Part 5 – Calculations

Objective

- Apply what we have learned to practice calculating local limits.
- We will calculate a local limit for a nonconservative pollutant (BOD) and a conservative pollutant (copper).



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Key Equations

$$Flow\,\frac{MG}{D} * 8.34\,\frac{lbs}{gal} * Concentration\,\frac{mg}{l} = Loading\,\frac{lbs}{day}$$

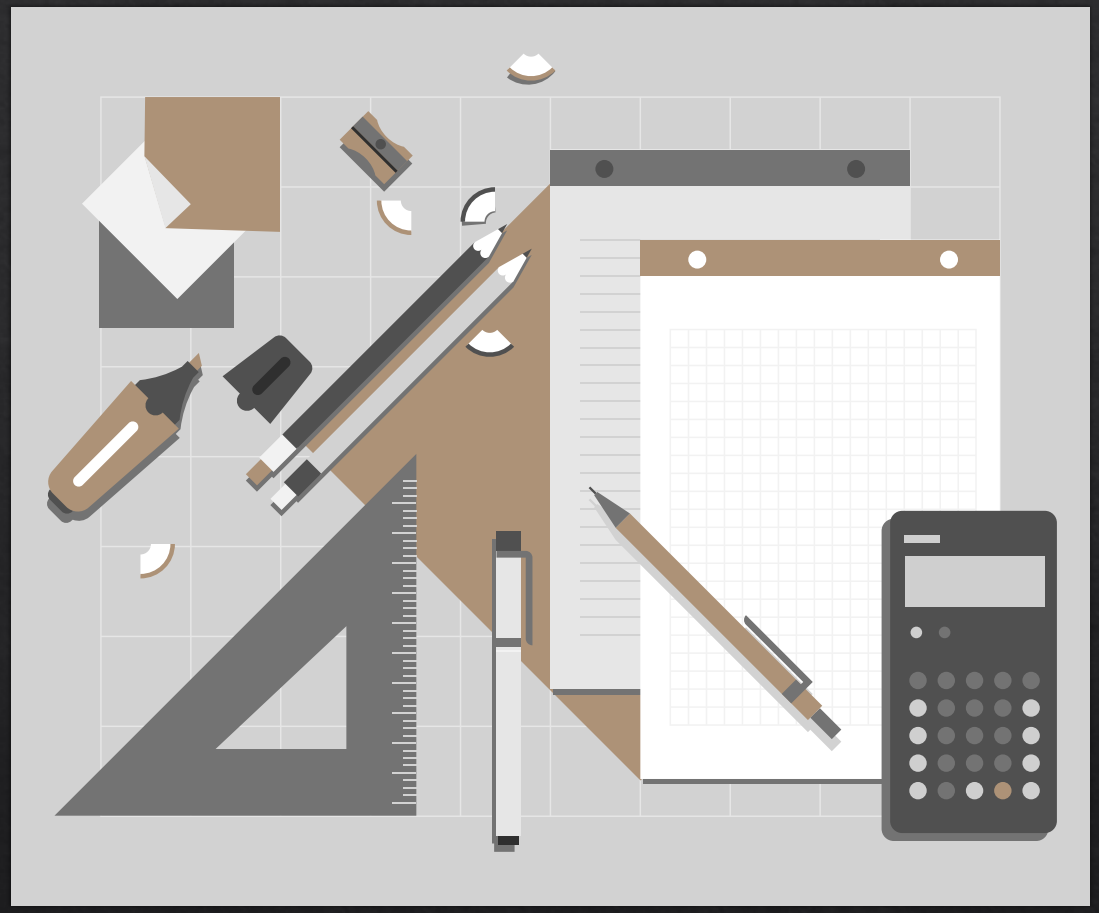
$$\frac{Limit_E\,\frac{lbs}{day}}{1 - R_{POTW}} = AHL_{Not\ SLudge}$$



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Significant Figures

- Significant figures can influence calculations.
- Excel backbone produces more exact numbers than are shown on slides.
- In today's intermediate steps, we will be less concerned with them.

