58
InterQuartile Range	0.50
LMDL % Used	50%

Confidence Intervals for the Mean Concentration

90% Confidence Interval	
0.61	0.89

99% Confidence Interval	
0.52	0.97

No recommendation made on levels of confidence needed

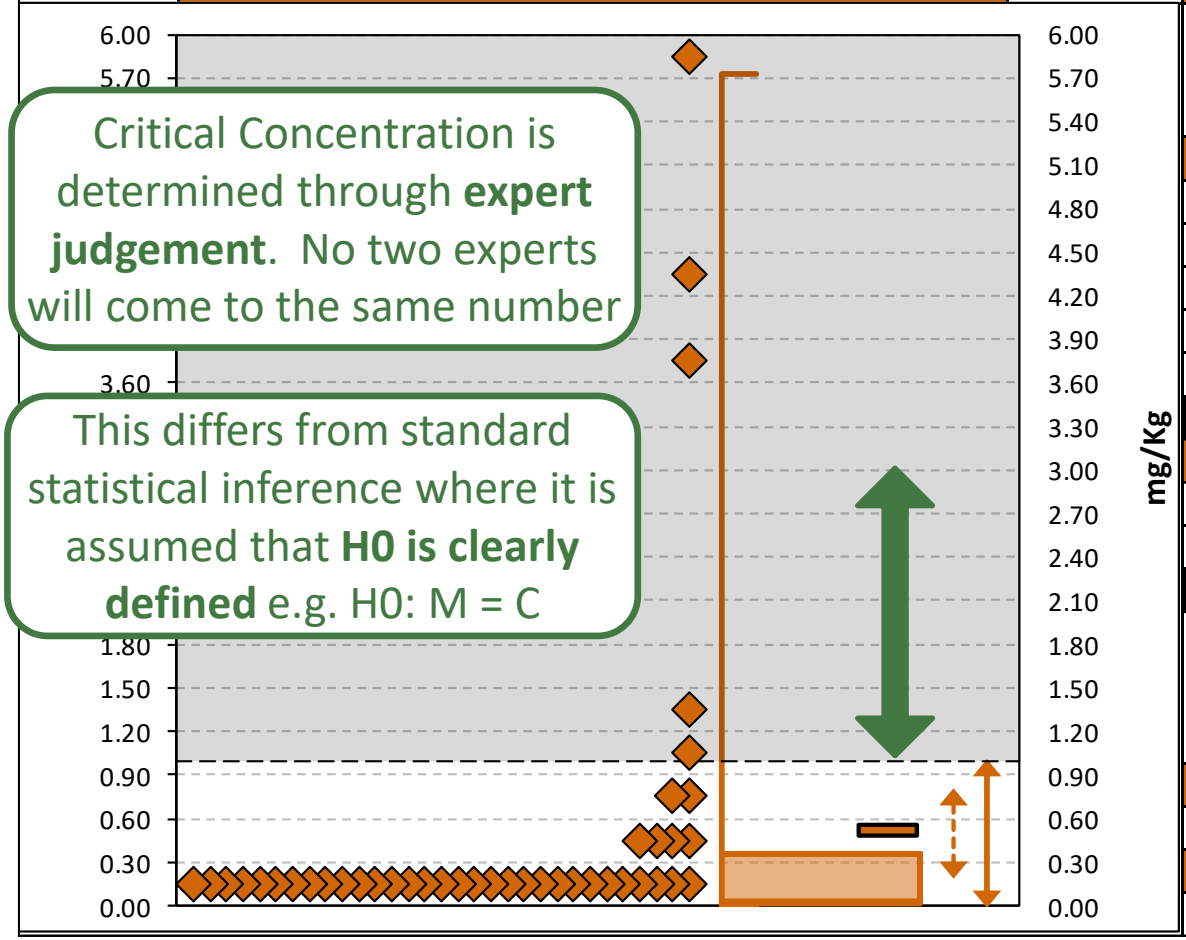
More links at https://bit.ly/3NQcJ4V

Critical Concentrations are not Fixed

Dot & Box Plots, Summary Statistics & Confidence Intervals

Dataset: **Fat Tailed**

Units: **mg/Kg**



Critical Concentration is determined through **expert judgement**. No two experts will come to the same number

This differs from standard statistical inference where it is assumed that **H0 is clearly defined** e.g. H0: M = C

