



Impact of a Water Effect Ratio in NPDES Permit Renewals

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Neuse River Compliance Association and Lower Neuse Basin Association



Preserving the Waters of the Lower Neuse River

NPDES
Permitting
Process

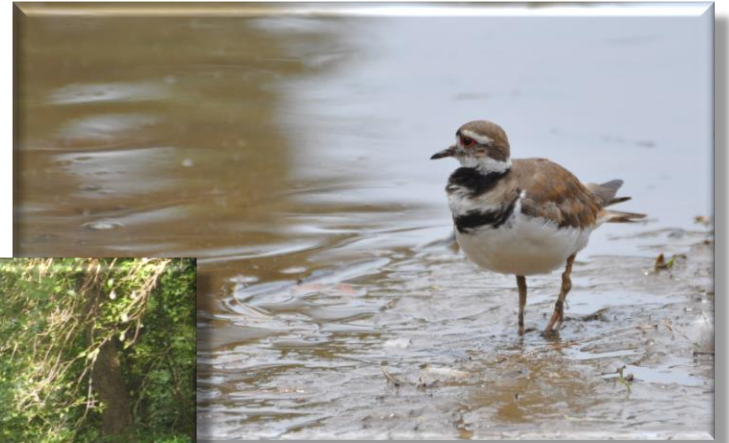
National
Aquatic Criteria
Development

Definitions

Site-Specific
Criteria Methods

Example
Calculations

Summary



Permitting Strategy

- Understand your watershed
 - Scale
 - Ecoregion
 - Water quality criteria and assessment
 - TMDLs (existing or pending)
- Know the applicable rules, policies, and guidance
- Receiving stream water quality monitoring
- Be aware of alternative permitting approaches

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**Preliminary
Discussions**

**Submit
Renewal
Application
(EPA Form 2A)**

**Receive
Draft Permit**

**Receive
Regulatory
Response**

**Receive
Final Permit**

30 days

30-60 days

90 days

- Review permit conditions
- Compare to previous permit
- Review Fact Sheet
- Request additional review time, if needed

- Regulatory basis correct?
- Flow basis for permit limits correct?
- Errors in calculations or methods?
- Reasonable potential?
- Prepare and submit comment letter

- Meetings and/or correspondence
- Appeal or accept?