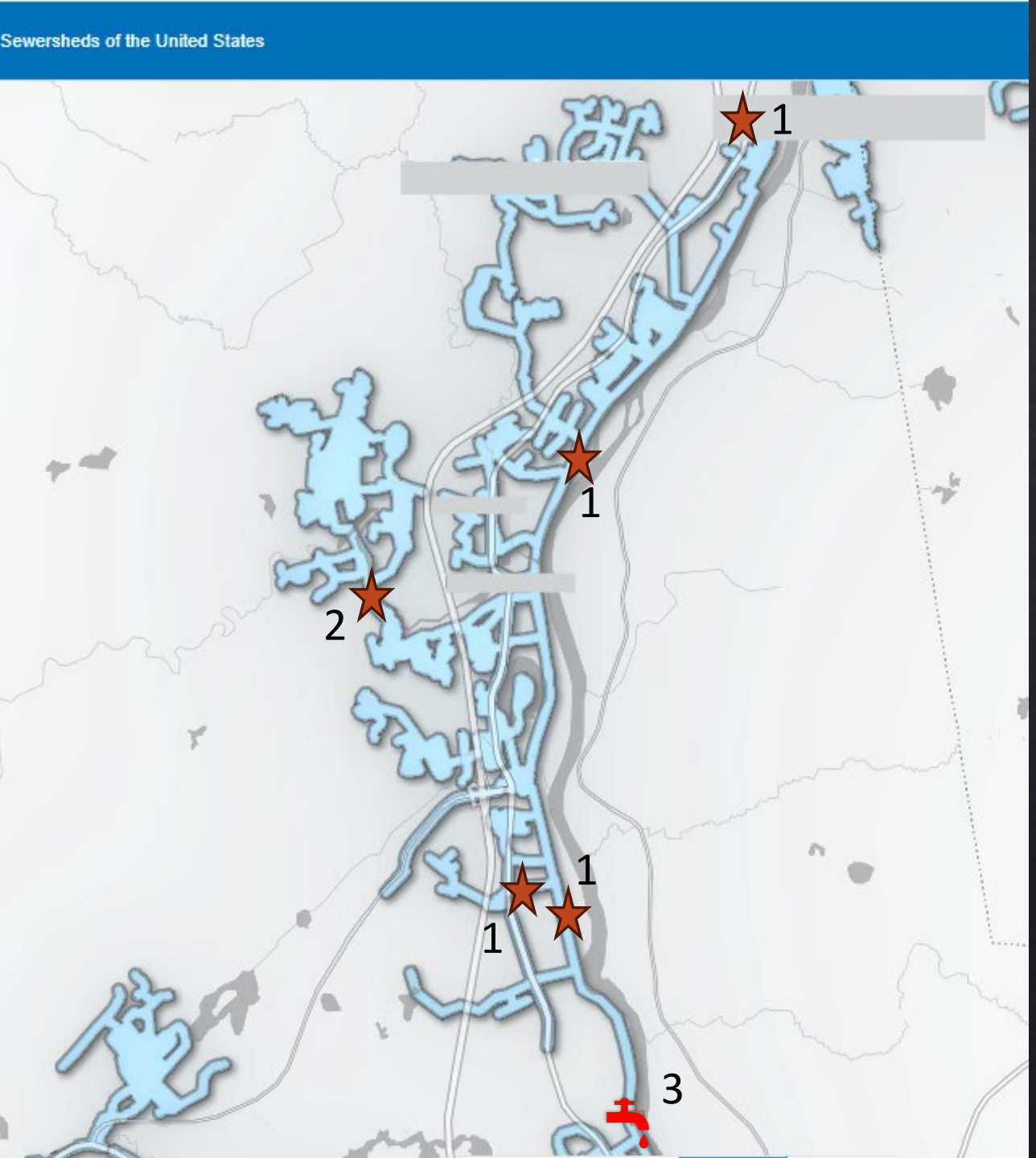


Example 1 - BOD

Sampling Locations

- IUs
- Domestic Only
- Influent
- Effluent
- ~~Primary Effluent~~
- ~~Ambient (surface water discharge)~~
- Hauled Waste
  - Septage ~~and IU~~
- ~~Sludge~~
  - ~~Activated sludge?~~
  - ~~Lagoon?~~

