

# Understand Uncertainty for Confident Results

**Kevin Thompson**

*Sr. Manager of Technical and Engineering*

# Webinar survey – your feedback is appreciated!

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The screenshot shows a webinar interface with several panels and callouts:

- Ask Question:** A callout box says "You can type your questions here anytime during the presentation." The panel includes a text input field and a "Submit" button.
- Slides:** The main content area shows a slide titled "Understand Uncertainty for Confident Results" by Kevin Thompson, Sr. Manager of Technical and Engineering. A callout box says "Gain access to the different resources." pointing to the slide content.
- Related Content:** A sidebar panel with links for "Value of CRMs", "Products", and "ERA Accreditations".
- Speaker Bio:** A panel for Kevin Thompson, Sr. Manager of Technical and Engineering at Waters/ERA, with a profile picture and an email icon.
- How can we support you?:** A survey section titled "Tell Us What You're Looking For" with a dropdown menu. A callout box says "Please take a few seconds to fill out this survey, which will help us better understand your needs and improve our future webinars."
- Media Player:** A video player at the bottom showing a 0:00 duration.

## Understanding Uncertainty

- Key Learning Topics
  - Identify sources of uncertainty
  - Quantify their impact
  - Apply uncertainty analysis to support decision making, compliance, and continuous improvement
- Speaker – Kevin Thompson
  - Sr. Manager of Technical and Engineering

## Overview

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- Introduction to measurement uncertainty
- Regulatory requirements measurement uncertainty
- How do you determine uncertainty?
- CRMs and how do I use uncertainty with my CRM?

## What is measurement uncertainty?

- Uncertainty (of Measurement)
  - Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.
  - Statement of the range that contains the true value of a measurement
  - Frequently stated at 95% confidence interval

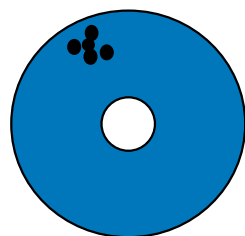
Certified Reference Material				
▪ Certificate of Analysis ▪				
<b>Product:</b>	WatR™ Pollution PFAS in Wastewater			
<b>Catalog Number:</b>	404			
<b>Lot No.:</b>	P336-404			
<b>Certificate Issue Date:</b>	March 13, 2023			
<b>Expiration Date:</b>	December 12, 2024			
<b>Revision Number:</b>	1.0			
<b>Revision Date:</b>	April 18, 2023			
<i>Product use instructions are included as part of the certification packet and are paginated separately from this Certificate of Analysis. Please reference the product use instructions for catalog #404 revision 123022.</i>				
<b>CERTIFICATION</b>				
Parameter	Certified Value <sup>1</sup>	Uncertainty <sup>2</sup>	QC Performance Acceptance Limits <sup>3</sup>	PT Performance Acceptance Limits <sup>4</sup>
	ng/L	%	ng/L	ng/L
11-chloroicosafuoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	300	9.5	254 - 363	219 - 372

- 300 ng/L with 9.5% uncertainty
- 300 ng/L ± 28.5 ng/L

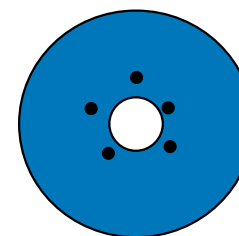
Ref ISO Guide 98-3 Uncertainty of Measurement – Part 3 Guide to the expression of Uncertainty in Measurement (GUM:1995)

# Accuracy, Precision, Uncertainty

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*Precise process*  
*Unknown bias*

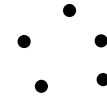


*Higher error*  
*Controlled bias*

# Accuracy, Precision, Uncertainty



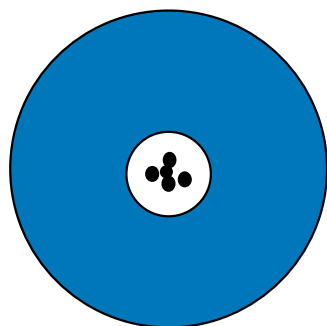
*Precise process*  
*Unknown bias*



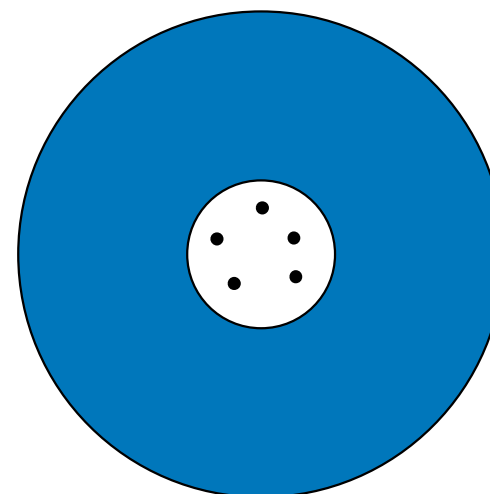
*Higher error*  
*Controlled bias*

## Accuracy, Precision, Uncertainty

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*Precise process*  
*Unknown bias*



*Higher error*  
*Controlled bias*

## Uncertainty is not...

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Uncertainty is not a tolerance

