Hudson River PCBs Site

Engineering Performance Standards For Dredging

Presentation to Peer Review Panel

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TAMS, *an EarthTech Company*

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Residuals

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Outline

- Requirements of the ROD
- Definitions
- Objectives
- Residual Standard
  - **Sampling Requirements**
  - **Residual Criteria**
  - **Contingencies**
- Supporting Analysis
  - **Percent Removal**
  - **Residual Distributions**
  - **Statistical Basis for Criteria**
- Example Application
- Anticipated Refinements
- Public Comments

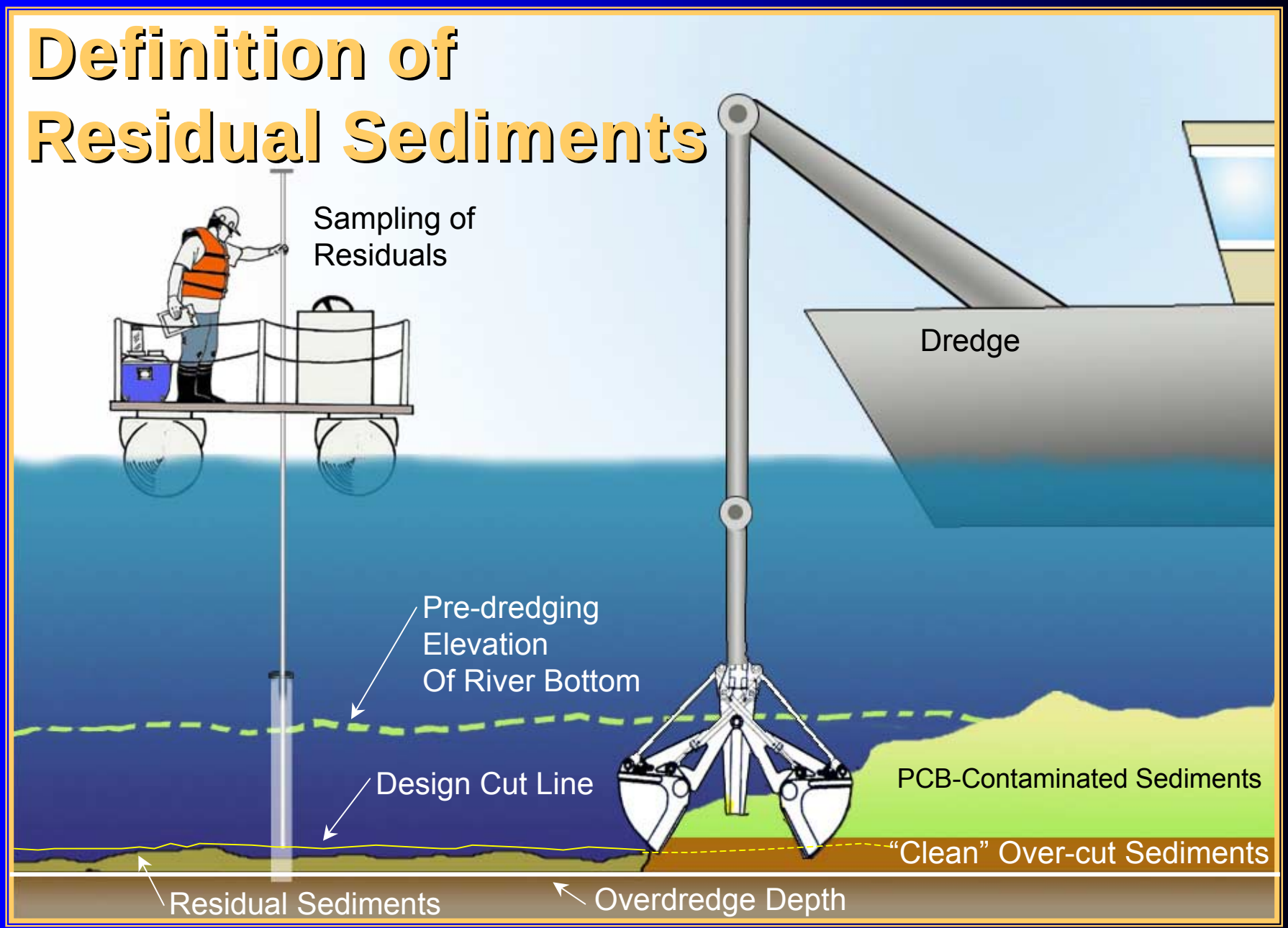
Requirements of the ROD

- Hudson River Record of Decision [USEPA, 2002]:
  - "Removal of all PCB-contaminated sediments within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling)" ROD § 13.1, page 95
  - "Backfill of dredged areas with approximately one foot of clean material to isolate residual PCB contamination and to expedite habitat recovery, where appropriate;" ROD § 13.1, page 96

Objectives of the Residuals Performance Standard

- Detect and manage contaminated sediments that may remain after dredging attains design cut-lines
- Verify achievement of anticipated residual of ~1 mg/kg Tri+ PCBs (prior to backfilling) on a statistical basis

Definition of Residual Sediments



Additional Definitions

- Residual Sediments
  - Mixture of redeposited, disturbed and underlying sediment
- Surface Sediment:
  - 0 to 6 inches in depth
- Certification Unit:
  - Area of targeted river bottom approximately 5 acres in size
- Backfill
  - Certified clean material to be used to sequester surface residual concentrations
- Cap
  - Engineered cover to be placed over residual contaminated sediments that do not comply with the standard

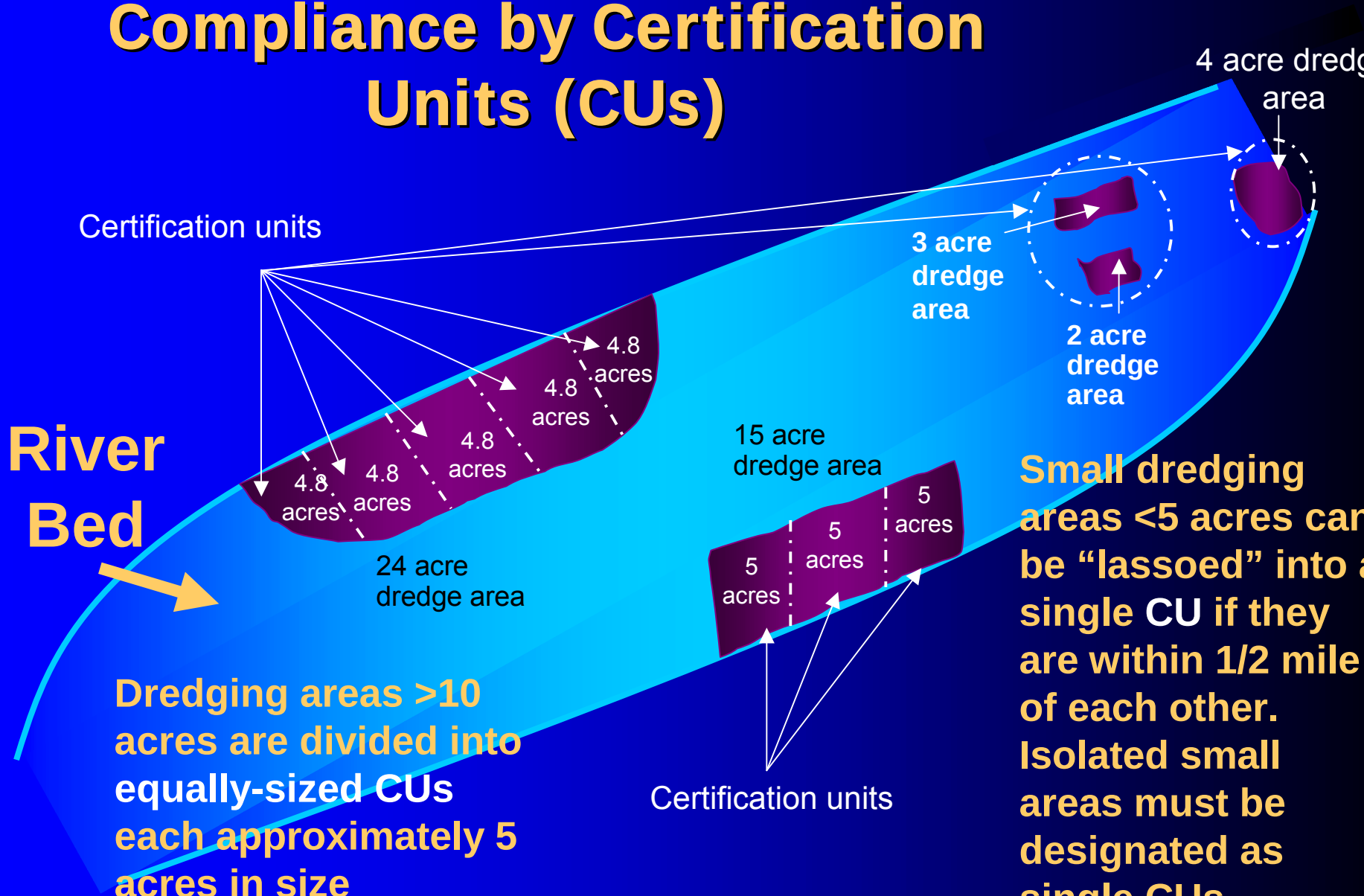
Components of the Residuals Performance Standard