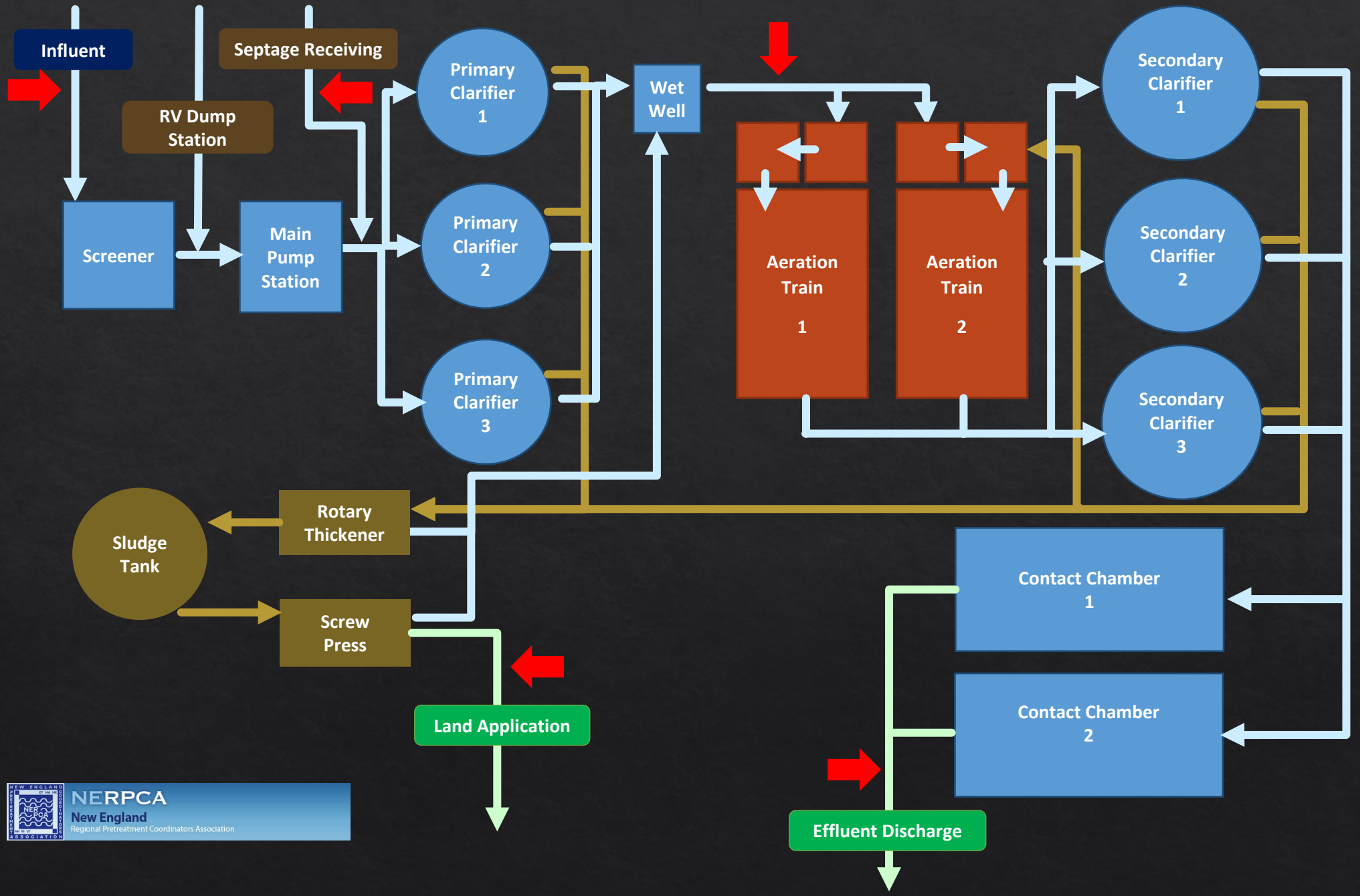
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Sewershed

1. Specific industries.
2. Domestic only.
3. Discharge to a surface water.

Map courtesy of EPA https://www.epa.gov/cwns/sewersheds?tab=map with additions made.



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Influent Loading

- Septage comes in after influent sample location.
  - Will have its own line item in final calculation.
- Don’t have RV data so add flow to influent and assume the same properties.



- Influent location includes IUs and domestic so do not add their contribution in separately at this step.
  - We use that data later.

Facility and POC Information

- Looking at BOD specifically.
  - Not conservative – transforms through treatment.
- Average POTW effluent flow is 2.2 MGD, permitted for 5.0 MGD.
  - NPDES requires monthly ≥85% removal of BOD.
- One IU with significant BOD loading.
  - Permitted monthly average 4,500 lbs/day and 1 MGD.
  - Actual monthly average 3,000 lbs/day and .6 MGD.

Removal Efficiency – MRE

BOD and its removal are required to be monitored in the NPDES permit.

$$R_{POTW} = \frac{\bar{I} - \bar{E}}{\bar{I}}$$

$$\frac{259\frac{mg}{l} - 6\frac{mg}{l}}{259\frac{mg}{l}} * 100\% = 97.7\%$$

Not 0.977%!

AHLs

- NPDES limits (may need to convert from concentration).
- WQS.
- Sludge disposal considerations.
- Inhibition (activated sludge, nitrification).
- Design Criteria – conventional pollutants.

Questions?



NPDES AHL

- Monthly average limit as well as removal efficiency limit.
  - NPDES average monthly effluent BOD limit of 1,200 lbs/day.
  - Removal efficiency is 97.7% which is > 85%.