**NPDES
Permitting
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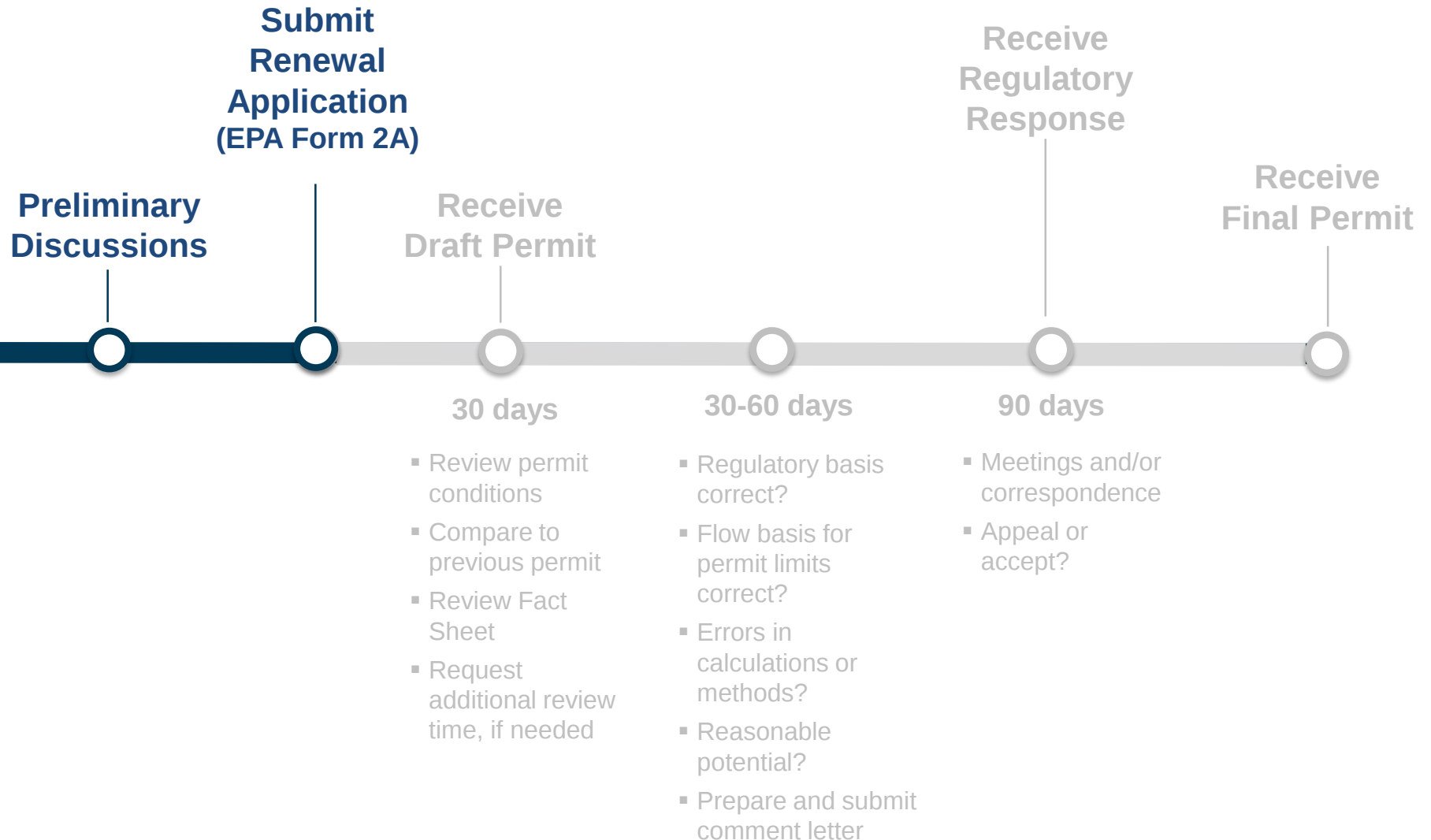
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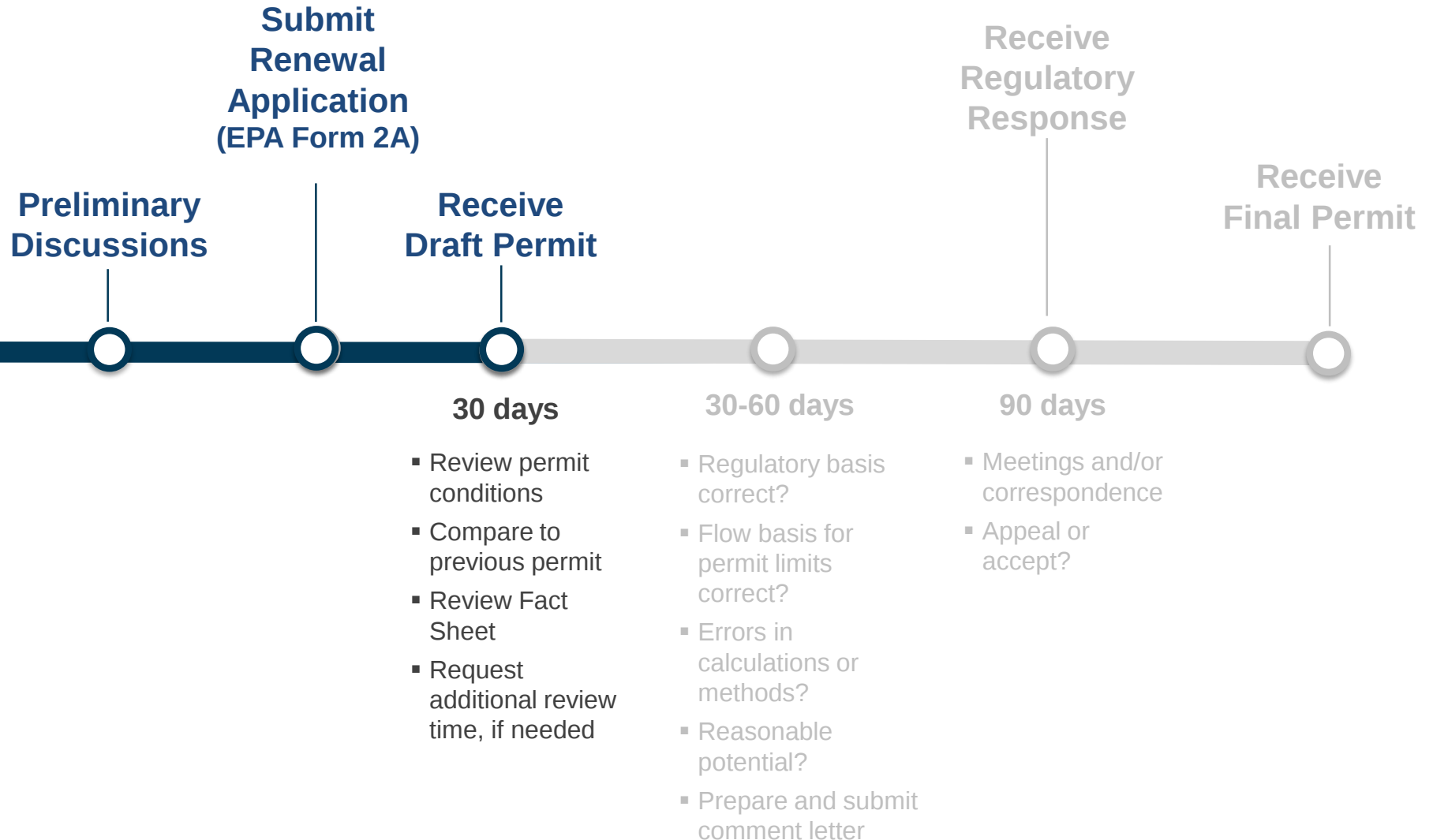
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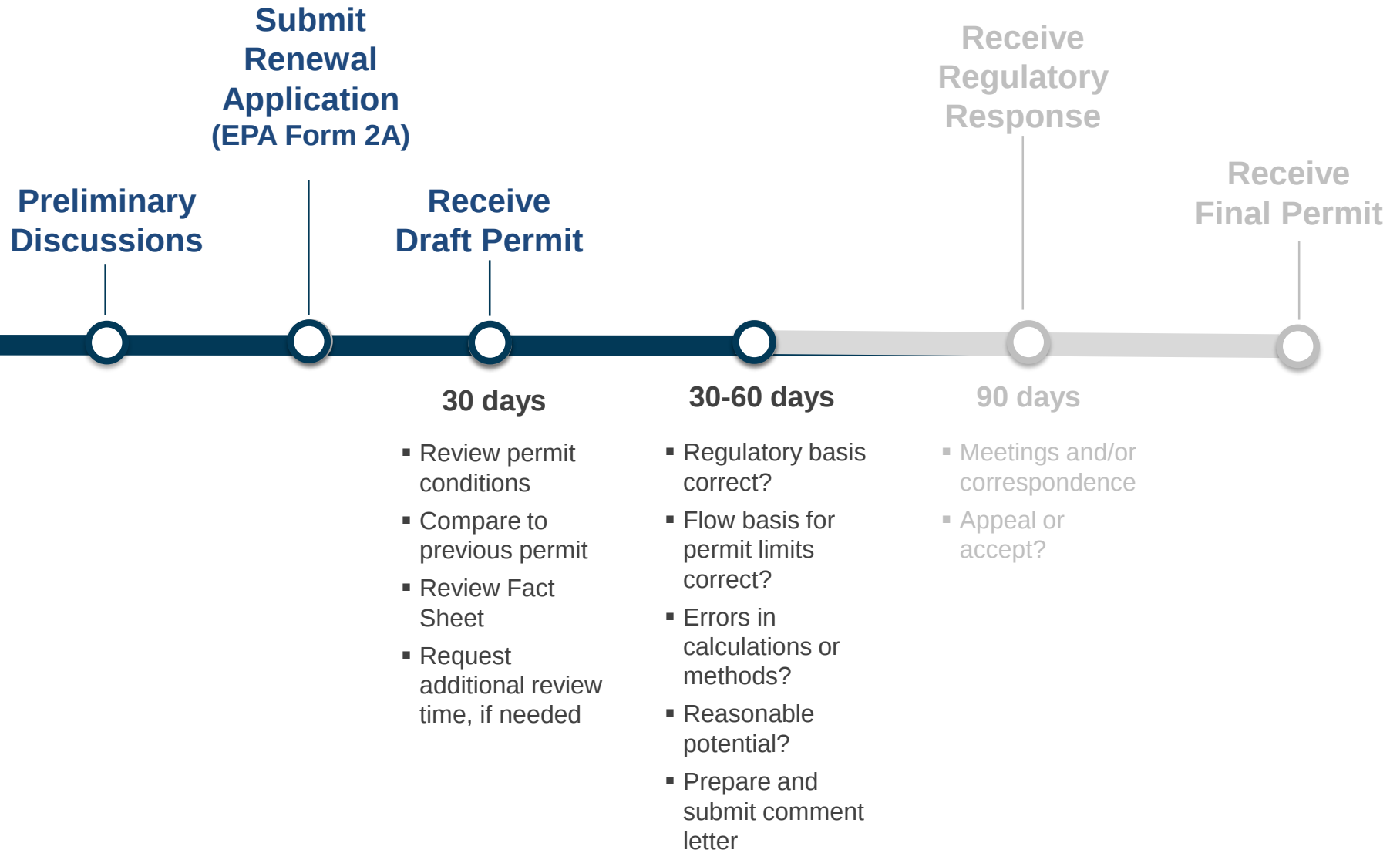
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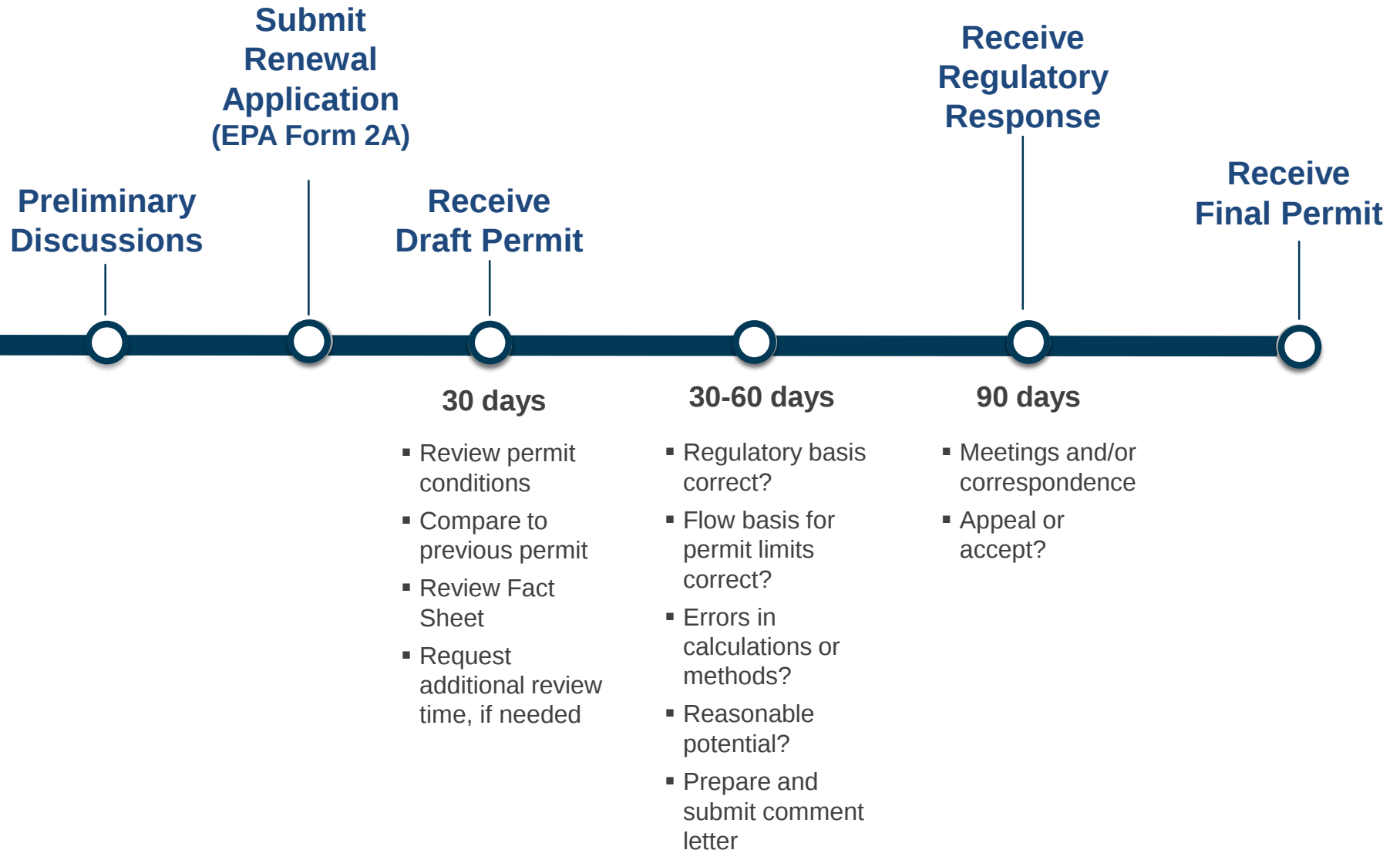
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FACILITY NAME AND PERMIT NUMBER:		Form Approved 1/14/99 OMB Number 2040-0080
FORM 2A NPDES	NPDES FORM 2A APPLICATION OVERVIEW	
APPLICATION OVERVIEW		
Form 2A has been developed in a modular format and consists of a "Basic Application Information" packet and a "Supplemental Application Information" packet. The Basic Application Information packet is divided into two parts. All applicants must complete Parts A and C. Applicants with a design flow greater than or equal to 0.1 mgd must also complete Part B. Some applicants must also complete the Supplemental Application Information packet. The following items explain which parts of Form 2A you must complete.		
BASIC APPLICATION INFORMATION:		
A. Basic Application Information for all Applicants. All applicants must complete questions A.1 through A.8. A treatment works that discharges effluent to surface waters of the United States must also answer questions A.9 through A.12. B. Additional Application Information for Applicants with a Design Flow $\geq$ 0.1 mgd. All treatment works that have design flows greater than or equal to 0.1 million gallons per day must complete questions B.1 through B.8. C. Certification. All applicants must complete Part C (Certification).		
SUPPLEMENTAL APPLICATION INFORMATION:		