Summary Statistics Actual Values

Number of Samples	42
Maximum	5.73
Upper Quartile	0.35
Median	0.03
Lower Quartile	0.01
Minimum	0.00
Critical Concentration	1.00
Mean Concentration	0.50
Standard Deviation	1.22
InterQuartile Range	0.34
LMDL % Used	50%

Confidence Intervals for the Mean Concentration

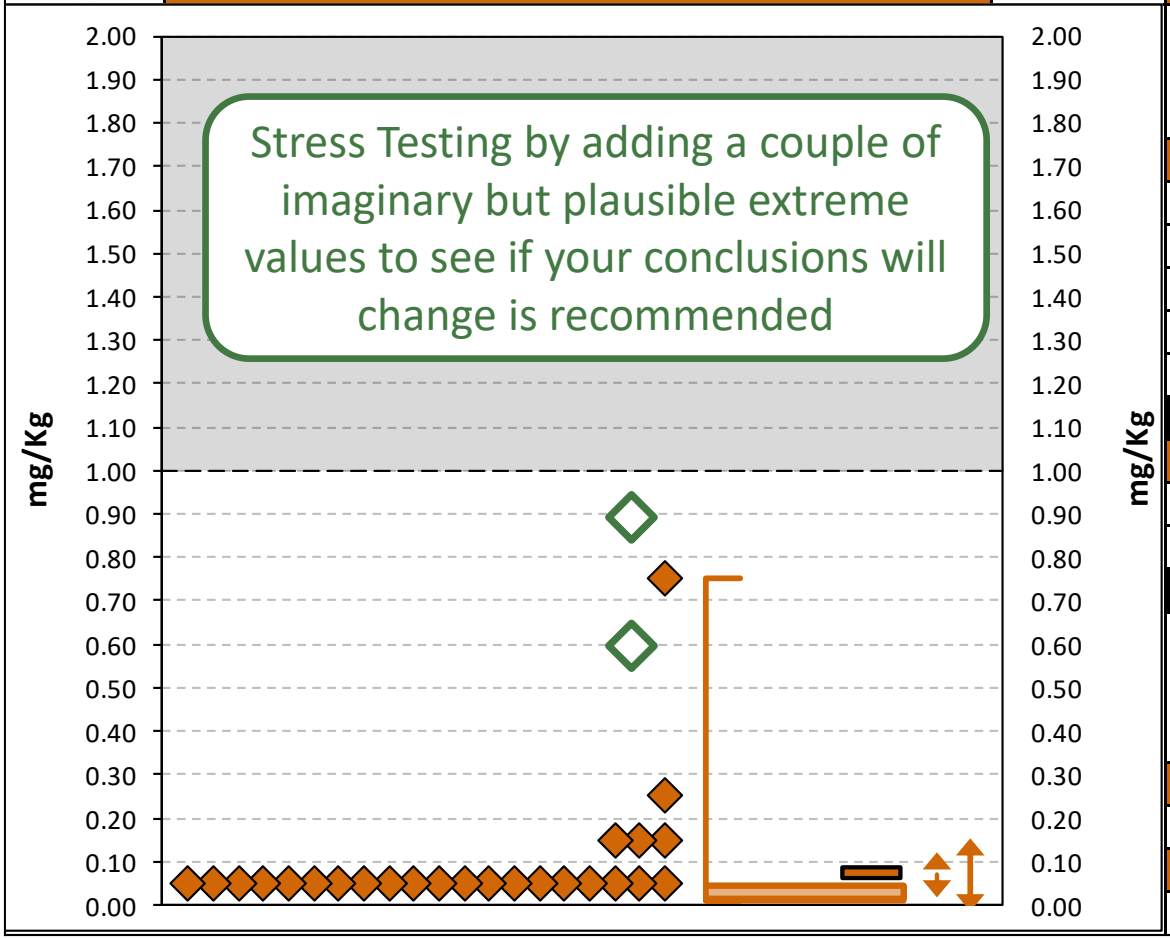
90% Confidence Interval	
0.18	0.82
99% Confidence Interval	
-0.01	1.01

In future, confidence intervals could be for expected harm?