- Implement a post-dredging sampling and analysis program to characterize residual PCB concentrations
- Direct the comparison of collected data to the ROD clean-up goal and related action levels
- Determine the next remediation step based on program findings

Residuals Sampling Program

- Certification units (CUs) - approximately 5-acre basis
- 40 sediment cores per CU(80 ft on center)
- Coring depth - 6 inches or refusal
- Analyze 0-6 inch sample
- Analyze deeper strata if necessary
- Sediment Profile Imaging (SPI) at 25% of coring locations

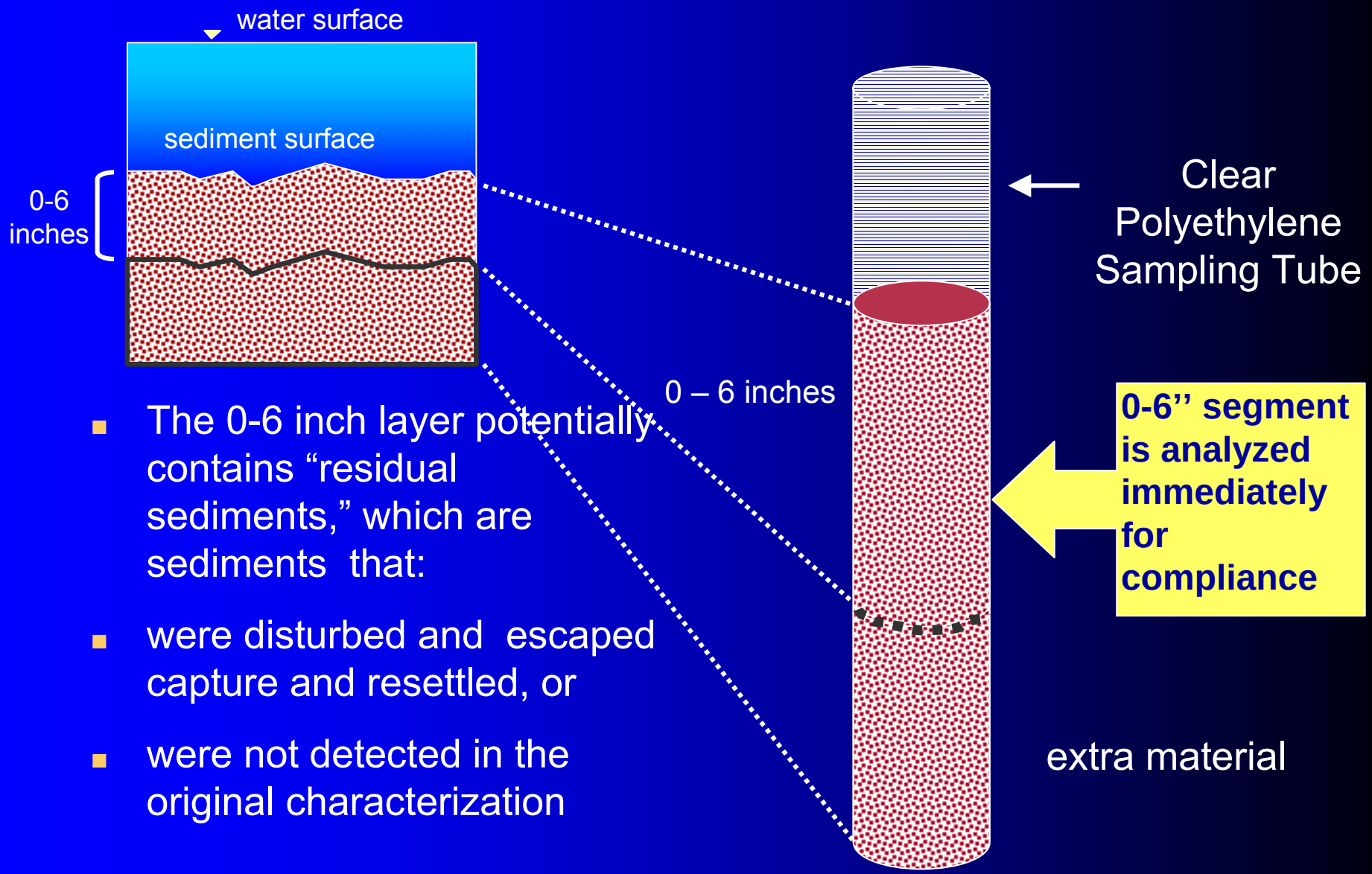
Compliance by Certification Units (CUs)



Dredging areas >10 acres are divided into equally-sized CUs each approximately 5 acres in size

Small dredging areas <5 acres can be "lassoed" into a single CU if they are within 1/2 mile of each other. Isolated small areas must be designated as single CUs.

Sediment Core Collection



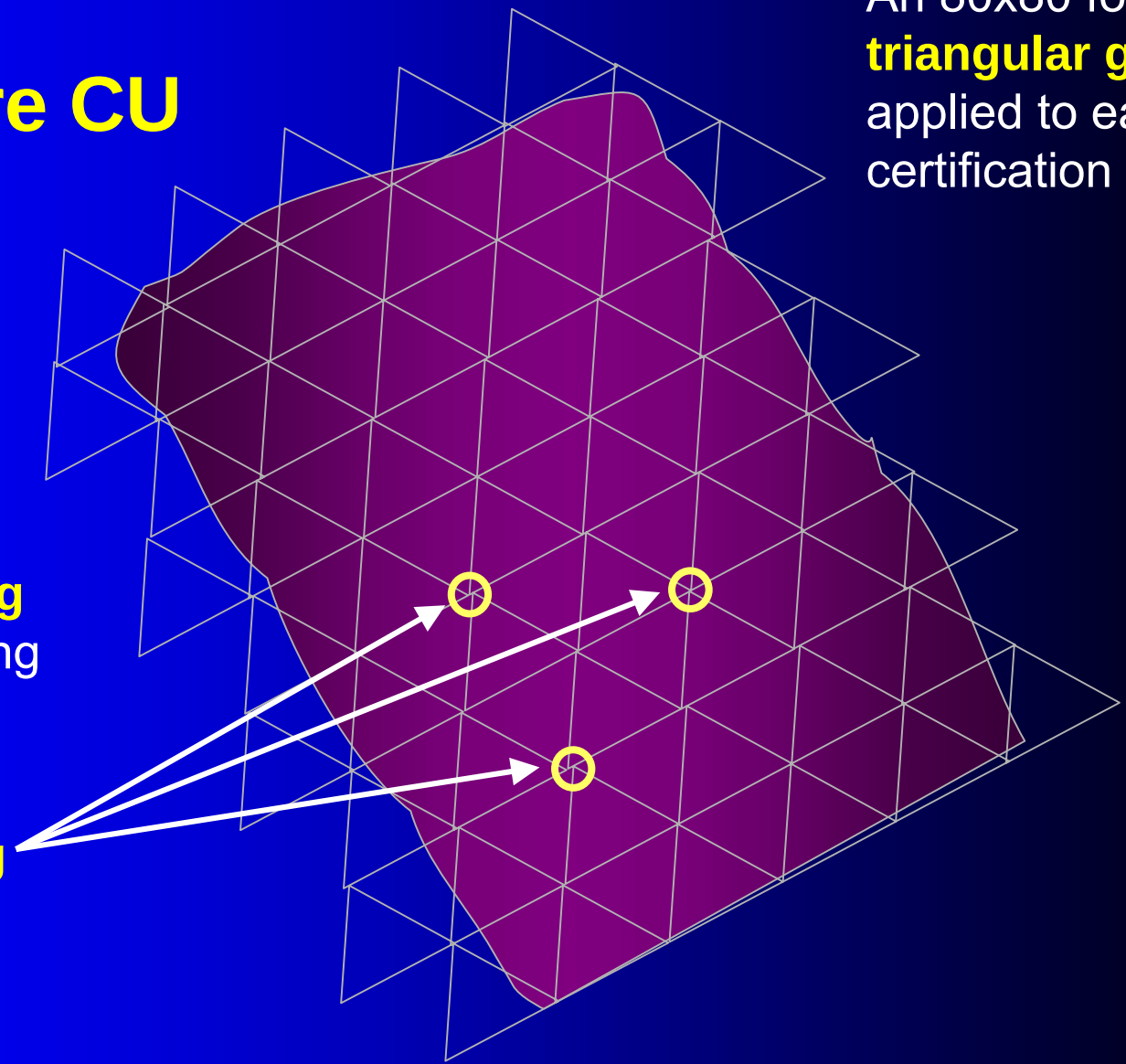
- The 0-6 inch layer potentially contains "residual sediments," which are sediments that:
- were disturbed and escaped capture and resettled, or
- were not detected in the original characterization

Post-Dredging Sampling

5-acre CU

An 80x80 foot **triangular grid** is applied to each certification unit.