D. Expanded Effluent Testing Data. A treatment works that discharges effluent to surface waters of the United States and meets one or more of the following criteria must complete Part D (Expanded Effluent Testing Data): 1. Has a design flow rate greater than or equal to 1 mgd. 2. Is required to have a pretreatment program (or has one in place), or 3. Is otherwise required by the permitting authority to provide the information. E. Toxicity Testing Data. A treatment works that meets one or more of the following criteria must complete Part E (Toxicity Testing Data): 1. Has a design flow rate greater than or equal to 1 mgd. 2. Is required to have a pretreatment program (or has one in place), or 3. Is otherwise required by the permitting authority to submit results of toxicity testing. F. Industrial User Discharges and RCRA/CERCLA Wastes. A treatment works that accepts process wastewater from any significant industrial users (SIUs) or receives RCRA or CERCLA wastes must complete Part F (Industrial User Discharges and RCRA/CERCLA Wastes). SIUs are defined as: 1. All industrial users subject to Categorical Pretreatment Standards under 40 Code of Federal Regulations (CFR) 403.6 and 40 CFR Chapter I, Subchapter N (see instructions); and 2. Any other industrial user that: a. Discharges an average of 25,000 gallons per day or more of process wastewater to the treatment works (with certain exclusions); or b. Contributes a process wastestream that makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the treatment plant; or c. Is designated as an SIU by the control authority. G. Combined Sewer Systems. A treatment works that has a combined sewer system must complete Part G (Combined Sewer Systems).		
ALL APPLICANTS MUST COMPLETE PART C (CERTIFICATION)		

