WQBELs Part III: Determining the Need for Chemical-specific WQBELs

NPDES Permit Writers' Course
Online Training Curriculum

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Establishing WQBELs in NPDES Permits

Part I: Identifying the Applicable Water Quality Standards

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Part II: Characterizing the Effluent and Receiving Water

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Part III: Determining the Need for Chemical-specific WQBELs

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Part IV: Calculating Chemical-specific WQBELs

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Review

- Part I:
  - Water quality ***standards*** apply throughout the water body (or segment of a water body) as defined by the state, territory, or tribe
  - ***Effluent limitations*** apply at the compliance point established in the permit (generally "end of pipe")
- Part II:
  - identified pollutants of concern
  - determined whether the water quality standards allow us to consider mixing and dilution
  - selected a modeling approach (generally a steady-state approach)
  - identified critical conditions
  - established an appropriate dilution allowance or mixing zone for each pollutant of concern

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Determining the Need for WQBELs

- **Question**: *When must a permit writer establish effluent limitations derived from state water quality standards?*
- **Answer:** Limitations must control all pollutants or pollutant parameters…which…are or may be discharged at a level which will ***cause***, have the ***reasonable potential to cause***, or ***contribute*** to an excursion above any state water quality standard, including state narrative criteria for water quality. [40 CFR 122.44(d)(1)(i)]

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Reasonable Potential Analysis (RPA)

- We can conduct a "reasonable potential analysis" based on
  - numeric criteria
  - narrative criteria
    - numeric interpretation
    - qualitative interpretation

- A reasonable potential analysis can be completed
  - with effluent data
  - without effluent data
    - data from other sources or from similar discharges
    - qualitative information

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Approaches to Conducting RPA

- *Technical Support Document for WQ-based Toxics Control* (TSD)
  - Calculate expected receiving water concentration after accounting for available dilution and other mitigating factors (e.g., volatilization) under critical conditions
  - Compare calculated receiving water concentration to all applicable criteria
- Great Lakes Water Quality Guidance [40 CFR Part 132]
- State-specific
  - Wide variety of approaches
  - Must be consistent with the provisions in § 122.44(d)

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Determining the Need for WQBELs – TSD Approach

Step 1: Determine the Appropriate Water Quality Model

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Step 2: Determine the Expected Receiving Water Concentration Under Critical Conditions

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Step 3: Answer the Question: *Is there reasonable potential?*

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Step 4: Document Decisions

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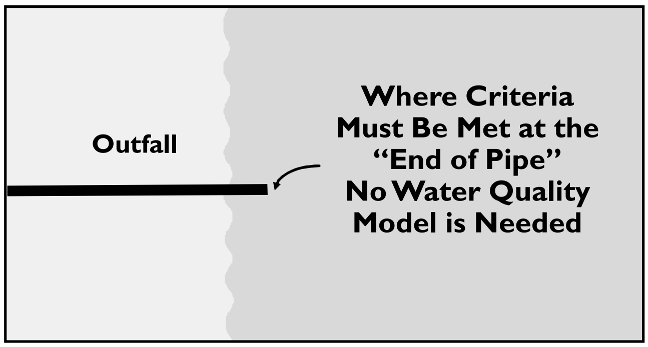
Step 1: Determine the Appropriate Water Quality Model

Where dilution or mixing is not considered, no water quality model is needed.



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Step 1: Determine the Appropriate Water Quality Model

Streeter-Phelps

CORMIX

Mass-balance equation

QUAL2K

"Essentially, all models are wrong, but some are useful." – George E.P. Box

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Determining the Need for WQBELs – TSD Approach

Step 1: Determine the Appropriate Water Quality Model

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Step 2: Determine the Expected Receiving Water Concentration Under Critical Conditions

↓

Step 3: Answer the Question: *Is there reasonable potential?*

↓

Step 4: Document Decisions

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Step 2: Determine Expected Receiving Water Concentration Under Critical Conditions

Effluent and Receiving Water Characteristics *(Part II)* → **Selected Water Quality Model** → **Receiving Water Concentration**

- For steady-state modeling under ***critical conditions*** the permit writer projects:
  - a single **receiving water concentration**
  - to compare to each applicable **water quality criterion**

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Determining the Need for WQBELs – TSD Approach

Step 1: Determine the Appropriate Water Quality Model

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Step 2: Determine the Expected Receiving Water Concentration Under Critical Conditions

↓

Step 3: Answer the Question: *Is there reasonable potential?*

↓

Step 4: Document Decisions

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Step 3: Answer the Question: Is There Reasonable Potential?