Core samples are collected at 40 individual **sampling nodes** spaced along the grid.



Issues for the Residuals Standard

- 5 acre and 20 acre certification
- 40 samples per certification unit (5-acre area)
- Target concentration less than 1 mg/kg Tri+ PCB
  - Mean Tri+ PCB must be less than 1 mg/kg
- Inventory removal must be achieved

Issues for the Residuals Standard

- Accommodate compliance on small-scale (5 acres) and macro-scale (20 acres during Phase 1)
- Criteria to address inherent sediment variability
- Limit the number of re-dredging attempts required (once sediment inventory is removed)
- Capping contingency (for areas with persistent residuals)

Residuals Standard Criteria

- **5-acre Criteria:**
  - Mean Tri+ PCB ≤ 1 mg/kg
  - No more than 1 point > 15 mg/kg
  - No point >27 mg/kg
- **20-acre criteria**
  - Mean Tri+ PCB ≤1 mg/kg

Residuals Standard Criteria: Non-compliant Certification Units

- Mean between 1 and 3 mg/kg Tri+ PCB
  - Is 20-acre mean satisfied?
    - Yes => Backfill - Confirm backfill at less than 0.25 mg/kg
    - No => Redredge

  OR

  - Redredge where needed

  OR

  - Cap recalcitrant areas

Residuals Standard Criteria: Non-compliant Certification Units

- Mean between 3 and 6 mg/kg Tri+ PCBs
  - Redredge or
  - Cap noncompliant portion
  - Remainder must satisfy criteria (mean ≤ 1 mg/kg)

Residuals Standard Criteria: Non-compliant Certification Units

- Mean greater than 6 mg/kg Tri+ PCB
  - Recharacterize depth of contamination
    - If inventory >6 inches, continue dredging (1st attempt not complete)
  - Redredging required (2x max) then
  - Cap noncompliant portion
  - Remainder must satisfy criteria (mean ≤ 1 mg/kg)

Statistical Basis for the Criteria

99% Prediction Limit (PL) – 27 ppm Tri+ PCBs.

97.5% PL – 15 ppm Tri+ PCBs.

99% Upper Confidence Limit (UCL) – 6 ppm Tri+ PCBs.

95% UCL – 3 ppm Tri+ PCBs.

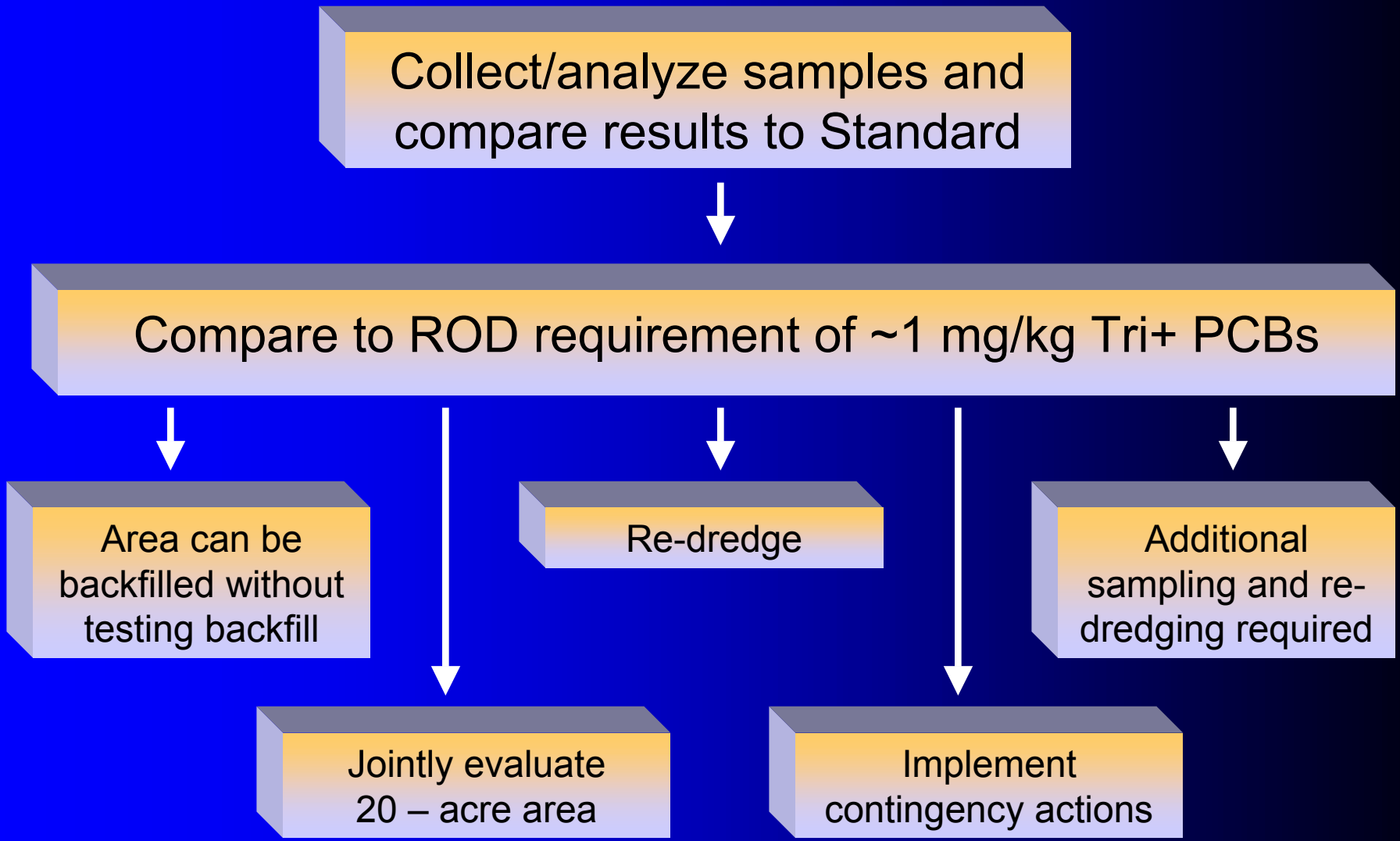
Criteria derived from statistical analysis of case study data.

Residuals Data Evaluation

Initial Calculations

- Calculation of the mean and median PCB concentration in the CU
- For Phase 1, calculation of the 20-acre mean concentration (the average of the mean concentration in the CU and the means of the 3 previously dredged CUs within 2 miles of the current CU)

Application of the Standard



Supporting Analyses

- Relative Level of Cleanup (% Removal)
- Anticipated Residual Distribution
- Anticipated Variance
- Determine Appropriate Metrics

Percent Concentration Reductions at Other Sites

• Grasse River	90%
• GM Massena	99%
• Fox River SMUs 56/57	90%
• Cumberland Bay	98 %
• New Bedford Harbor	97% (0-1 foot layer)
• Marathon Battery	99.6%
• Lake Jarnsjon	99%