Application Form 2A

Effluent Testing Information:

Use 40 CFR Part 136 methods

Must be based on at least three samples/scans

No more than 4-½ years apart

BOD, TSS, DO, fecal coliform, pH, temperature, NH₃-N, TKN, NO₃-NO₂ phosphorus, TRC, TDS, O&G

Majors / Pretreatment:

WET (second species) – 4 quarterly tests or one seasonal per year over 4 years

Priority pollutant scans (3)

Draft Permit Review

- [Fact Sheet](#) – Basis for effluent monitoring requirements and all other permit conditions
- You must provide comments to preserve right to appeal any provisions (e.g., standing)

Statute

- Goals
- Enforceable?
Yes

Rule

- Implementation
of goals
- Enforceable?
Yes

Policy and Guidance

- Implementation
of rules
- Enforceable?
Sometimes

- North Carolina has replaced total recoverable metal standards with dissolved metal standards
 - Federal rule requires that NPDES permit limits for toxic metals be total recoverable
 - Hardness dependent (receiving stream and effluent)
 - Adjustment to published criterion necessary to calculate water quality-based effluent limit (WQBEL) in NPDES permits
- Action levels were NOT retained for copper, zinc, and silver

Metal	Former Total Freshwater Aquatic Life Standard (ug/L)	Current Freshwater Dissolved Aquatic Life Standard (ug/L)	
	Chronic at 50 mg/L Hardness	Chronic 25 mg/L	Acute 25 mg/L
Arsenic	50	150	340
Beryllium	6.5	6.5	65
Cadmium	2 / 0.4 trout	0.15	0.82 / 0.51 trout
Chromium (total)	50	Removed	
Chromium III	none	24	180
Chromium VI	none	11	16
Copper	7 (AL)	2.7	3.6
Iron	1 (AL)	Removed	
Lead	25	0.54	14
Nickel	88	16	140
Silver	0.06 (AL)	0.06	0.30
Zinc	50 (AL)	36	36

- National criteria based on toxicity data for species with populations in North America
 - Short term acute toxicity – short term exposure, 48 to 96 hours
 - Chronic toxicity – long term exposure, 96 hours through life span
- Developed under Section 304(a) of Clean Water Act
- Water quality aquatic life criterion:
 - Highest concentration of a pollutant in water that is not expected to pose a significant risk to majority of species in a given environment
- Organisms exposed to single pollutant in laboratory water
 - Site-specific parameters (e.g., form and metal speciation) will affect toxicity of a pollutant that may over or under-estimate an aquatic criterion

For example: national criteria for copper data set based on laboratory tests using 4 most sensitive species:

#1 *Ceriodaphnia reticulata*



#3 Northern Squawfish (*P. oregonensis*)



#2 Daphnia



#4 Gammarus

- Test results obtained in “laboratory” conditions as total recoverable in 1980s
- In early to mid 1990s, EPA changed course and recommended that criteria be applied as a “dissolved” criteria
 - Dissolved metals represent bioavailable fraction
- EPA provided acute conversion factors (ACFs) & chronic conversion factors (CCFs) to convert the laboratory-derived total recoverable criteria to “dissolved”
- Most states’ criteria are hardness-dependent equations
- Hardness, dissolved organics, and suspended solids reduce toxicity
 - The softer the water, the more toxic the water

- [Published criterion](#) – Typically as recommended by EPA, but also established by state
- [Dissolved metal](#) – The metal passes through either a 0.45- μm or 0.40- μm membrane filter
- [Total recoverable metal](#) – The metal that remains in water after a being acidified and digested by strong acid and the insoluble material that has been separated either by gravity settling or by large pore filtration
- [Translator](#) – The ratio of the dissolved to total recoverable metal in downstream water
- [Water Quality Based Effluent Limit \(WQBEL\)](#) – Water quality based effluent limit

- Criterion Continuous Concentration (CCC) – The highest instream concentration of a pollutant to which organisms can be exposed indefinitely without causing unacceptable effect
 - Chronic concentration
- Criterion Maximum Concentration (CMC) – The highest instream concentration of a pollutant to which organisms can be exposed for a brief period of time without causing an acute effect
 - Acute concentration
- Acute Conversion Factor (ACF) – Acute conversion factors (total to dissolved), EPA derived
- Chronic Conversion Factor (CCF) – Chronic conversion factors (total to dissolved), EPA derived