- If the projected receiving water concentration exceeds the applicable water quality criterion, then there is reasonable potential and the permit writer must establish WQBELs
- If the projected receiving water concentration is equal to or less than the applicable water quality criterion, then there is no reasonable potential and we have not demonstrated a need to establish WQBELs

Let's look at some examples.

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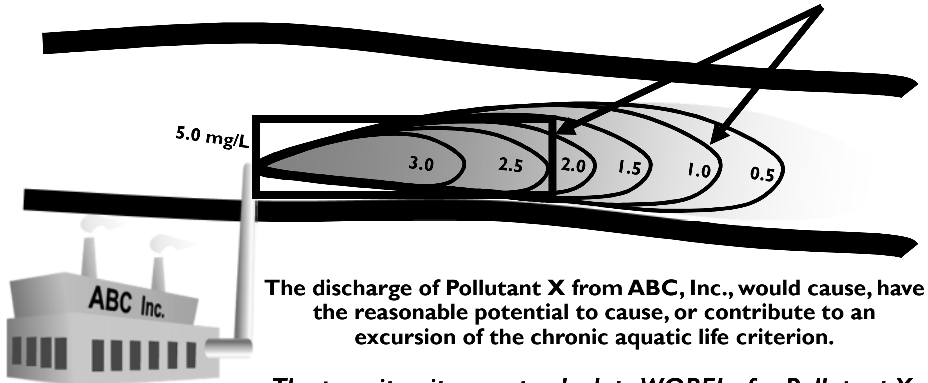
Example: Reasonable Potential Analysis
Steady-State, Incomplete Mixing Under Critical Conditions

Steady-State, Incomplete Mix Assessment

Chronic Aquatic Life Water Quality Criterion for Pollutant X = 1.0 mg/L



The discharge of Pollutant X from ABC, Inc., would cause, have the reasonable potential to cause, or contribute to an excursion of the chronic aquatic life criterion.

The permit writer must calculate WQBELs for Pollutant X.

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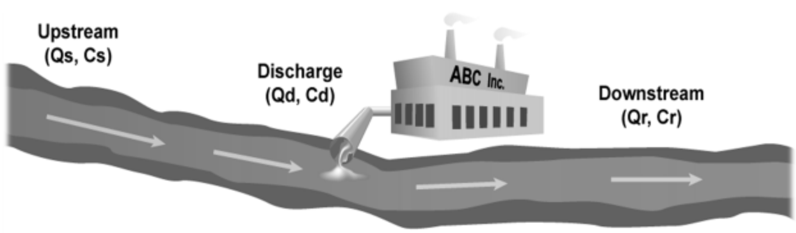
Mass Balance Equation



- Mass-Balance Equation: QsCs + QdCd = QrCr
  - Q = Flow (mgd or cfs)
  - C = Pollutant concentration (mg/l)
  - Mass = [Concentration] [Flow]

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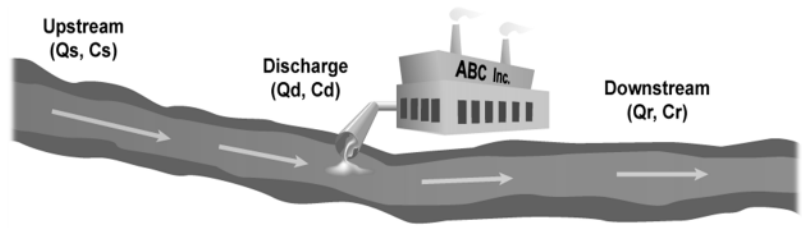
Steady-State Complete Mix Assessment
QsCs + QdCd = QrCr