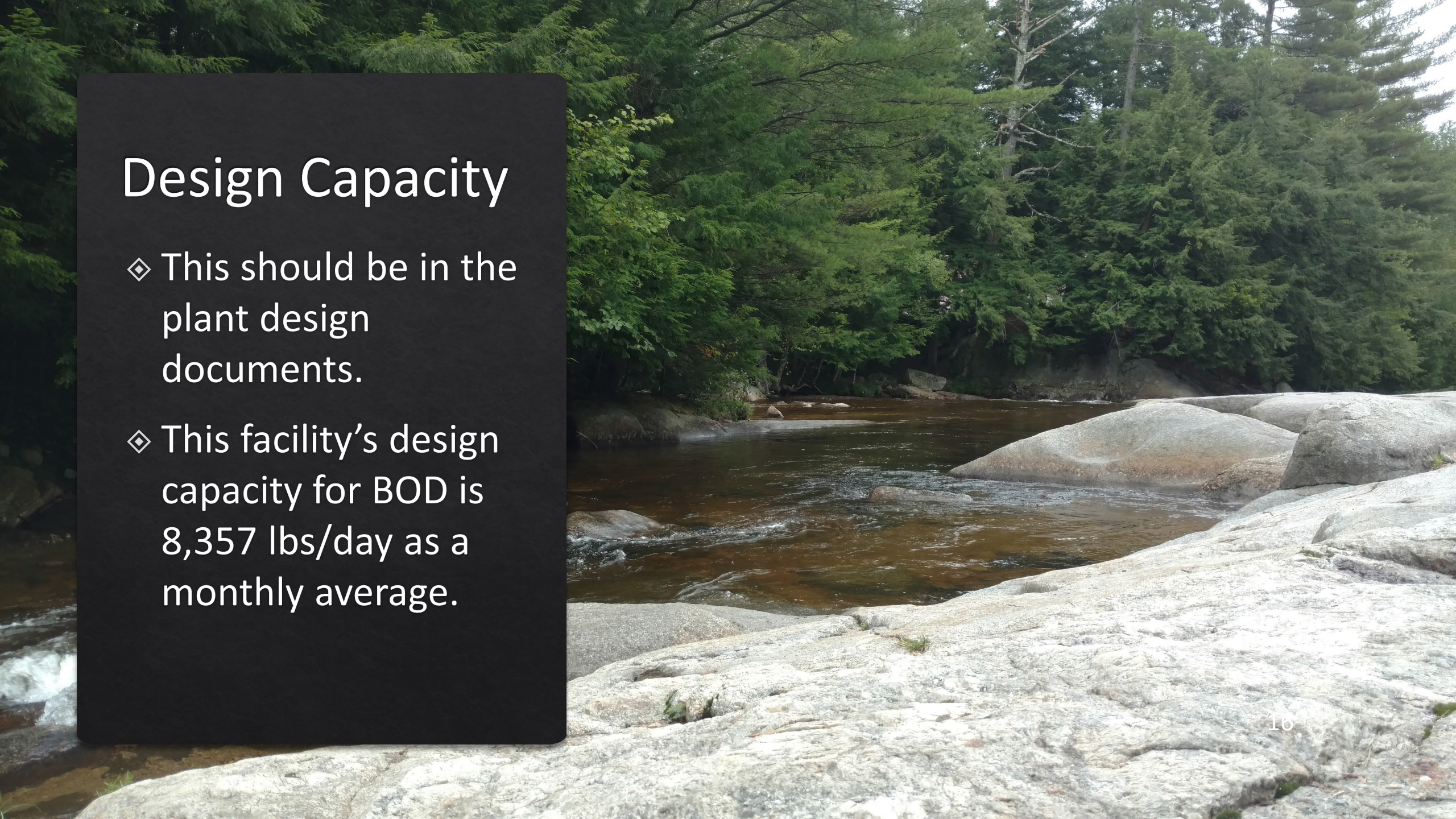
$$AHL_{NPDES} = \frac{E_{NPDES\ Loading}\ \frac{lbs}{day}}{1 - R_{POTW}} = \frac{1{,}200\ \frac{lbs}{day}}{1 - 0.977} = \mathbf{52{,}173\ \frac{lbs}{day}}$$

- At 86% removal, it would be 8,571 lbs/day.

AHL Tracking

AHLs (lbs/day)				
NPDES	Design	WQS	Sludge	Inhibition
52,173	?	?	?	?

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Design Capacity

- This should be in the plant design documents.
- This facility's design capacity for BOD is 8,357 lbs/day as a monthly average.

AHL Tracking

AHLs (lbs/day)				
NPDES	Design	WQS	Sludge	Inhibition
52,173	8,357	?	?	?

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WQS AHL

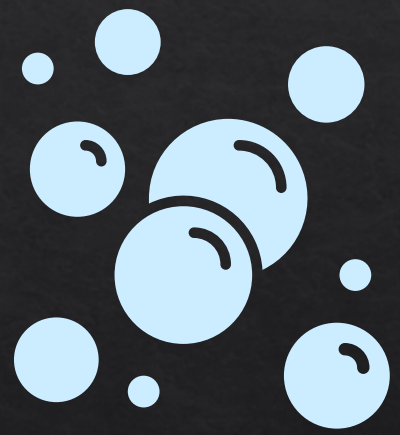
- The permit already accounts for the 30 mg/l monthly average effluent BOD.
- Doing this exercise would be redundant even if it gives a more stringent value.
- Remember, NPDES limits are based on design flow and LLs are based on average flow.



Sludge AHL

- No sludge disposal limits.

Inhibition AHL



- Lack of any data to show inhibition of activated sludge or nitrification.
- No literature inhibition values.
- Assume design capacity takes this into consideration.