- Wasteload Allocation (WLA) – Allowable concentration of a pollutant in a receiving stream
- Reasonable potential is where an effluent is projected or calculated to cause an exceedance of instream standards based on:
 - Existing controls on point and nonpoint sources
 - Variability of the pollutant in the effluent
 - Sensitivity of the species to toxicity testing
 - Dilution of the effluent in the receiving water

- Compliance with dissolved metal criterion is based on EPA-derived conversion factors
 - Represents the fraction of total recoverable metal that is dissolved
- A [Translator](#) is needed to convert the dissolved metal criterion to a total metal concentration for NPDES permit compliance

Total Criterion → Dissolved Criterion → Total Criterion



- Three approaches:
 - Assume all metal is in dissolved form (1:1 relationship)
 - Linear partitioning method
 - Site-specific chemical translator

Linear Partitioning Method

- Supported by EPA
- An equation for the distribution of metal at equilibrium between the particulate and dissolved metal form
 - Partition coefficient K_p (Slope of particulate versus dissolved metal data)
 - Particulate fraction is a function of TSS concentration
 - *DEQ using statewide average effluent TSS of 10 mg/L*

$$f = \frac{1}{1 + \{[K_{po}] [TSS^{(1+a)}][10^{-6}]\}}$$

Where for copper:

$$K_{po} = 1.04 \times 10^6$$
$$a = -0.7436$$

From: *The Metals Translator: Guidance For Calculating a Total Recoverable Permit Limit From a Dissolved Criterion*" (EPA 823-B-96-007)

NPDES
Permitting
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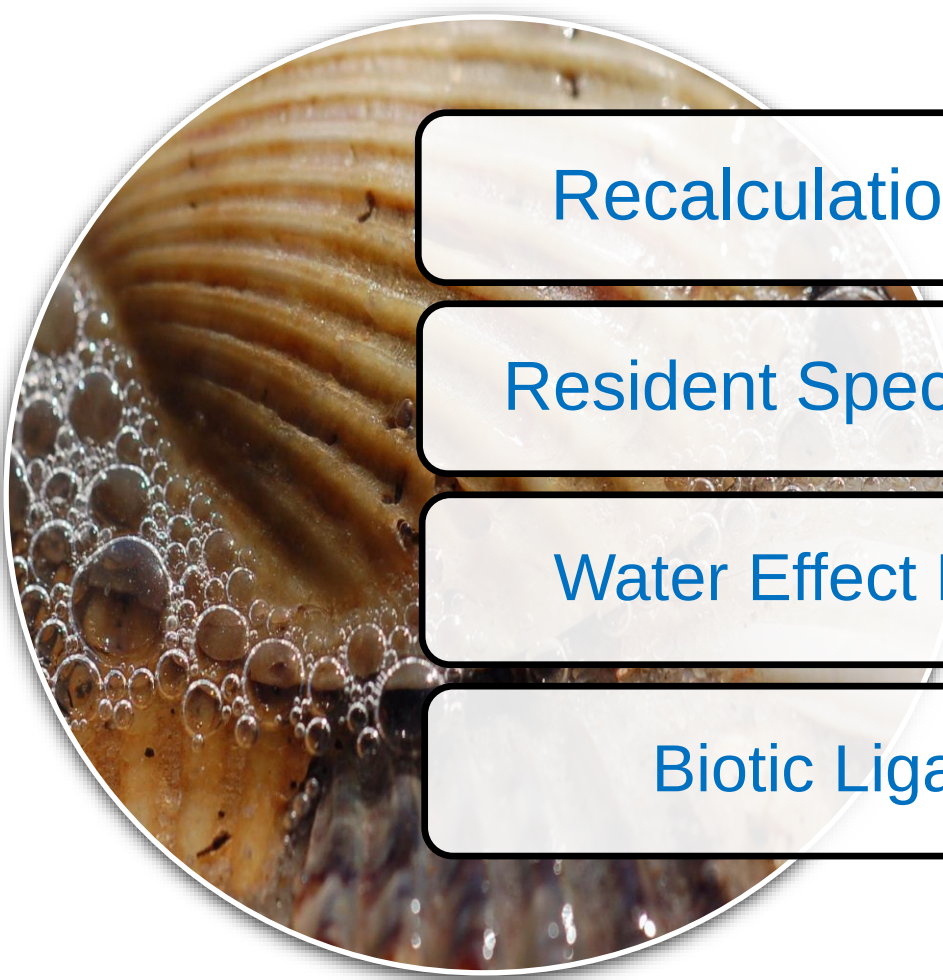
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Recalculation Procedure

Resident Species Procedure

Water Effect Ratio Method

Biotic Ligand Model

Recalculation Procedure

- Method allows modifications in national acute toxicity data set
 - Eliminates data for aquatic species not present at a particular site
 - Maintain database of non-resident species that serve as surrogates for taxonomically related species
 - Recalculates the criterion after deleting toxicity values of non-occurring species from the data set
- No laboratory testing, but may require fieldwork
 - Benthic surveys
 - Fish community surveys

Recalculation Procedure

Advantages	Disadvantages
Inexpensive calculation	Can be expensive if fieldwork is required
Can be performed quickly if field data is available	Difficult to prove a species is not present if habitat is present, causing limited toxicity data being removed
	Method does not generally result in a favorable outcome

Resident Species Procedure

- Tests the toxicity of the pollutant to resident species in site-specific water
 - Simulation of WET testing with site-specific species
- Site-specific criterion is calculated using the toxicity data for each species per EPA national aquatic life guidelines
 - None of the species in the dataset are surrogates
 - Procedure does allow national data set to be used

Resident Species Procedure

Advantages	Disadvantages
Procedure considers bioavailability of pollutant based on characteristics of receiving water	Expensive testing requirements
Does allow for species in the national data set to be used	Difficult to obtain a large enough database to do a statistical comparison to produce a site-specific criterion
	Least used method