Determine the concentration of ***Pollutant X*** (the pollutant of concern) in the water body downstream of the discharge:

$$Cr = \frac{QsCs + QdCd}{Qr}$$

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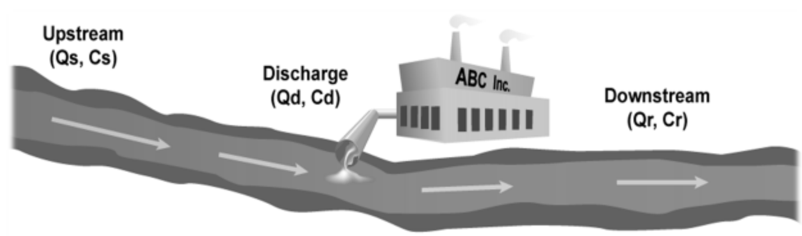
Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	**= Critical stream flow (1Q10) for acute criterion**	**= ???????**
Qd	**= Critical effluent flow from discharge flow data**	**= ???????**
Qr	**= Sum of critical stream flow and critical effluent flow**	**= ???????**
Cs	**= Critical upstream pollutant concentration**	**= ???????**
Cd	**= Critical effluent pollutant concentration**	**= ???????**

$$Cr = \frac{QsCs + QdCd}{Qr}$$

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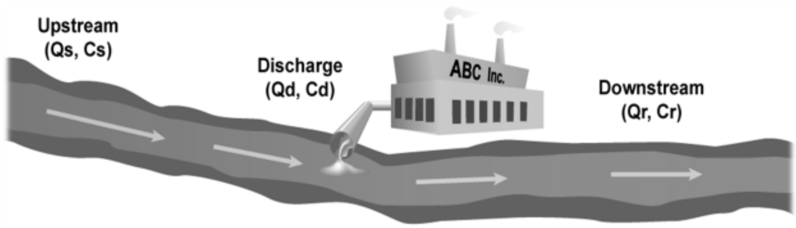
Calculating Receiving Water Concentration Under Critical Conditions



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Qs = Critical ***stream flow*** from water quality standards

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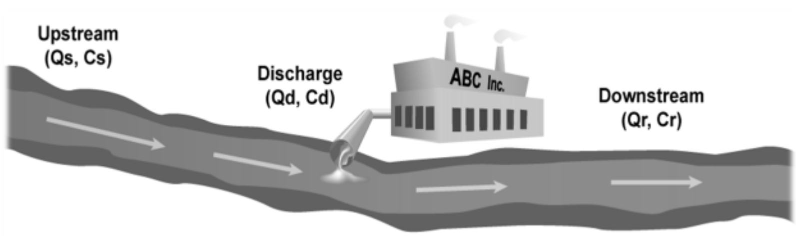
Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X:	**= 1.0 mg/L**
Qs = Critical stream flow (1Q10) for acute criterion	**= 1.2 cfs**
Qd = Critical effluent flow from discharge flow data	**= ???????**
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$$Cr = \frac{QsCs + QdCd}{Qr}$$

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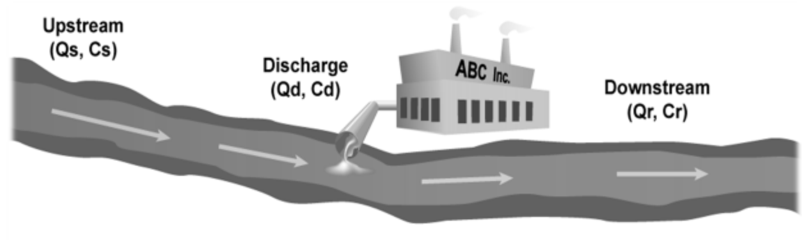
Calculating Receiving Water Concentration Under Critical Conditions



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Qd = Critical ***effluent flow*** from discharge flow data

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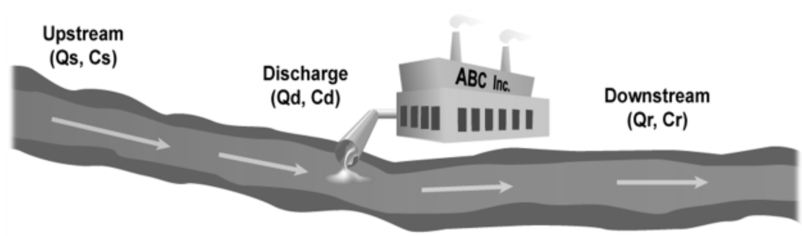
Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