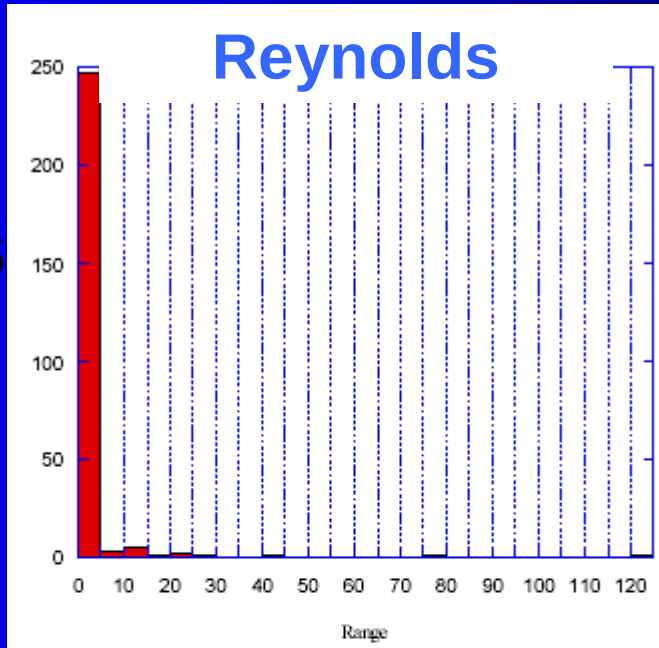
Desired Hudson River 96-98 %

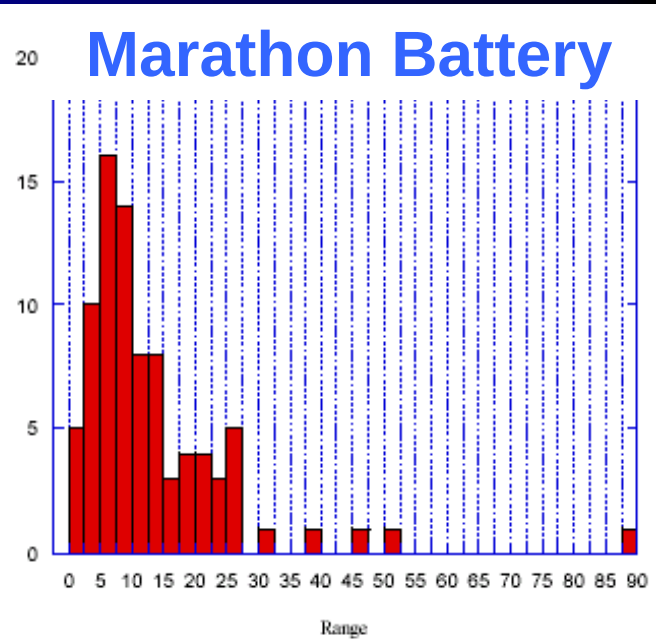
Residual Distributions

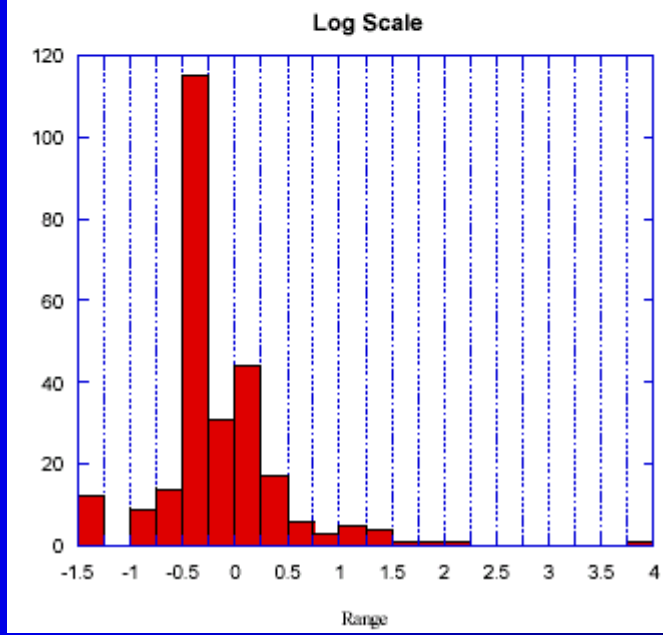
Residuals Histograms

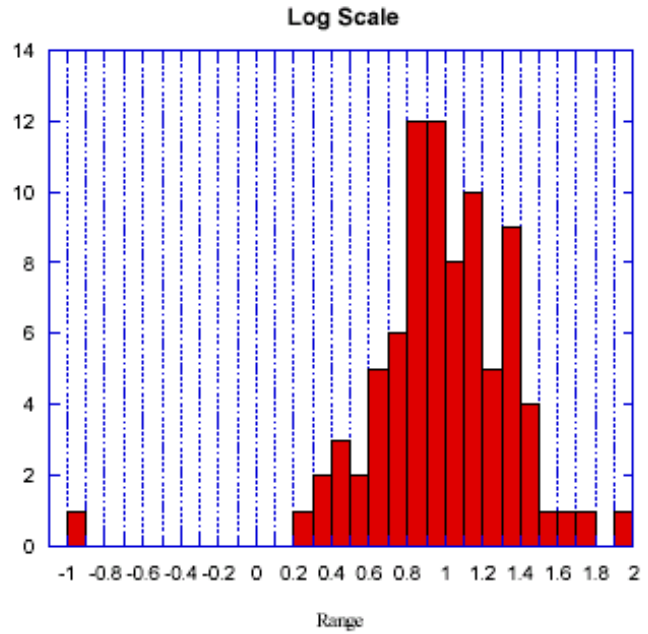
Untransformed

Log-transformed





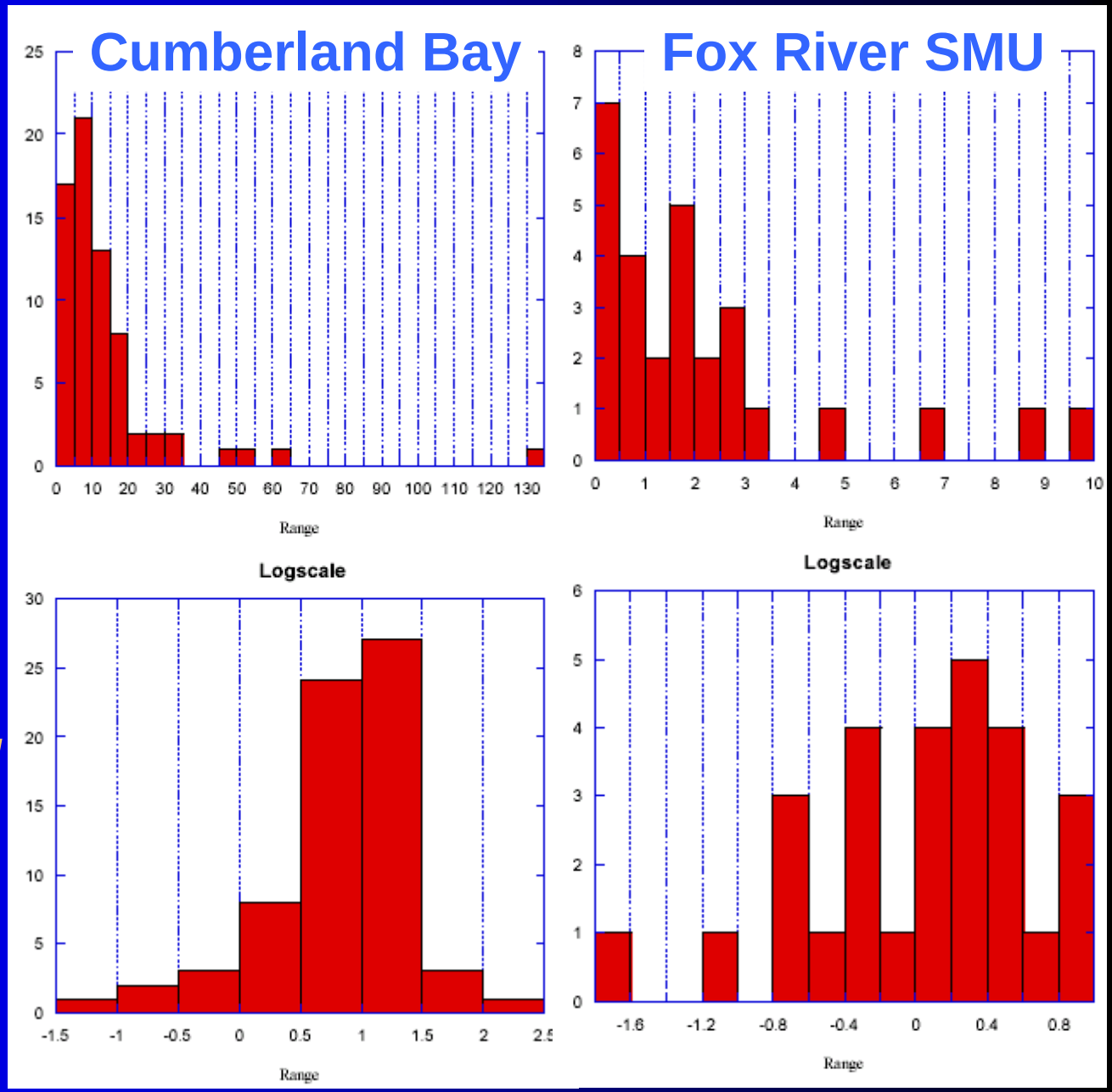




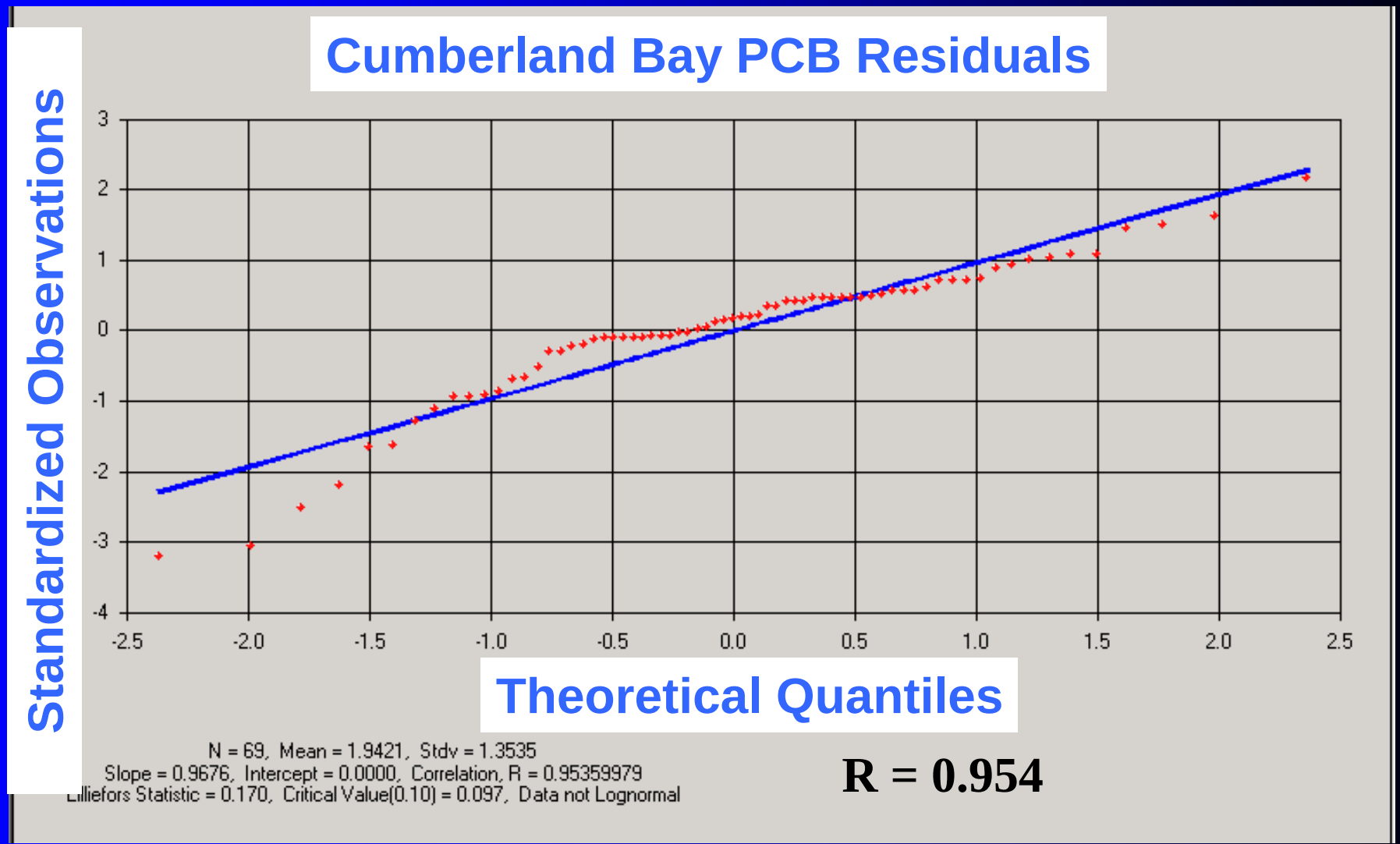
Residuals Histograms

Untransformed

Log-transformed



Q-Q Plot


Cumberland Bay PCB Residuals
Standardized Observations
3
2
1
0
-1
-2
-3
-4
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
Theoretical Quantiles
N = 69, Mean = 1.9421, Stdv = 1.3535
Slope = 0.9676, Intercept = 0.0000, Correlation, R = 0.95359979
Lilliefors Statistic = 0.170, Critical Value(0.10) = 0.097, Data not Lognormal
R = 0.954

Residual Distributions

- Few sites are truly log-normal but...
- Log-normal distribution can approximate most sites well
- Non-parametric tests can also be used