Water Effect Ratio (WER) Method

- Ratio of the toxicity of a metal in site water to toxicity of the same metal in standard laboratory water
 - Used to derive site-specific limits for certain metals from national and state aquatic life criteria originally developed using laboratory toxicity data
 - Compensates for site-specific factors such as hardness, alkalinity, organic carbon, etc.
 - Influence the bioavailability and toxicity of metals
- More common and popular method with generally good results

Water Effect Ratio (WER) Method

Interim Method, 1994

- Published in 1994
- Use with any metal
- 3 testing events with a primary species
- 1 testing event with a secondary species
- Uses actual flows to create SIMSTREAM
- Sampling events with 3- week intervals
- Complicated derivation of final WER
- 6 months

Copper Streamlined, 2001

- Published in 2001 for copper only
- 2 testing events with one species
- Sampling events with a 4-week interval, need low dry weather stream flow
- Uses design flows to create SIMSTREAM
- Final WER is the geometric mean of the two WERs
- 4 months

Water Effect Ratio (WER) Screening Analysis

- Literature review
 - Typically produces wide range in WER values
- Quick toxicity study to validate pursuit of a full study
 - Estimate of flow conditions
- Results are an estimated value and only meant to convey feasibility
 - Full test results could be very different
- WER study plan must be submitted to DWR for review and approval prior to proceeding with WER study

Step 1: Sample collection

Upstream receiving stream and final effluent samples are collected and transported to the laboratory



Step 2: SIMSTREAM constructed at laboratory

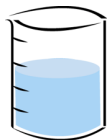
Final effluent and receiving stream are combined to create a simulated downstream water sample



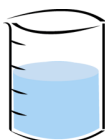
Step 3: Prepare Lab Water Treatments

- Spike lab water with increasing amounts of copper
- Submit each treatment for total and dissolved copper
- Acute toxicity tests (48 hr) are used to conduct WER for chronic criteria (CCC)
 - Hybrid approach used whereby CMC is used to establish chronic criteria (CCC)
 - Valid if test species (e.g., *Ceriodaphnia dubia*) has 48-hour mortality endpoint between CCC and CMC values
 - Apply cmcWER result to cccWER
 - Use of acute test much less expensive than chronic tests

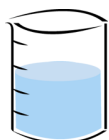
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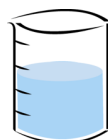
2.8 ppb



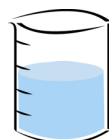
4.3 ppb



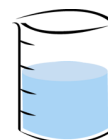
6.6 ppb



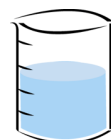
10.1 ppb



15.6 ppb



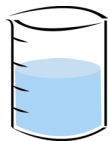
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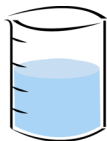
Step 4: Prepare SIMSTREAM Treatments

- Spike SIMSTREAM with increasing amounts of copper
- Submit each treatment for total and dissolved copper
- Use each treatment in a 48-hour toxicity test
 - Again, hybrid approach to apply cmcWER to cccWER

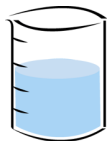
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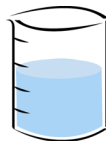
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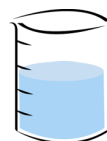
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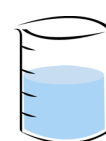
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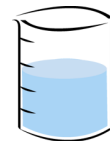
52 ppb



76 ppb



120 ppb



Step 5: Conduct Toxicity Test

- Lab water and site water toxicity tests result in LC50 values.
- The LC50 represents the copper concentration that causes 50% of the test organisms to die during the test.