- **Qs = Critical stream flow (1Q10) for acute criterion = 1.2 cfs**
- **Qd = Critical effluent flow from discharge flow data = 0.31 cfs**
- **Qr = Sum of critical stream flow and critical effluent flow = ???????**
- **Cs = Critical upstream pollutant concentration = ???????**
- **Cd = Critical effluent pollutant concentration = ???????**

$$Cr = \frac{QsCs + QdCd}{Qr}$$

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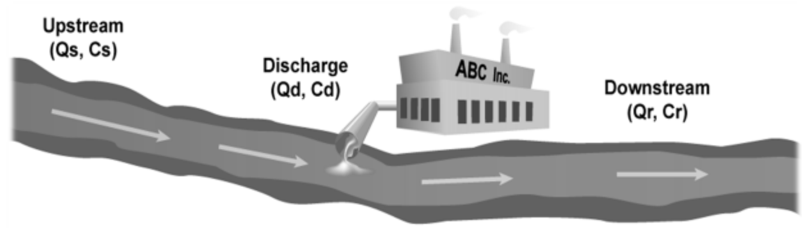
Calculating Receiving Water Concentration Under Critical Conditions



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Qr = **Sum** of upstream flow (Qs) and discharge flow (Qd)

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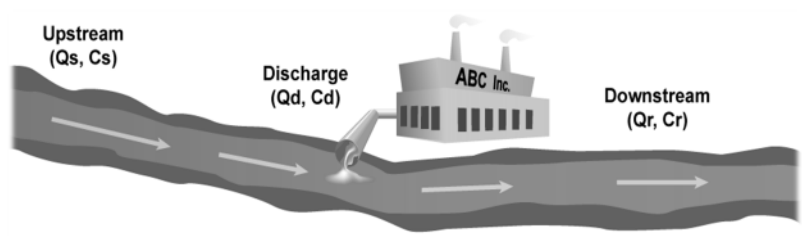
Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

- **Qs = Critical stream flow (1Q10) for acute criterion = 1.2 cfs**
- **Qd = Critical effluent flow from discharge flow data = 0.31 cfs**
- **Qr = Sum of critical stream flow and critical effluent flow = 1.51 cfs**
- **Cs = Critical upstream pollutant concentration = ???????**
- **Cd = Critical effluent pollutant concentration = ???????**

$$Cr = \frac{QsCs + QdCd}{Qr}$$

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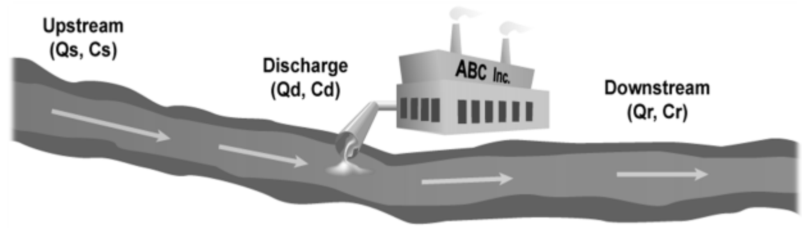
Calculating Receiving Water Concentration Under Critical Conditions



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Cs = Critical ***background*** (upstream) pollutant ***concentration*** from ambient monitoring data

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Critical Background Pollutant Concentration

- Single critical value that establishes remaining assimilative capacity of the receiving water
- Best established using site-specific receiving water data
  - federal / state ambient data
  - ambient data provided by applicant
- Approaches where ambient data are not available
  - require applicant to collect data
  - permitting authority collect data
  - assumed critical background concentration

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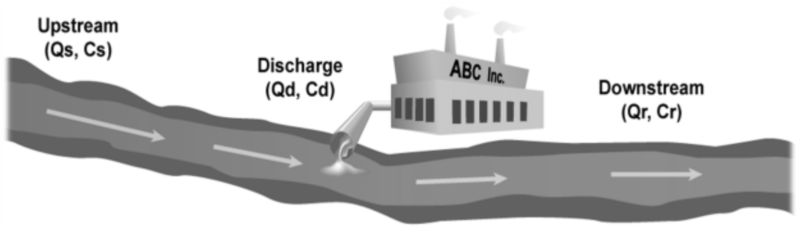
Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