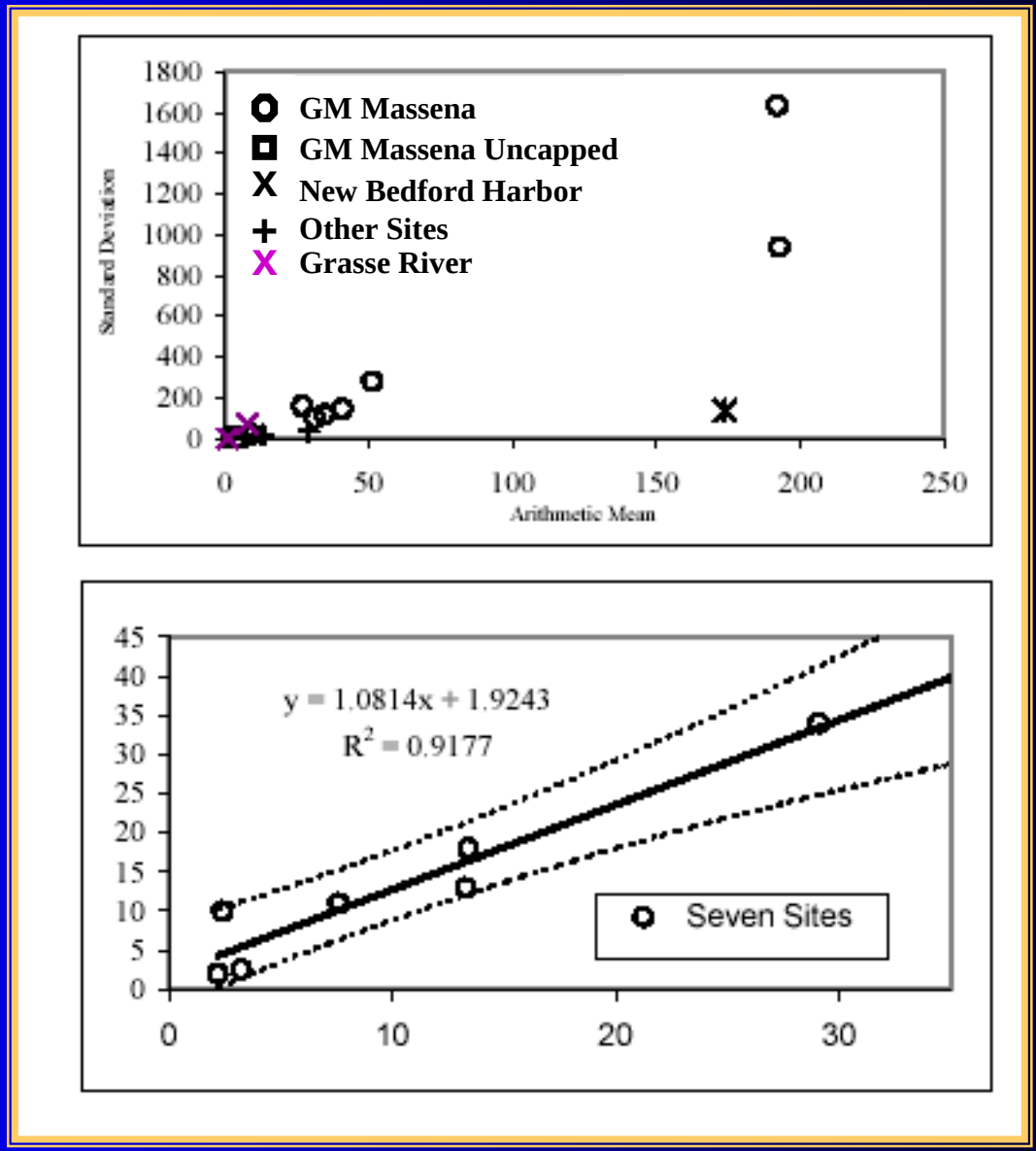
Assessment of Variance

- Untransformed Basis
- Log Basis

Mean vs. Standard Deviation

$\bar{X}$ *vs.* S_x

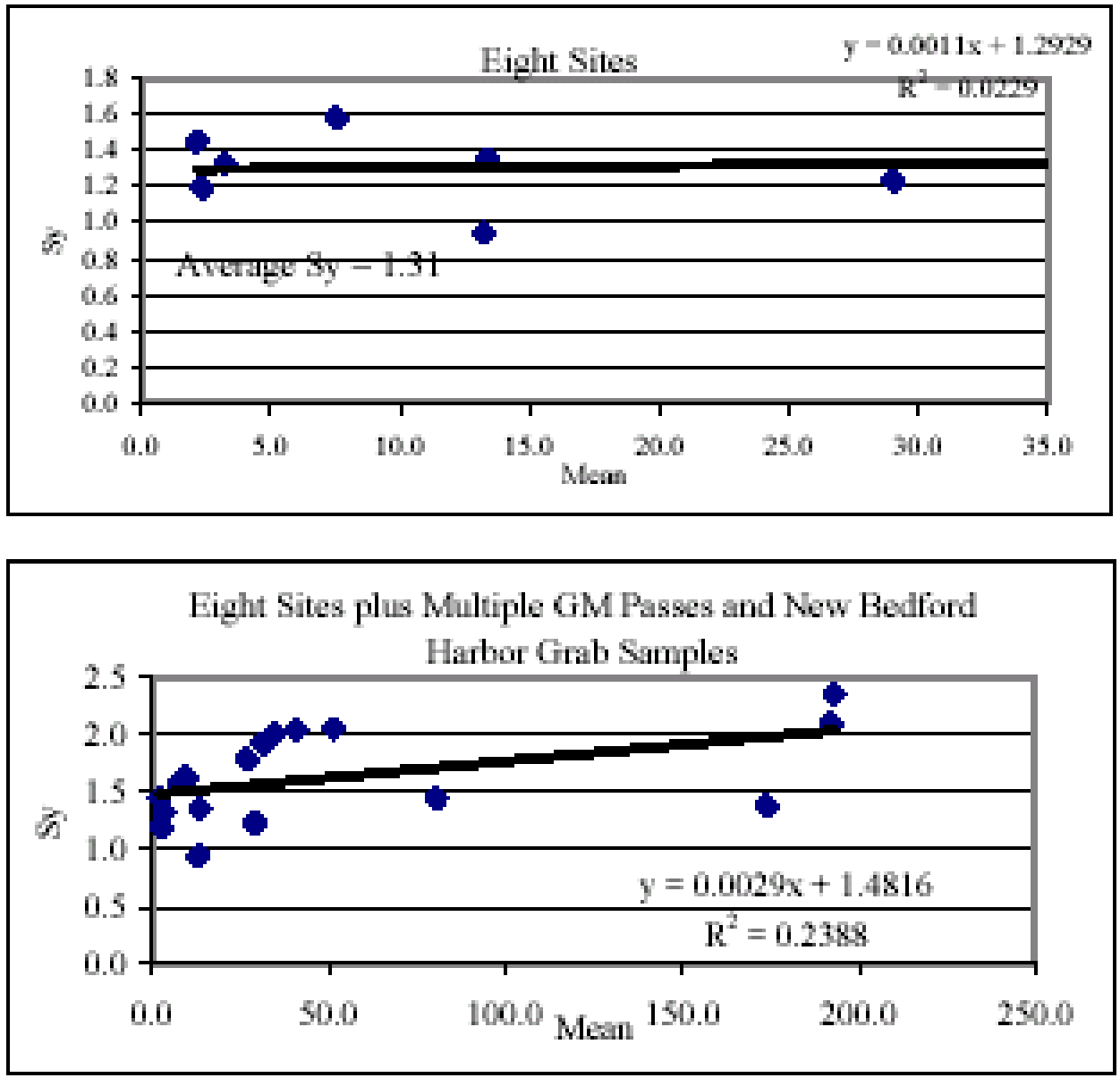
Untransformed



Mean vs. Standard Deviation (Log)

$\overline{X}$ *vs.* S_y

Log Transformed



Residual Criteria Estimation

Equation 2

$$UCL = \bar{x} + \frac{S_x \sqrt{((1/\alpha) - 1)}}{\sqrt{n}}$$

Non parametric

Equation 3

$$UCL = e^{\left(\bar{y} + 0.5 \cdot S_y^2 + \frac{S_y \cdot H_{1-\alpha}}{\sqrt{n-1}}\right)}$$

Log-Normal

Equation 4

$$PL = e^{\left(\bar{y} + t(\alpha, n-1)\sqrt{S_y^2 + \frac{S_y^2}{n}}\right)}$$

Log-Normal

Proportional

$$M_{cs} / M_{hr} = L_{cs} / L_{hr} \qquad (1)$$

Propor-tional

Linear Regression Mean vs. Sx [1]	
Sx at 1 ppm	3
Equation	Nonparametric Chebyshev UCL (Eqn. 2)
95% UCL	3
99% UCL	6

S_x

Average of PL Values Calculated Using the Sx from Each Case Study Parametric Assymetric PL (Table 3) [1]	
Equation	Parametric Assymetric PL (Eqn. 4)
97.5% PL	15
99% PL	27

S_y

Average Sy of the Case Studies	
Sy [2]	1.31
Equation	H-UCL (Eqn. 3)
95% UCL	4
99% UCL	6
Equation	Parametric Assymetric PL (Eqn. 4)
97.5% PL	15
99% PL	25

S_y

Range of UCL and PL Values Using the Variance from Each Individual Case Study (shown on Table 3)	
Equation	Proportion (Eqn. 1)
95% UCL	1-3
99% UCL	2-6
97.5% PL	3-15
99% PL	4-23
Equation	Nonparametric Chebyshev UCL (Eqn. 2)
95% UCL	3-24
99% UCL	5-54
Equation	Parametric Assymetric PL (Eqn. 4)
97.5% PL	7-25
99% PL	10-48

$\frac{S_y}{X}$

Criteria for Standard

99% Prediction Limit (PL) – 27 ppm Tri+ PCBs

97.5% PL – 15 ppm Tri+ PCBs

99% Upper Confidence Limit (UCL) – 6 ppm Tri+ PCBs

95% UCL – 3 ppm Tri+ PCBs

Determine Number 0f Samples Using “DEFT”