MAHL

AHLs (lbs/day)				
NPDES	Design	WQS	Sludge	Inhibition
52,173	8,357	N/A	N/A	N/A

- Select the most stringent.
- The “H” is for headworks.
  - We looked at effluent to calculate allowable influent for NPDES.

Done

- We did it!
- It’s over!
- Now we can go home!



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Psych!



MAHL -> LL?

- Does the monthly average exceed 80% of design capacity in the last 12 months?
- Monthly average influent BOD loading ranged from 3,512 lbs/day to 6,362 lbs/day.

$$\frac{6{,}362\,\frac{lbs}{day}}{8{,}357\,\frac{lbs}{day}} = 76\%$$

Surcharging

- Knowing that higher organic loading means more treatment, surcharging can be used.
- Even though 80% was not hit, can still consider pursuing a limit.
- Typically see LL or surcharge.
  - No LL required because of max average monthly being <80% of MAHL.
  - 80% is a recommendation, protecting the plant is paramount.
  - The SUO will need to be updated to reflect the decision either way.



Questions?



Pursue LL

- As there is an SIU with considerable BOD loading, an LL will be pursued. 
- This also helps us work through the MAIL process and final steps.

MAIL

$$MAHL * (1 - SF) - (domestic + septage + GF) = MAIL$$

- MAHL = 8,357 lbs/day.
- Safety Factor (SF) - EPA recommends a minimum of 10%.
- Growth Factor (GF) – Hear of a dairy looking to go in so 500 lbs/day.



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Domestic

- RV waste is low volume and will be lumped in with domestic.
- Average flow is 2.2 MGD and total IU actual flow is .75 MGD.

Average Effluent – IU – Septage = Domestic Flow

$$2.2\ \frac{MG}{D} - \ 0.75\ \frac{MG}{D} - 0.012\ \frac{MG}{D} = 1.44\frac{MG}{D}$$



Influent Domestic Load

$$Flow\,\frac{MG}{D} * 8.34\,\frac{lbs}{gal} * Conc.\,\frac{mg}{l} = Loading\,\frac{lbs}{day}$$

$$1.44\,\frac{MG}{D} * 8.34\,\frac{lbs}{gal} * 250\,\frac{mg}{l} = 2{,}998\,\frac{lbs}{day}$$



Septage

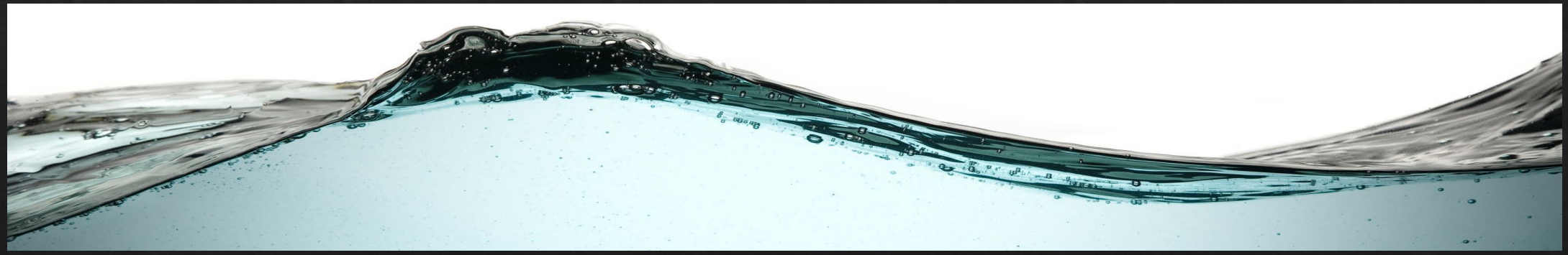
Septage flow is 0.012 MGD with an average BOD of 2,000 mg/L and density of 8.5 lbs/gal.

$$0.012\ \frac{MG}{D} * 8.5\ \frac{lbs}{gal} * 2{,}000\ \frac{mg}{l} = 204\ \frac{lbs}{day}$$

MAIL

$$MAHL * (1 - SF) - (domestic + septage + GF) = MAIL$$

$$8{,}357\,\frac{lbs}{day} * (1 - .1) - \left(2{,}998\,\frac{lbs}{day} + 204\,\frac{lbs}{day} + 500\,\frac{lbs}{day}\right) = 3{,}819\,\frac{lbs}{day}$$