Qs	**= Critical stream flow (1Q10) for acute criterion**	**= 1.2 cfs**
Qd	**= Critical effluent flow from discharge flow data**	**= 0.31 cfs**
Qr	**= Sum of critical stream flow and critical effluent flow**	**= 1.51 cfs**
Cs	**= Critical upstream pollutant concentration**	**= 0.80 mg/L**
Cd	**= Critical effluent pollutant concentration**	**= ???????**

$$Cr = \frac{QsCs + QdCd}{Qr}$$

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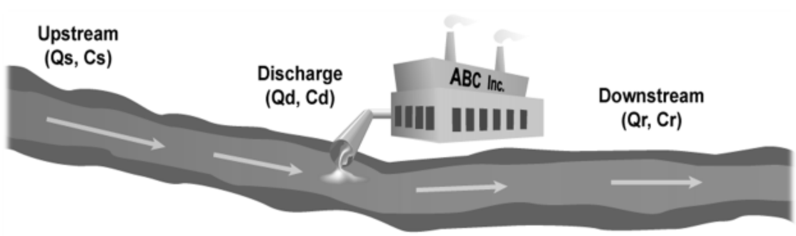
Calculating Receiving Water Concentration Under Critical Conditions



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Cd = Critical ***effluent*** pollutant ***concentration***

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Determining a Critical Value for Cd

- Examine data for ABC Incorporated
- Number of samples (n) = 6
- Concentrations of Pollutant X:

Cd(1) = 1.2 mg/L ~~**Cd(2) = 0.92 mg/L**~~
Cd(3) = 0.87 mg/L **Cd(4) = 1.3 mg/L**
Cd(5) = 0.74 mg/L **Cd(6) = 1.0 mg/L**

- Maximum Observed Effluent Concentration = 1.3 mg/L

Question: Would this C_d represent the "critical" condition?

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Determining a Critical Value for Cd

- Answer: ***Not likely***
  - Our limited data set does not account for day-to-day ***variability*** in effluent quality (i.e., the facility probably did not self-monitor on its worst possible day)
  - When determining reasonable potential, "…the permitting authority shall use procedures which account for…the ***variability*** of the pollutant or pollutant parameter in the effluent…" [§ 122.44(d)(1)(ii)]

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Determining a Critical Value for Cd

- Follow permitting authority procedures to determine the critical value for C_d
  - permitting authority regulation, policy, or guidance
  - EPA's *Technical Support Document for Water Quality-based Toxics Control* (TSD)
    - uses a statistical analysis that assumes effluent data follow a lognormal distribution

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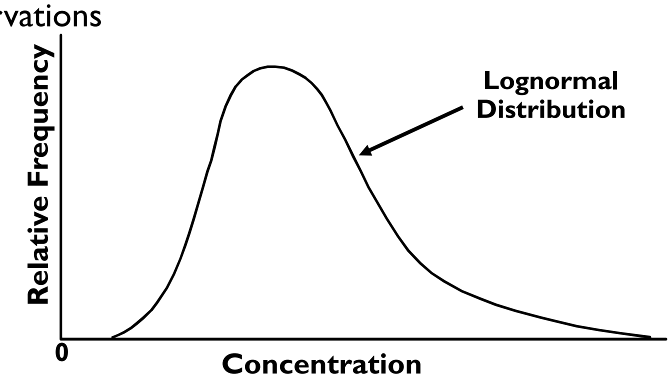
Lognormal Distribution

- *Lognormal Distribution*: the probability distribution of any random variable whose logarithm is normally distributed
- *Relative Frequency*: the fraction or ratio of the number of observations in a category or class to the total number of observations



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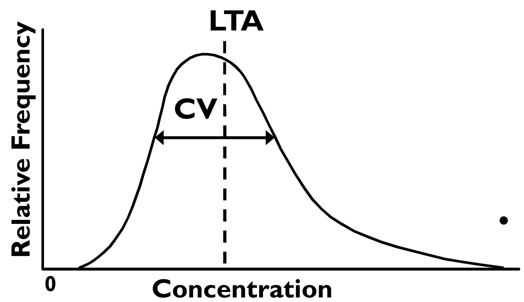
Defining a Lognormal Distribution



- ***Long-term Average (LTA):*** for a continuous random variable, the value at which the area under the distribution curve to the left of the value equals the area under the distribution curve to the right of the value
- ***Coefficient of Variation (CV):*** a statistical measure of the relative variation of a distribution or set of data calculated as the standard deviation divided by the mean