More links at https://bit.ly/3NQcJ4V

Sometimes, the Decision is Clear & Obvious

Dot & Box Plots, Summary Statistics & Confidence Intervals



Dataset	Clear & Obvious
Units	mg/Kg

Summary Statistics Actual Values

Number of Samples	25
Maximum	0.75
Upper Quartile	0.05
Median	0.02
Lower Quartile	0.01
Minimum	0.01
Critical Concentration	1.00
Mean Concentration	0.07
Standard Deviation	0.15
InterQuartile Range	0.04
LMDL % Used	100%

Confidence Intervals for the Mean Concentration

90% Confidence Interval	
0.02	0.12
99% Confidence Interval	
-0.02	0.15

Cost of sampling & testing can be high at times

More links at https://bit.ly/3NQcJ4V

Feedback from CL:AIRE & ASA

Nicola Harries, Technical Director, CL:AIRE

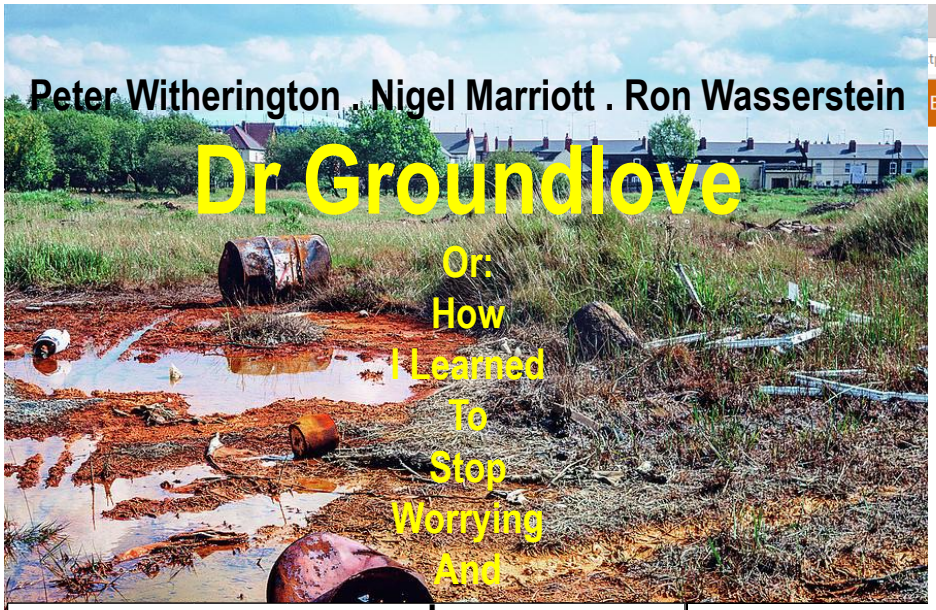
"Feedback from users has been extremely positive, where practitioners who have attended training courses on the new guidance, confirm that they now will be able to make better decisions and understand the importance of collecting and interpreting datasets. The guidance has already been ***downloaded over 5,500 times****, with international interest in the publication by Australian practitioners as a well written, easy to use guidance document. ."*

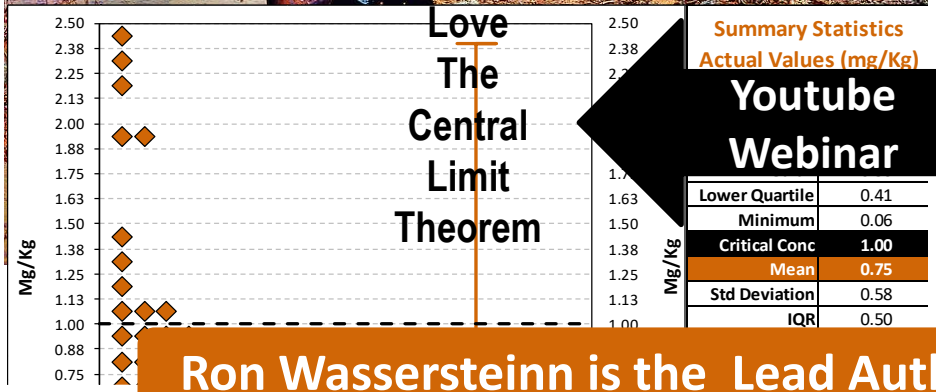
Ron Wasserstein, Lead author of ASA 2016 Statement

"extremely happy … it was the epitome of what the ASA hoped to see"

More links at https://bit.ly/3NQcJ4V

Visit https://bit.ly/3NQcJ4V for all Links





Summary Statistics
Actual Values (mg/Kg)

Lower Quartile	0.41
Minimum	0.06
Critical Conc	1.00
Mean	0.75
Std Deviation	0.58
IQR	0.50

Youtube Webinar

Ron Wassersteinn is the Lead Author of ASA 2016 Statement on p-values

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