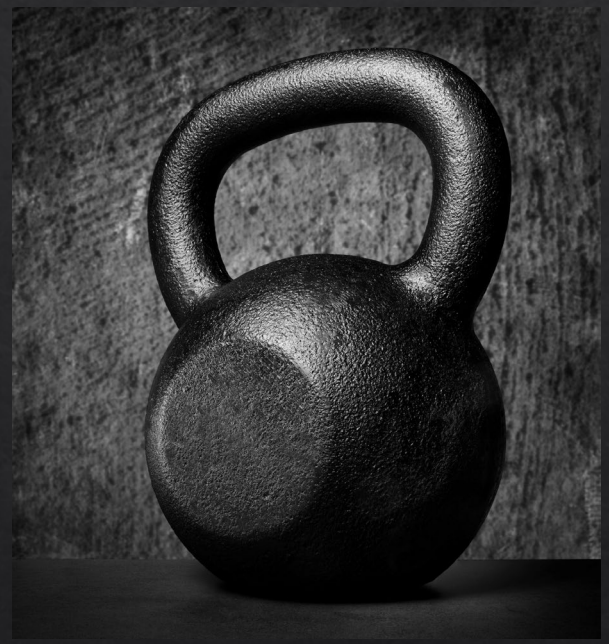
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Load

- Allocate a total of 3,819 lbs/day as the MAIL.
- One IU needs most of the load, their average need is:

$$0.6\ \frac{MG}{D} * 8.34 \frac{lbs}{gal} * 500 \frac{mg}{l} = 2{,}502 \frac{lbs}{day}$$

- Allocate 3,750 lbs/day as a monthly average limit to the one industry and have 69 lbs/day for other existing IUs.



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Uniform Concentration

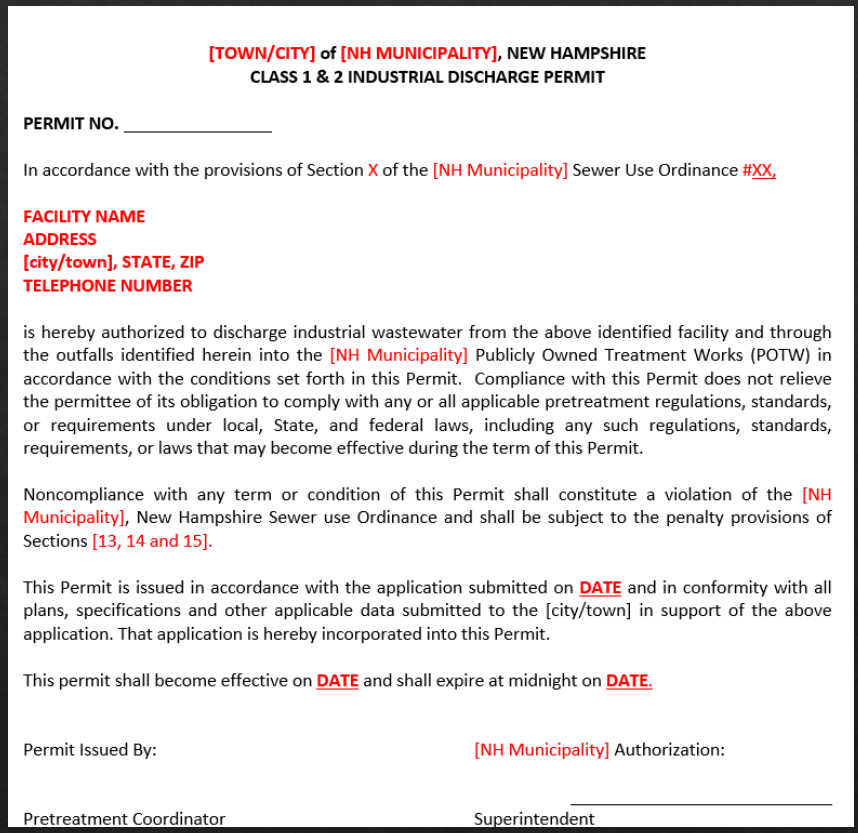
- Uniform concentration would look like:

$$\frac{3{,}819\,\frac{lbs}{day}}{0.75\,\frac{MG}{D} * 8.34\,\frac{lbs}{gal}} = 611\,\frac{mg}{l}$$

- The IU of concern can meet this but does this protect the POTW?
- Will the one IU try to fight this for more allocation?

Final Steps

- Let's choose allotment, that means the SUO needs to have the MAIL as a LL.
- SUO gets public noticed with the local limit and adopted.
- IDPs will need to be updated.
- Internal documentation on allotments is created.



[TOWN/CITY] of [NH MUNICIPALITY], NEW HAMPSHIRE
CLASS 1 & 2 INDUSTRIAL DISCHARGE PERMIT

PERMIT NO. _____

In accordance with the provisions of Section X of the [NH Municipality] Sewer Use Ordinance #XX,

FACILITY NAME
ADDRESS
[city/town], STATE, ZIP
TELEPHONE NUMBER

is hereby authorized to discharge industrial wastewater from the above identified facility and through the outfalls identified herein into the [NH Municipality] Publicly Owned Treatment Works (POTW) in accordance with the conditions set forth in this Permit. Compliance with this Permit does not relieve the permittee of its obligation to comply with any or all applicable pretreatment regulations, standards, or requirements under local, State, and federal laws, including any such regulations, standards, requirements, or laws that may become effective during the term of this Permit.