Tolerance is an allowable range for measurement results



Uncertainty is not directly bias or error

Error is the difference from the measured value to the true value

*You will never know the “True Value”*

## Why do we use uncertainty?

### Comparison of results

- Allows you to make a value judgement about your data

### Tolerance evaluation

- Risk based decision on the impact of having a true value outside of your tolerance range

### Test selection

- Select the appropriate test given the variable under test

### Regulatory requirements

- ISO17025
- TNI Vol 1 Module 2
- ISO17034

## Uncertainty for testing labs

- ISO 17025:2017
- Section 7.6: Evaluation of uncertainty
  - Labs must identify all significant sources and contributions of uncertainty
  - Requires a lab to evaluate uncertainty
  - Use theoretical values or practical experience for estimation when it can't be measured
- Section 7.8.3 Specific requirements for test reports
  - Requires reporting of results in same units or relative terms
- Annex A:
  - Uncertainty Budget
  - Decision Rule for Pass/Fail

Source: ISO 17025:2017 - General requirements for the competence of testing and calibration laboratories

## Uncertainty for testing labs

- The NELAC Institute (TNI)
- TNI Volume 1 Module 2
  - Specifically requires analytical uncertainty as part of the assessment
  - Requires you to use routine data vs recorded tabulated information
  - Replicate sampling; PT Studies; LCS; RMs; Control Charting
- Additional considerations in Module 6 to guide Radiochemistry Labs

Source: TNI Standard Vol 1:2016, Management and Technical Requirements for Laboratories Performing Environmental Analysis

## Uncertainty and CRMs

- ISO 17034:2016
  
- Requires specific uncertainty components
  - Short term shipping stability
  - Long term stability
  - Raw material uncertainty
  - Homogeneity of the lot when applicable
  
- 17034 accreditation requires a lab to meet the requirements of ISO17025

Source: ISO 17034:2016 General requirements for the competence of reference material producers

## Determining measurement uncertainty



**DETERMINE YOUR  
SOURCES AND  
CONTRIBUTIONS**



**MEASURE OR  
ESTIMATE THEIR  
IMPACT**



**COMBINE THE  
COMPONENTS AND  
EXPAND**

Standard Uncertainty: uncertainty expressed as a standard deviation

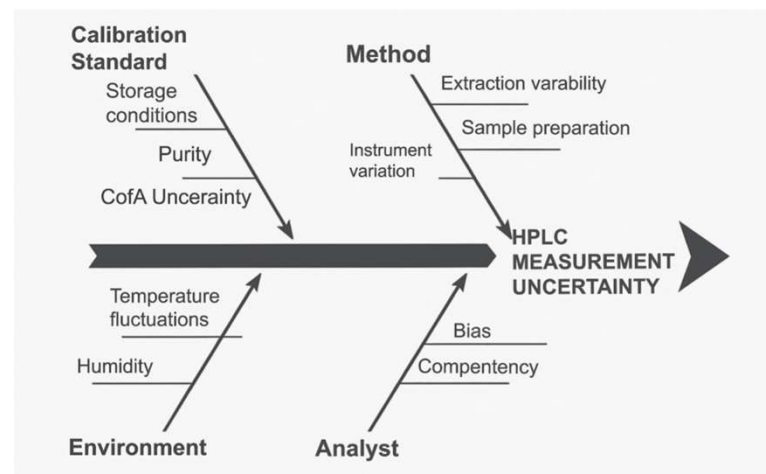
Type A: Statistical analysis of series of observations

Type B: Occurs by other means; Manufacturer's specifications; Reference tables, Expert judgement, etc.

Ref ISO Guide 98-3 Uncertainty of Measurement – Part 3 Guide to the expression of Uncertainty in Measurement (GUM:1995)

## Determine your sources and measure

- Evaluate your process and identify steps that may have uncertainty contributions
  - Process Map, Fishbone, Bubble Diagram
  - Identify the major contributions and sub-contributors
- Measure
  - Different analyst, Instrument, or day
  - Calculate standard deviation of each contributor
- Group variables that can't be isolated
- Determine how to get Type B values
  - CofA's, manufacturer info etc.



## Combine the components

- Combined Standard Uncertainty: Factor used to state the combination of the process's uncertainty
  - Root Sum of squares for major contributors
- Expanded Uncertainty
  - $K = 1$  is “unexpanded” ~68% confidence interval
  - $K = 2$  is ~95% confidence interval
  - $K = 3$  is ~99% confidence