Units: ppm

Action Level (Mean) 1

Baseline Condition Mean <= 1

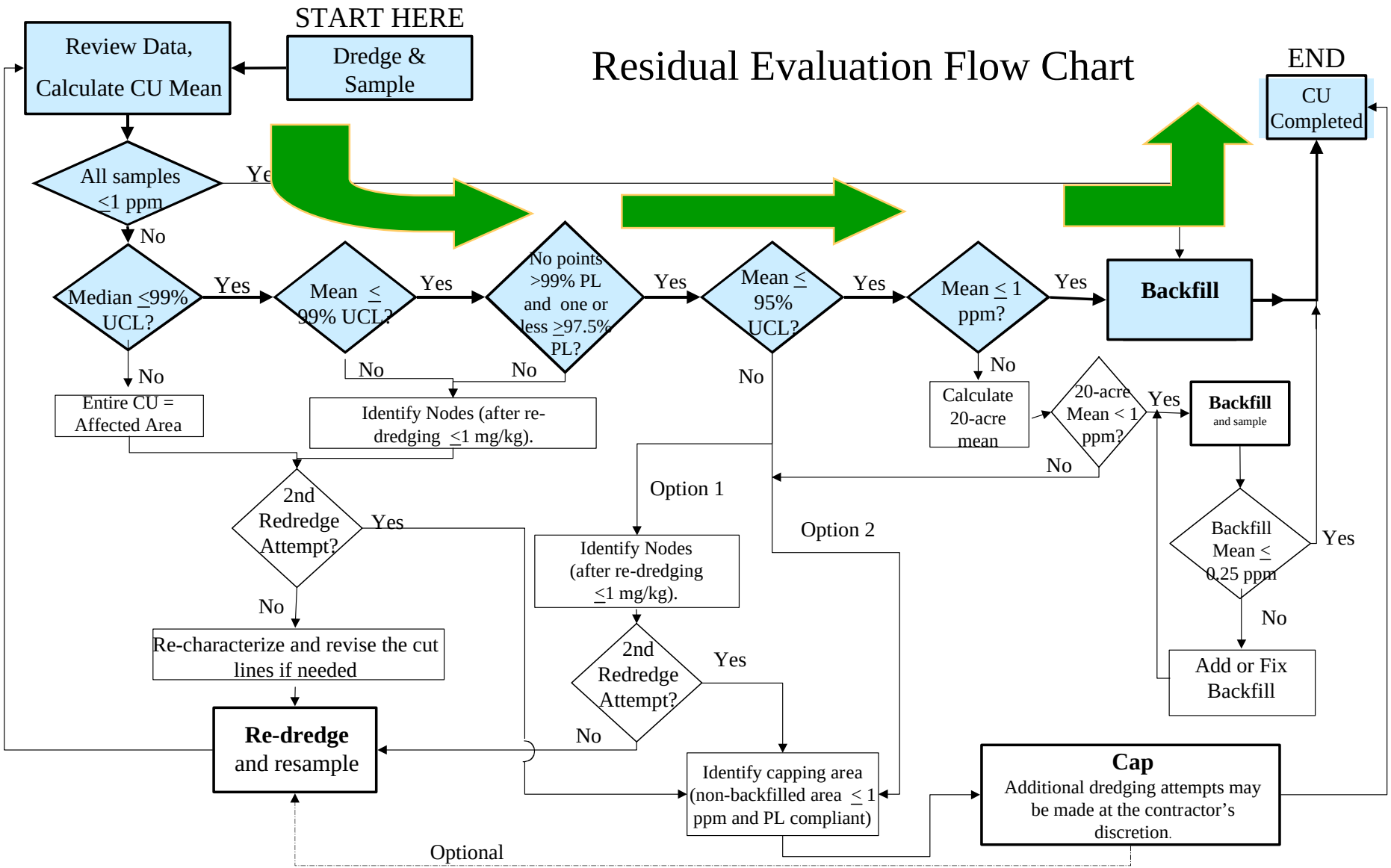
Standard Deviation 3

		5 Acre CU		40 Acres	20 Acres
Desired Mean and Upper Limit	1-1.5	1-1.5	1-2.4	1-1.5	1-1.5
False Rejection **Probability**	0.1	0.3	0.1	0.1	0.1
False Acceptance **Probability**	0.05	0.3	0.05	0.045	0.21
Number of Samples Required	**310**	**40**	**41**	**320**	**160**