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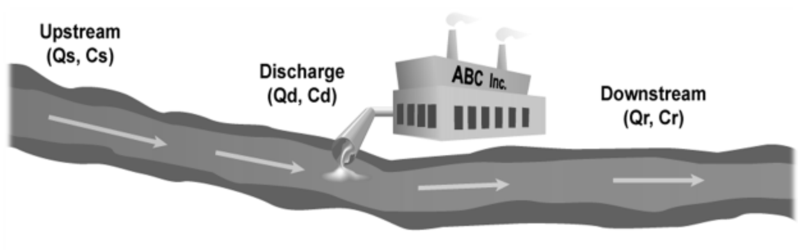
Calculating Receiving Water Concentration Under Critical Conditions



$$Cr = \frac{QsCs + QdCd}{Qr}$$

Recall… we want to determine:

Cd = Critical ***effluent*** pollutant ***concentration***

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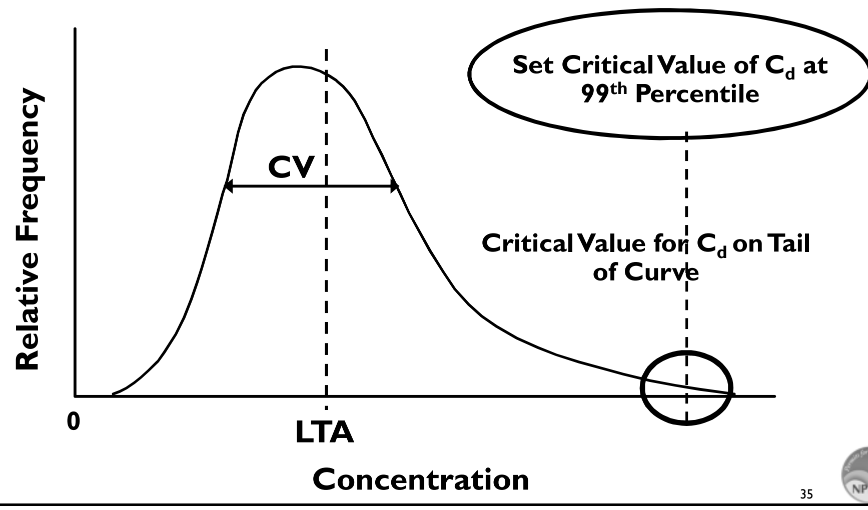
Determining a Critical Value for Cd



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Determining a Critical Value for Cd

- Examine data for ABC Incorporated using the TSD statistical approach
- Number of samples (N) = 6
- Concentrations of Pollutant X:

Cd(1) = 1.2 mg/L	**Cd(2) = 0.92 mg/L**
Cd(3) = 0.87 mg/L	**Cd(4) = 1.3 mg/L**
Cd(5) = 0.74 mg/L	**Cd(6) = 1.0 mg/L**

- Maximum Observed Effluent Concentration = 1.3 mg/L
  - CV = 0.6 (EPA recommends a default CV value of 0.6 if there are < 10 data points available)

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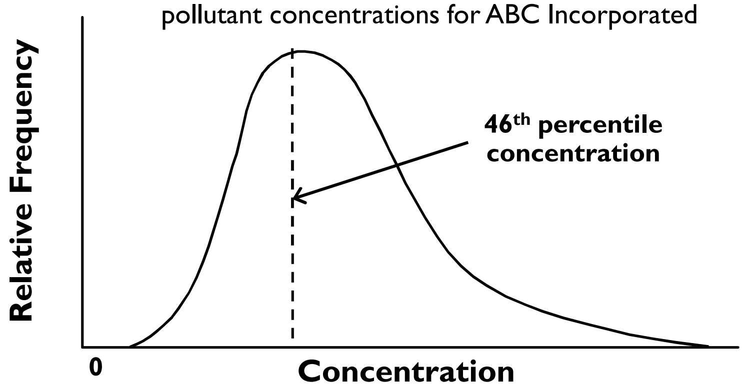
Determining a Critical Value for Cd

Statistics tell us that we can be **99%** sure that **the largest value of our 6 measurements** of the concentration of Pollutant X will be at or greater than the ***46th percentile*** of the lognormal distribution of all effluent pollutant concentrations for ABC Incorporated