Step 6: Calculate the Water-Effect Ratio

- Normalize LC50 results to same hardness
- Water Effect Ratio =

$$\text{LC50 in Site Water} / \text{LC50 in Lab Water}$$

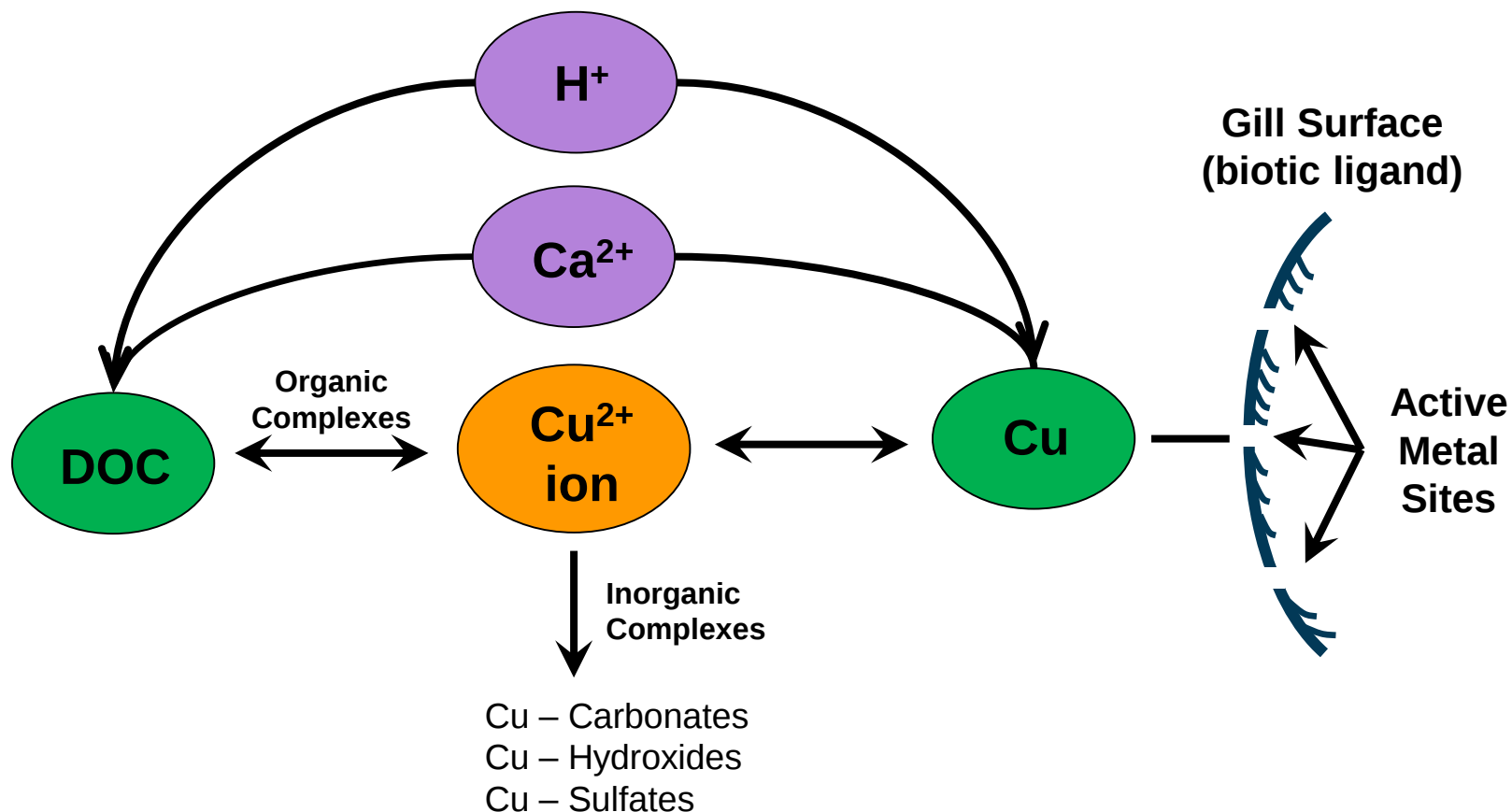


Water Effect Ratio

Advantages	Disadvantages
Procedure can be applied to any metal	Moderately expensive
Procedure can be applied to freshwater and salt water systems	Six month timeframe to complete testing
Rules allow for a NPDES permit approach (e.g., no rulemaking or EPA involvement)	Screening test should be conducted to assess feasibility
Popular method	
Generally produces a successful outcome	

Biotic Ligand Model (BLM)

- Developed to incorporate metal speciation and complexation with inorganics (e.g., hardness, sulfate), organics (dissolved organic carbon), and biotic ligands
- Metal toxicity is simulated as the accumulation of metal at a biologically sensitive receptor (biotic ligand)
 - Inorganics and organics also bind to metal, reducing accumulation at the biotic ligand
- EPA-approved model for copper
 - Lead, zinc, and cadmium included in model
 - Model only performs water quality calculation for copper
- BLM estimates quantity of metal accumulation at the biotic ligand receptor site to predict toxicity



Conceptual Diagram of Copper Speciation and Gill Model

From The Biotic Ligand Model: Technical Support Document for Its Application to the Evaluation of Water Quality Criteria for Copper, U.S. Environmental Protection Agency, Office of Science and Technology (2009).

Biotic Ligand Model

Advantages	Disadvantages
Results are implemented directly into the calculated criterion as a replacement for hardness	Time involved in collecting adequate water chemistry data (effluent and receiving stream)
Water chemistry data less expensive to collect (TDS ions, hardness, temperature, pH, humic acid content, dissolved carbon, sulfide, etc.)	Model developed only for copper (water quality calculation); three other metals not an automatic calculation
Generally produces a successful outcome	Not as widely used method

Translator Method

Published Criterion, Total
Recoverable

x [CCF or ACF]

Published Criterion,
Toxic Form (dissolved)Translator using
EPA coefficients &
TSSCondition-specific
criterion, total
recoverable

Translator Method

$$(\exp \{0.8545 \times [\ln (59) + (-1.702)]\}) = 5.9 \text{ ug/L}$$

x [0.96]

5.7 ug/L

$$1/(1 + \{ [K_{po}] [ss(1+a)] [10^{-6}] \}) = 0.369$$

$$(5.7 \text{ ug/L}) / 0.369 = 15.48 \text{ ug/L}$$

Dissolved WER Method

Published Criterion,
Total Recoverable

x [CCF or ACF]

Published Criterion,
Toxic Form (dissolved)x [WER_{dissolved}]
** geomean of measured WERs

Site-specific criterion, dissolved

site-specific translator

Site-specific criterion, total
recoverable

Dissolved WER Method

$$(\exp \{0.8545 \times [\ln (59) + (-1.702)]\}) = 5.9 \text{ ug/L}$$

x [0.96]

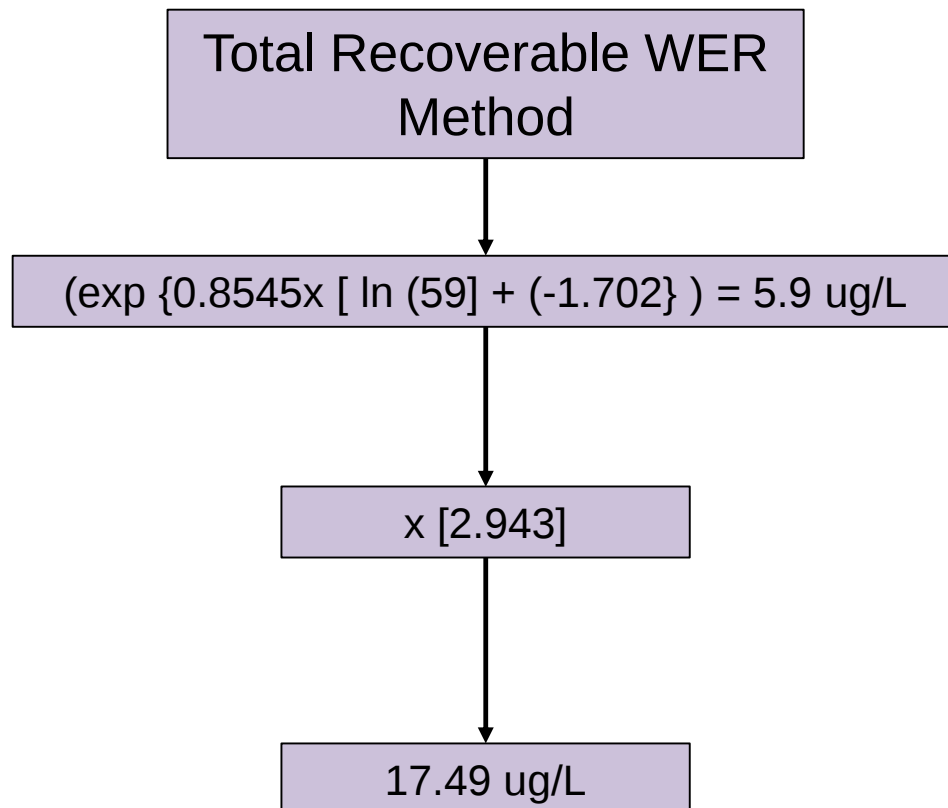
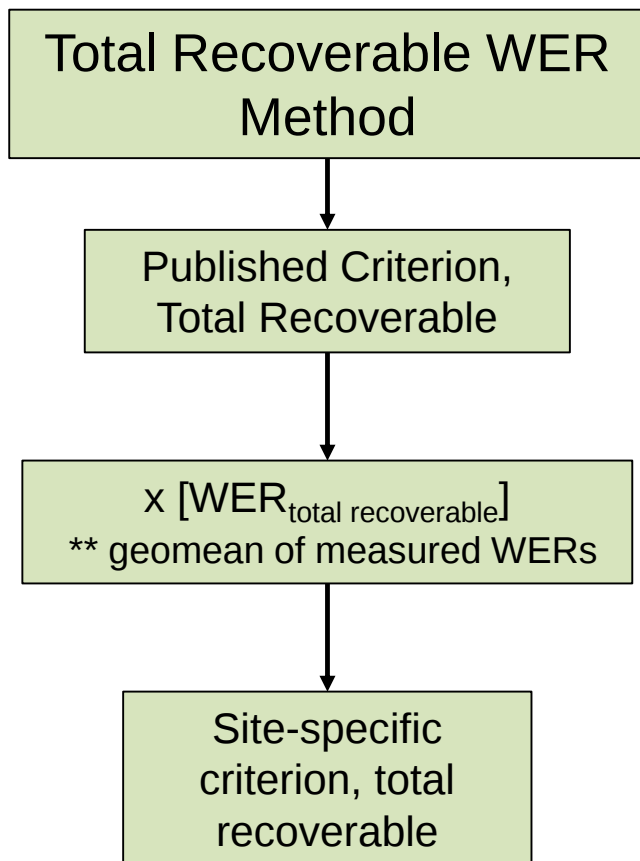
5.7 ug/L