Noncompliance with any term or condition of this Permit shall constitute a violation of the [NH Municipality], New Hampshire Sewer use Ordinance and shall be subject to the penalty provisions of Sections [13, 14 and 15].

This Permit is issued in accordance with the application submitted on **DATE** and in conformity with all plans, specifications and other applicable data submitted to the [city/town] in support of the above application. That application is hereby incorporated into this Permit.

This permit shall become effective on **DATE** and shall expire at midnight on **DATE.**

Permit Issued By: [NH Municipality] Authorization:

Pretreatment Coordinator Superintendent

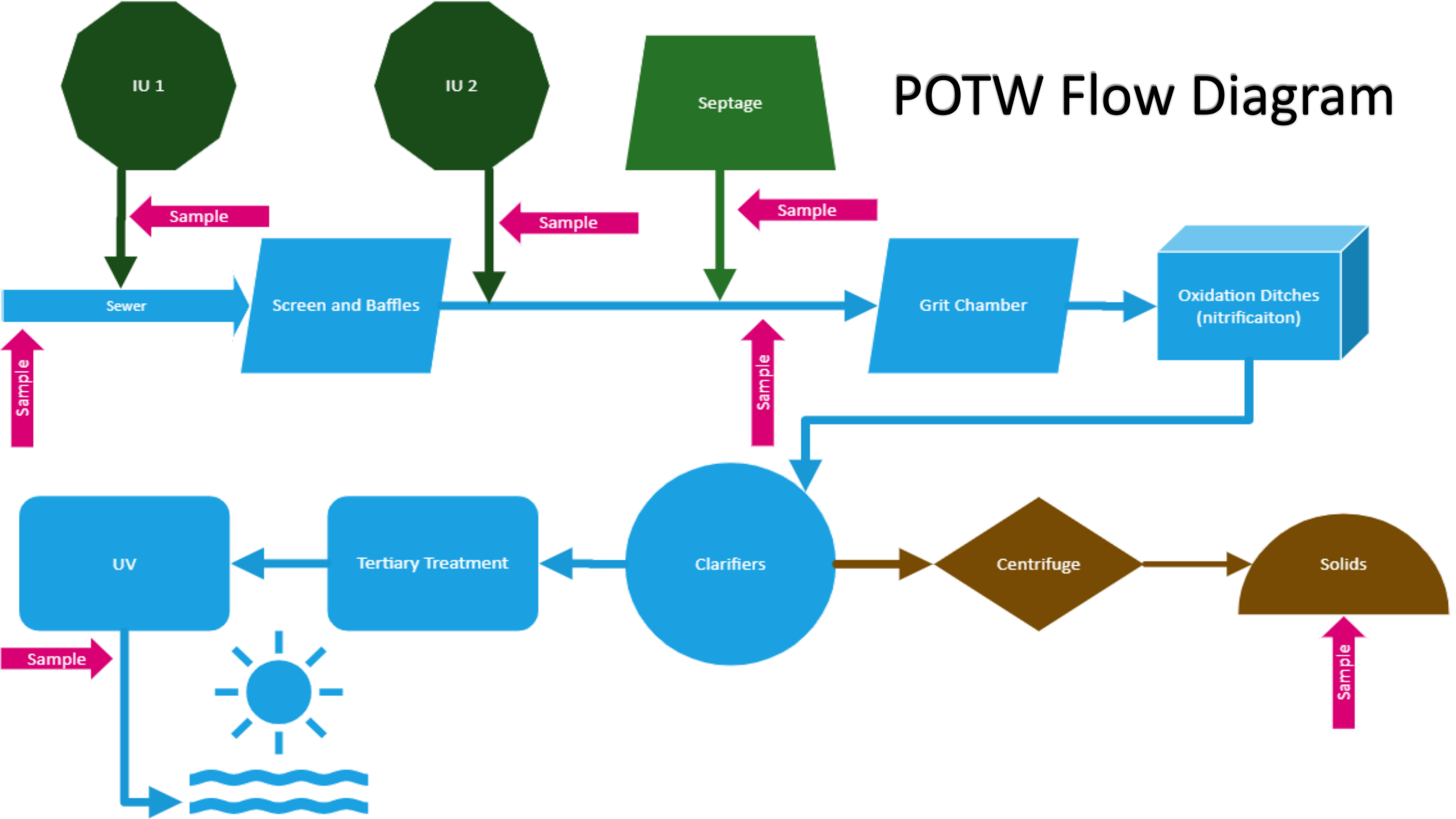
Questions?