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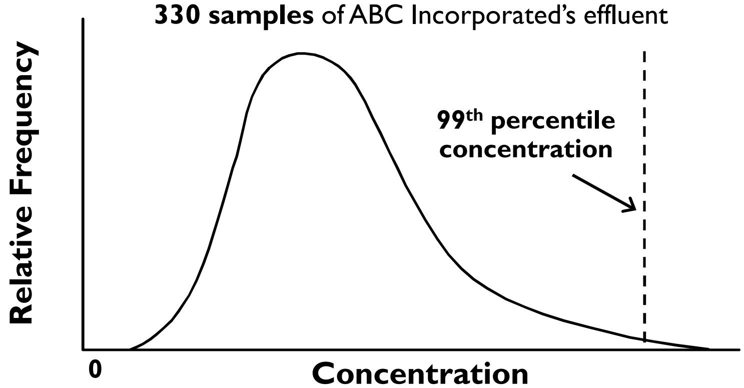
Determining a Critical Value for Cd

To be **99 percent sure** that we have captured the ***99th percentile*** concentration of Pollutant X (which we will call the ***critical or upper-bound*** concentration), we would need to use the highest concentration measured from **330 samples** of ABC Incorporated's effluent



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Determining a Critical Value for Cd

- Our options:
  1. Measure the concentration of Pollutant X in *330 separate samples* of ABC Incorporated's effluent
  2. Use statistics for the lognormal distribution to find a *multiplier* that lets us
     - estimate the 99th percentile (which is what we want to find) from the 46th percentile (which is represented by the highest of our 6 measured concentrations)
- For any data set, to estimate the upper bound value, we need to know:
  - number of samples collected (N)
  - coefficient of variation (CV)
    - use a default of 0.6 if N < 10

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Reasonable Potential Multiplying Factors

(99% Confidence Level and 99% Probability Basis

Coefficient of Variation

Sample Number N	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
1	2.5	6.0	13.2	26.5	48.3	81.4	128.0	190.3	269.9	368.3
2	2.0	4.0	7.4	12.7	20.2	30.3	43.0	58.4	76.6	97.5
3	1.9	3.3	5.6	8.9	13.4	19.0	25.7	33.5	42.3	52.0
4	1.7	2.9	4.7	7.2	10.3	14.2	18.6	23.6	29.1	35.1
5	1.7	2.7	4.2	6.2	8.6	11.5	14.8	18.4	22.4	26.5
6	1.6	2.5	3.8	5.5	7.5	9.8	12.4	15.3	18.3	21.5
7	1.6	2.4	3.6	5.0	6.7	8.7	10.8	13.1	15.6	18.2
8	1.5	2.3	3.3	4.6	6.1	7.8	9.6	11.6	13.6	15.8
9	1.5	2.2	3.2	4.3	5.7	7.1	8.7	10.4	12.2	14.0
10	1.5	2.2	3.0	4.1	5.3	6.6	8.0	9.5	11.0	12.6
11	1.4	2.1	2.9	3.9	5.0	6.2	7.4	8.8	10.1	11.5
12	1.4	2.0	2.8	3.7	4.7	5.8	7.0	8.1	9.4	10.6
13	1.4	2.0	2.7	3.6	4.5	5.5	6.5	7.6	8.7	9.9
14	1.4	2.0	2.6	3.4	4.3	5.2	6.2	7.2	8.2	9.2
15	1.4	1.9	2.6	3.3	4.1	5.0	5.9	6.8	7.7	8.7
16	1.4	1.9	2.5	3.2	4.0	4.8	5.6	6.5	7.3	8.2
17	1.4	1.9	2.5	3.1	3.8	4.6	5.4	6.2	7.0	7.8
18	1.4	1.9	2.4	3.0	3.7	4.4	5.2	5.9	6.7	7.4
19	1.4	1.8	2.4	3.0	3.6	4.3	5.0	5.7	6.4	7.1
20	1.3	1.8	2.3	2.9	3.5	4.2	4.8	5.5	6.1	6.8

3.8

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Determining a Critical Value for Cd

- Examine data for ABC Incorporated using the TSD statistical approach
- Number of samples (N) = 6
- Concentrations of Pollutant X:

Cd(1) = 1.2 mg/L **Cd(2) = 0.92 mg/L**
Cd(3) = 0.87 mg/L **Cd(4) = 1.3 mg/L**
Cd(5) = 0.74 mg/L **Cd(6) = 1.0 mg/L**