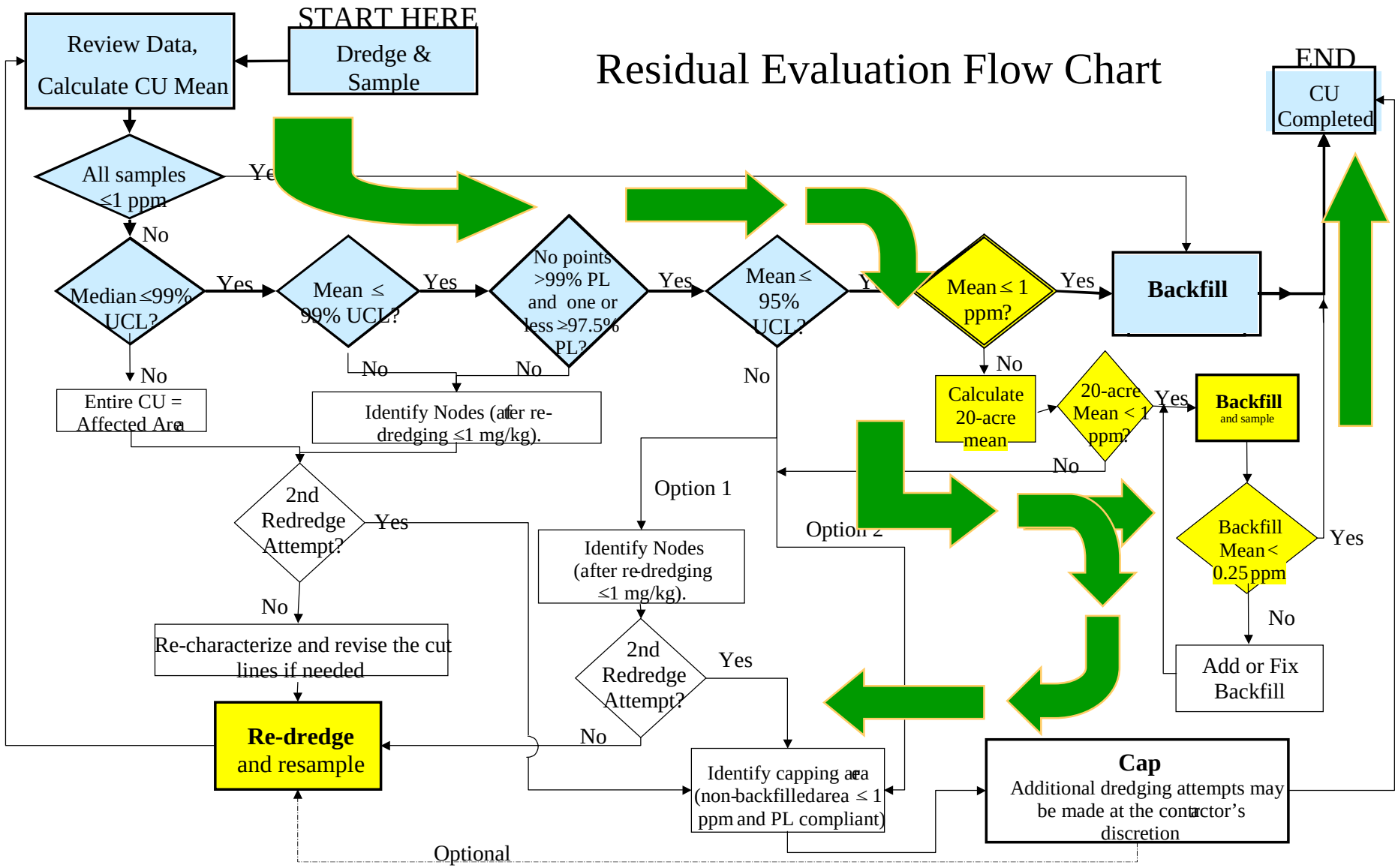
Example Applications

- Compliant CU
- 1-3 ppm
- 3-6 ppm
- >6 ppm

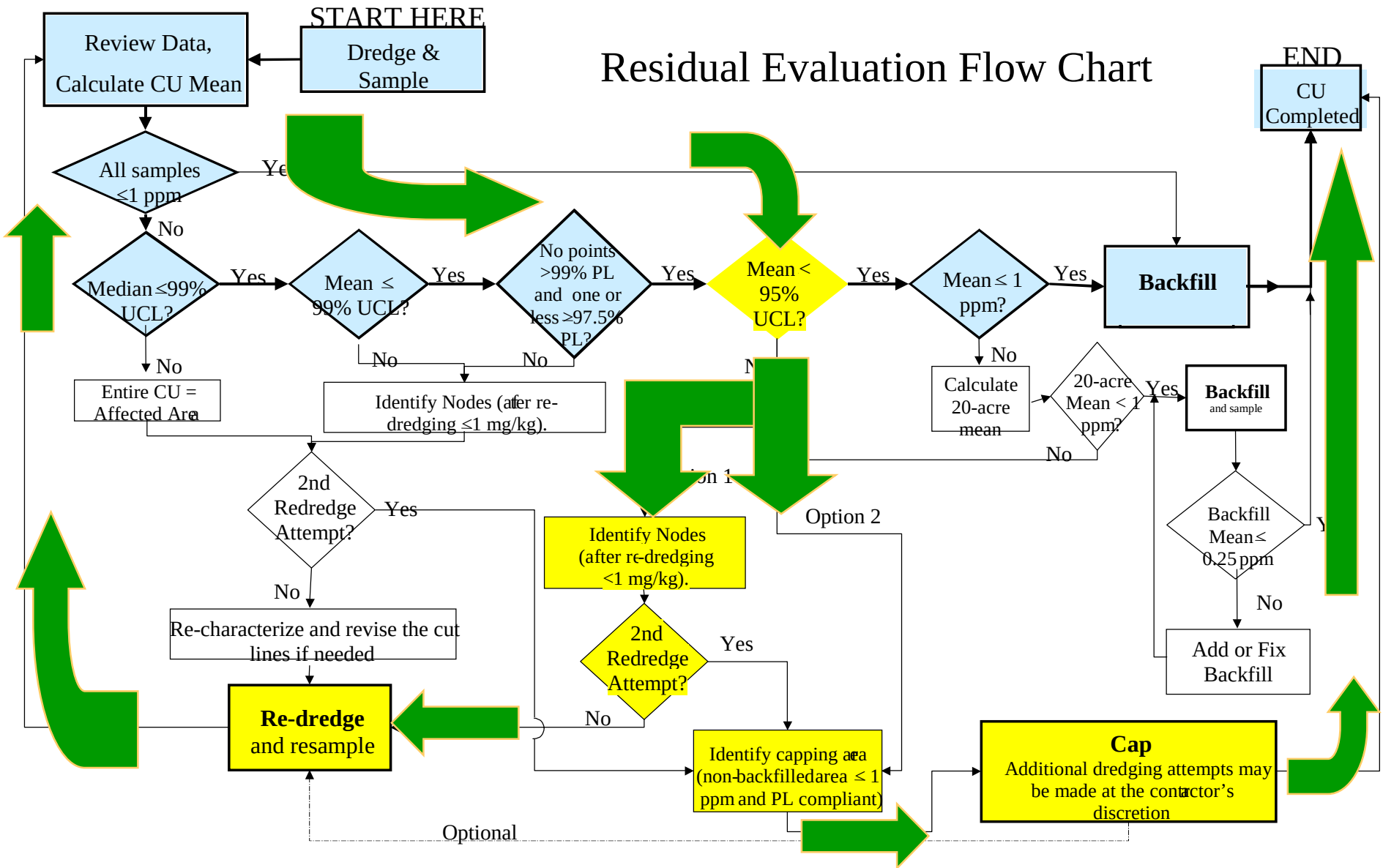
Compliant CU Example



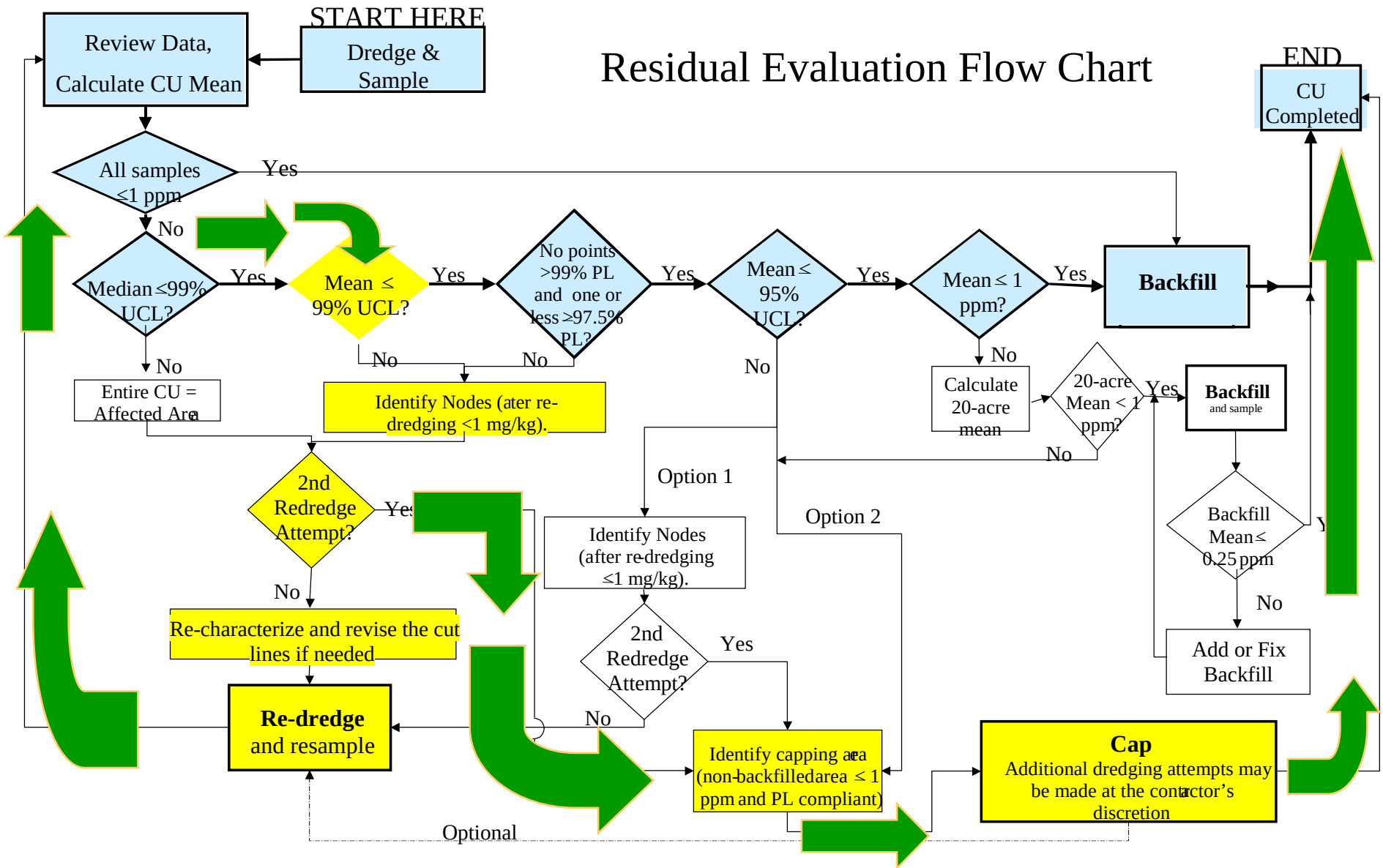
CU Mean 1 to 3 ppm



CU Mean 3 to 6 ppm



CU Mean >6 ppm


START HERE
Dredge & Sample
Review Data, Calculate CU Mean
Residual Evaluation Flow Chart
END
CU Completed
All samples ≤1 ppm
Yes
No
Median ≤99% UCL?
Yes
No
Entire CU = Affected Area
Mean ≤ 99% UCL?
Yes
No
Identify Nodes (ater re-dredging <1 mg/kg).
No points >99% PL and one or less ≥97.5% PL?
Yes
No
Mean ≤ 95% UCL?
Yes
No
Option 1
Option 2
Mean ≤ 1 ppm?
Yes
No
Calculate 20-acre mean
20-acre Mean < 1 ppm?
Yes
No
Backfill
Backfill and sample
Backfill Mean ≤ 0.25 ppm
No
Add or Fix Backfill
2nd Redredge Attempt?
Yes
No
Re-characterize and revise the cut lines if needed
Identify Nodes (after re-dredging ≤1 mg/kg).
2nd Redredge Attempt?
Yes
No
Re-dredge and resample
Identify capping area (non-backfilledarea ≤ 1 ppm and PL compliant)
Cap
Additional dredging attempts may be made at the contractor's discretion
Optional

Refinement of the Standard

- Statistical/geostatistical analyses of Phase 1 residuals data will be used to evaluate:
  - Size of CUs and no. of samples per CU.
  - Sampling depth.
- 20-acre joint evaluation areas may be increased to 40-acre areas in appropriate River Sections.
- Contingency Plans will be evaluated for:
  - Number of required re-dredging attempts.
  - Effectiveness of isolation caps.

Residuals Standard Summary

- Provides a flexible framework for dredging operations
- Ensures achievement of ROD goal of 1 ppm for remediated areas
- Provides sufficient guidance for field decisions without constant EPA input
- Requirements avoid repetitious dredging passes with little cleanup benefit and ensuing impacts to productivity schedule

Public Comment Concerns

- Effectiveness of Re-dredging
- Use of Sub-aqueous Caps
- Design of Caps and Backfill
- Residuals Sampling Scheme

Re-dredging Comments

- *Comment*: Waive the requirement for re-dredging.
- *Comment*: Require re-dredging instead of allowing capping.
- *Comment*: Criteria will prompt unneeded dredging