## Conductivity measurement example

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$$Rel. Exp. Unc. (\%) = \sqrt{(Calibration_{Unc.})^2 + (Ref. Temp_{Unc.})^2 + (Homogeneity_{Unc.})^2} \times k$$

where  $k = 2$  (95% confidence interval)

$$Rel. Exp. Unc. (\%) = \sqrt{(0.163\%)^2 + (0.40\%)^2 + (0.348\%)^2} \times 2$$

$$Rel. Exp. Unc. (\%) = \sqrt{0.026569 + 0.16 + 0.121104} \times 2$$

$$Rel. Exp. Unc. (\%) = \sqrt{0.307673} \times 2$$

$$Rel. Exp. Unc. (\%) = 0.5546828 \times 2$$

$$Rel. Exp. Unc. (\%) = 1.1\%$$

## Using a CRM certified value with uncertainty

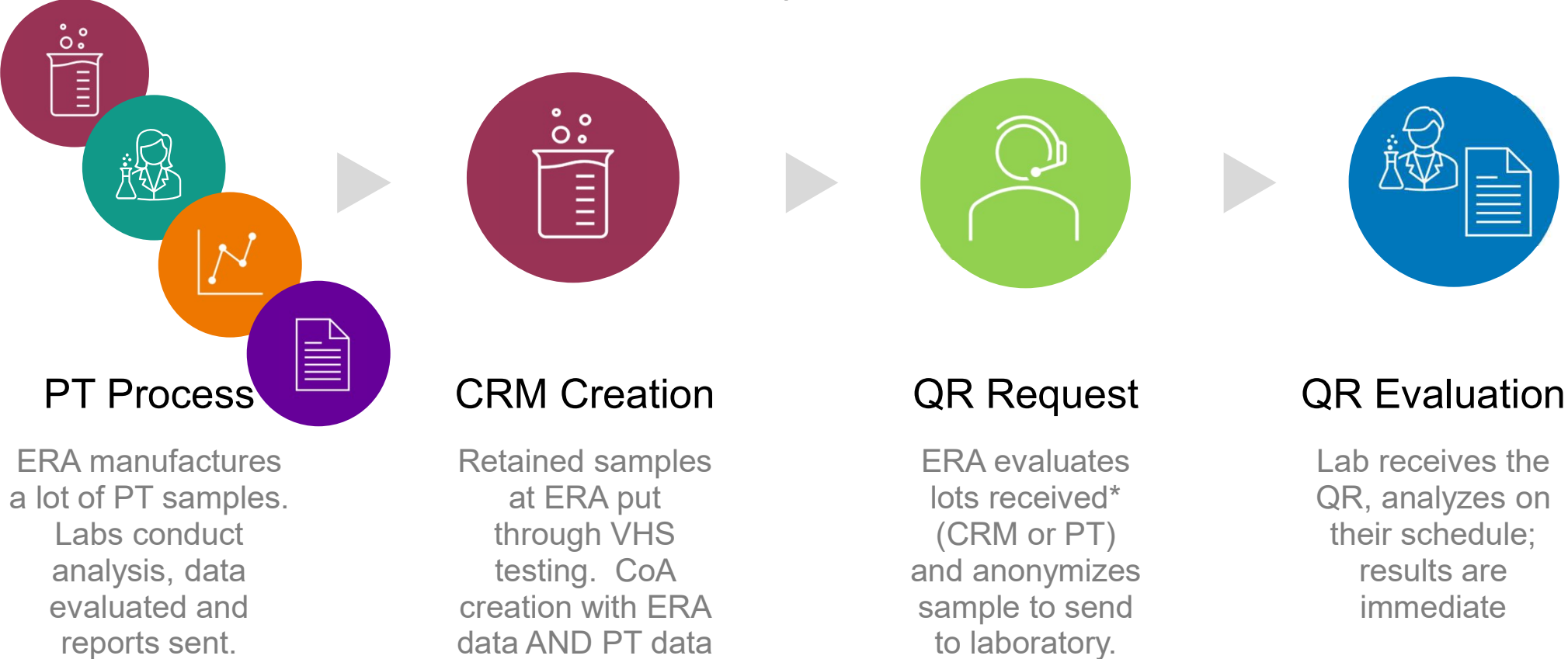
- Calibration with a CRM Uncertainty
  - Tolerance and Uncertainty should overlap
- Method Evaluation or Bias Detection
  - ISO Guide 33 2015-bias detection
  - Combine standard uncertainty value – “un-expanded”

$$|x_{found} - x_{CRM}| \leq k \sqrt{u_{found}^2 + u_{CRM}^2}$$

Sieber, J. (2020), How to Use and How Not to Use Certified Reference Materials in Industrial Chemical Metrology Laboratories, Advances in X-Ray Analysis, Lombard, IL, [online], [https://tsapps.nist.gov/publication/get\\_pdf.cfm?pub\\_id=928700](https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=928700) (Accessed December 13, 2025)

# ERA product overview and relationship

How does a PT become a CRM, then Quik Response?



\*Labs may not receive a QR from a previously tested lot

## Certified Reference Material

# ▪ Certificate of Analysis ▪

**Product:** WatR™ Pollution PFAS in Wastewater  
**Catalog Number:** 404  
**Lot No.** P336-404  
**Certificate Issue Date:** March 13, 2023  
**Expiration Date:** December 12, 2024  
**Revision Number:** 1.0  
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## Summary

- Uncertainty is statement of the range around a certified value in which the true value of a product or measurement exists.
- Uncertainty can be a complicated topic; Break it down to its components and it gets simpler
- Understanding uncertainty helps you to better understand your laboratory data

## **Live Q&A Session: Understand Uncertainty for Confident Results**

**Please submit your questions  
into the Q&A Chatbox**

*<https://www.eraqc.com>*