- Maximum Observed Effluent Concentration = 1.3 mg/L

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Determining a Critical Value for Cd

- Projected Critical (99th percentile) Value of Cd =
  - 1.3 mg/L x multiplier
- C_d = 1.3 mg/L x 3.8 = **4.9 mg/L**

C_d = 4.9 mg/L

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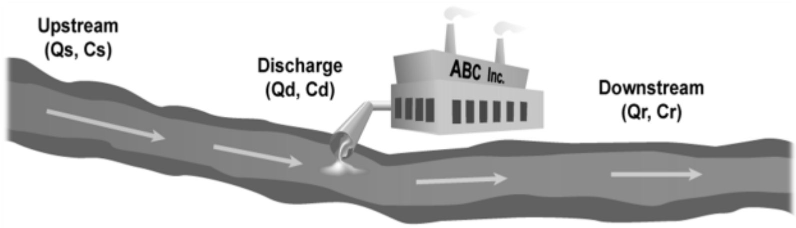
Calculating Receiving Water Concentration Under Critical Conditions



Criterion for protection of aquatic life from acute effects from Pollutant X: = 1.0 mg/L

- **Qs = Critical stream flow (1Q10) for acute criterion = 1.2 cfs**
- **Qd = Critical effluent flow from discharge flow data = 0.31 cfs**
- **Qr = Sum of critical stream flow and critical effluent flow = 1.51 cfs**
- **Cs = Critical upstream pollutant concentration = 0.80 mg/L**
- **Cd = Critical effluent pollutant concentration = 4.9 mg/L**

$$Cr = \frac{QsCs + QdCd}{Qr}$$

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Expected Receiving Water Concentration

$$C_r = \frac{QsCs + QdCd}{Qr}$$

$$C_r = \frac{(1.2\ \text{cfs})(0.80\ \text{mg/L}) + (0.31\ \text{cfs})(4.9\ \text{mg/L})}{(1.2\ \text{cfs}) + (0.31\ \text{cfs})}$$

$$C_r = 1.6\ \text{mg/L}$$

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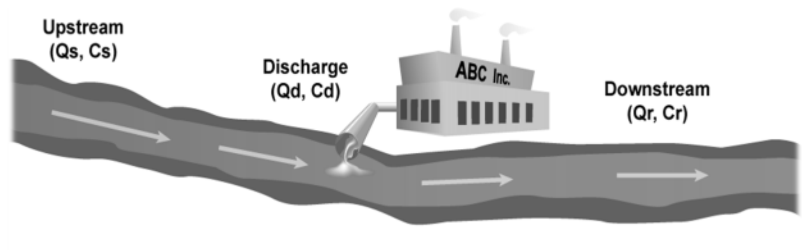
Is There Reasonable Potential?



- For ABC Incorporated:
  - Projected **Cr = 1.6 mg/L > 1.0 mg/L** (acute criterion)
  - The discharge of Pollutant X from ABC Incorporated would **cause, have the reasonable potential to cause, or contribute** to an excursion of the acute aquatic life criterion.
- The permit writer must calculate WQBELs for Pollutant X.

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What Next?

- We have considered only one aquatic life criterion. We still would need to consider, if available:
  - additional aquatic life criteria
  - human health criteria
  - wildlife criteria, etc.
- Repeat the entire analysis for additional pollutants of concern and additional outfalls
- For each pollutant for which we determine there is reasonable potential to exceed any of the criteria for that pollutant, *calculate chemical-specific WQBELs (Module 6D)*
- When there is no reasonable potential
  - determine whether any existing limitations should be retained
  - consider appropriate monitoring requirements

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Determining the Need for WQBELs – TSD Approach

Step 1: Determine the Appropriate Water Quality Model

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Step 2: Determine the Expected Receiving Water Concentration Under Critical Conditions

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Step 3: Answer the Question: *Is there reasonable potential?*

↓

Step 4: Document Decisions

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Step 4: Document Decisions

- Document in the fact sheet or statement of basis:
  - statutory and regulatory citations
  - the applicable water quality standards
  - the process used to determine:
    - appropriate water quality model
    - critical conditions
    - dilution allowance or mixing zone
  - the process used to conduct the reasonable potential determination for each pollutant of concern (including showing calculations)

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Feedback and Other Presentations

Questions or comments?

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