- *Response:* Requiring a max. of 2 re-dredging attempts balances ROD's removal objective with productivity goals, recognizing the potential for difficult areas.

  Can be modified after Phase 1, if appropriate.

Sub-aqueous Cap Comments

- *Comment*: Capping of contaminated sediments was rejected as a remedy in the FS.
- *Response:* Only residuals will be capped, not entire contaminant inventory, reducing risks associated with cap failure.

Backfill/Cap Design Comments

- *Comment*: Need a capping performance standard. Cap design must consider hydrodynamics and ecological setting
- *Response*: General Design Criteria in Residuals Standard (e.g., USEPA and USACE guidance)

  USEPA will review design prototypes in RD.

  Certified, site-specific cap designs required for implementation

Residuals Sampling Comments

- *Comment*: Analyze “fluff” overlying sediment in 0-6 inch sampling interval
- *Response*: SPI/other information will be used to evaluate the presence of “fluff” and the need to homogenize such a layer into the 0-6 inch sample

Residuals Sampling Comments

- *Comment: Allow composite sampling within CU*
- *Response:* Composite samples will not allow detection of PL exceedences at individual nodes and assessment of true CU mean

Residuals Sampling Comments

- *Comment*: Discretely sample residuals veneer
- *Response*: Sampling interval (0-6 inches) represents bioavailable layer, not residual thickness

  A contaminated veneer (2 cm > 4.81 ppm) will cause 0-6 inch sample to fail standard

Sub-aqueous Cap Comments

- *Comment*: Capping is not compatible with habitat and reduces water depth.
- *Response:* The cap prototypes will have to be designed appropriately in RD phase.

  Where possible (including navigation channel, if necessary), additional dredging is required to accommodate cap thickness.

Sub-aqueous Cap Comments

- *Comment:* No capping without CU-specific USEPA review and approval.
- *Response:* USEPA will review prototype designs during RD phase.

  USEPA will review all actions via CU-specific post-closure progress reports.

  Use of caps may be limited during Phase 2, if appropriate.