x [2.786]

15.89 ug/L

0.778

$$(15.89 \text{ ug/L}) / 0.778 = 20.43 \text{ ug/L}$$



Wasteload Allocation and Reasonable Potential

- Allowable Discharge Concentration, daily maximum:

$$C_{WLA,acute} = [(1Q_{10} + Q_{WWTP}) \times C_{s,acute} - 1Q_{10} \times C_b] / Q_{WWTP}$$

- Allowable Discharge Concentration, monthly average:

$$C_{WLA,chronic} = [(7Q_{10} + Q_{WWTP}) \times C_{s,chronic} - 7Q_{10} \times C_b] / Q_{WWTP}$$

- Reasonable Potential:

- Calculate multiplying factor
- From effluent data, determine maximum concentration

- Calculate predicted maximum effluent concentration:

- $C_{max} \times \text{Multiplication Factor} = C_{W-predict}$

- If $C_{W-predict} > C_{WLA}$, then permit limit

- Effluent Hardness
 - Median of data set
- Receiving stream hardness
 - Median of data set
 - Monitoring requirement in NPDES permits
- Period of record for Reasonable Potential Analysis
 - Data set between 12 and 58 data points
 - Maximum recorded value of data set
 - 95% probability statistics with 95% confidence interval
 - Background metals concentration of 0 ppm

- If you conduct a site-specific study, you can use the linear partitioning translator in lieu of a site-specific translator
 - EPA allows this choice
 - DWR was considering watershed specific translators (!!!!), but this is a long way out in the future
- DWR will allow an effluent TSS of 10 mg/L to be used in linear partitioning translator
 - Statewide median

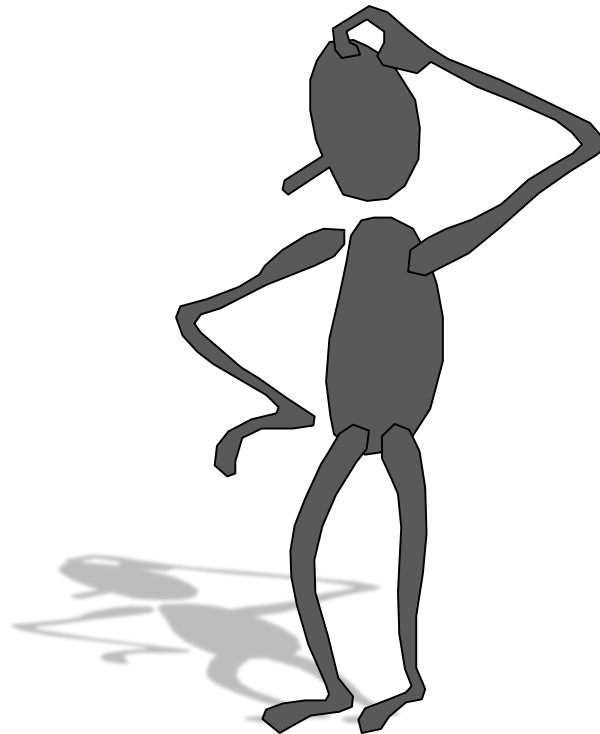
- If a pollutant is non-detect in effluent, but there is reasonable potential
 - Monitoring requirement in permit
 - Many dissolved criteria are $<$ than analytical detection
- Silver is a particular issue:
 - EPA has not adopted chronic criteria for silver
 - DWR adopted a chronic silver criteria based on one study in one NC watershed
- Another DWR policy:
 - No reasonable potential, but if a pollutant's maximum predicted effluent concentration $>$ 50% of condition-specific criteria, monitoring requirement even if LTMP

- Implications for pretreatment programs
- More stringent condition-specific water quality criteria = more stringent maximum allowable headworks load (MAHL)
 - Using example for 5 mgd WWTP, no dilution, 90% WWTP removal:
 - MAHL of 1.6 lb/d without WER and 14.9 lb/d with WER
 - May result in restrictions on industry
- Use condition-specific criterion for each metal in MAHL calculation
 - Check that the correct condition-specific standards are being applied to the pass-through loading calculations

[illegible]

Hazen

Questions?



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