Example 2 - Copper

New POTW

POTW Flow Diagram



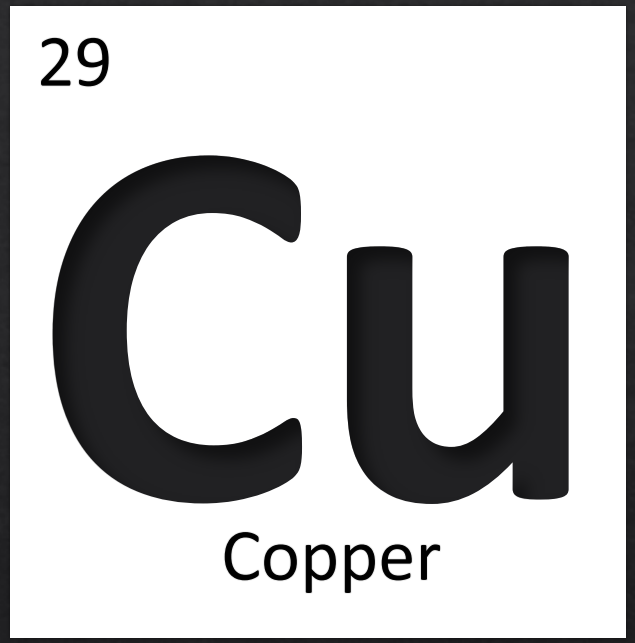
Data Checklist



- Have copper concentration and flow for:
  - Influent
  - Effluent
  - Sludge
  - IU Effluent
  - Septage
  - Domestic Only
- Also have:
  - Treatment plant schematic.
  - Sludge disposal limitations.
- Missing info can be calculated, or we can use literature values.

Facility and POC Information

- Looking at Copper specifically.
  - Conservative – would expect to see full mass balance.
- Average POTW effluent flow is 0.54 MGD, permitted for 1.25 MGD.
- SIU with 0.06 MGD average flow but does not work with copper.



Removal – MRE

$$\frac{0.089\,\frac{mg}{l} - 0.00211\,\frac{mg}{l}}{0.089\,\frac{mg}{l}} = \mathbf{97.6\%}$$

Avg. Influent

Avg. Effluent

The answer above is rounded.



Photograph courtesy of the Winnipesaukee River Basin Program

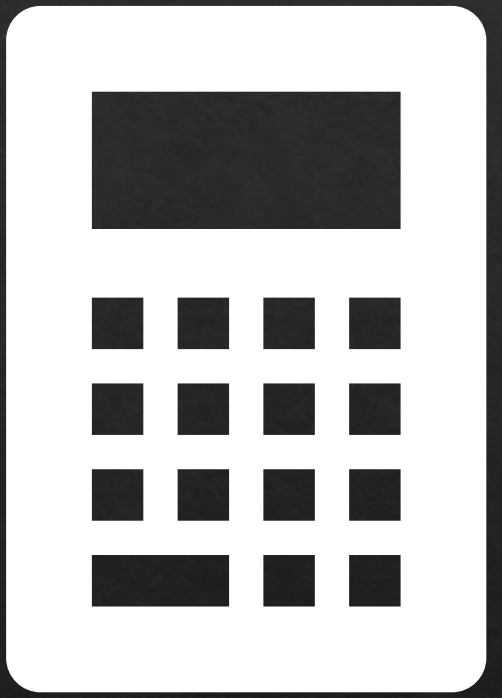
Questions?



Copper NPDES Limits AHL

- Monthly average effluent limit is 4.5 µg/L.
- No mass-based limit.
- Need to use actual average and not design flow.

Not 4.5 mg/l!



$$\frac{0.54\frac{MG}{D} * 8.34\frac{lbs}{gal} * 0.0045\frac{mg}{l}}{1 - .976} = \mathbf{0.853\frac{lbs}{day}}$$

Flow

Effluent Limit

R_{POTW}

Copper NPDES Limit

- Using literature removal rate:

$$\frac{0.54\,\frac{MG}{D} * 8.34\,\frac{lbs}{gal} * 0.0045\,\frac{mg}{l}}{1 - .86} = \mathbf{0.14\,\frac{lbs}{day}}$$

Flow

Effluent Limit

$R_{POTW(Lit)}$

6x

- This is roughly a six times more stringent AHL.

WQS and Design AHL

- WQS AHL not typically calculated if there is a NPDES limit.
- No design limit.



Results

AHLs (lbs/day)				
NPDES	Design	WQS	Sludge	Inhibition
0.85	N/A	N/A	?	?

Sludge AHL

Already have sludge flow in tons/year.

Equation 5.9: AHLs Based on Sludge Land Application and Surface Disposal Criteria (for conservative pollutants)

$$AHL_{sldg} = \frac{(8.34)(C_{slgstd})(PS/100)(Q_{sldg})(G_{sldg})}{R_{potw}}$$

Where:

AHL_{sldg}	=	AHL based on sludge, lb/day
C_{slgstd}	=	Sludge standard, mg/kg dry sludge
PS	=	Percent solids of sludge to disposal,
Q_{sldg}	=	Total sludge flow rate to disposal, ~~MGD~~
R_{potw}	=	Plant removal efficiency from headworks to plant effluent, as decimal
G_{sldg}	=	Specific gravity of sludge, kg/L
8.34	=	Unit conversion factor

tons/day

US EPA (2004, July). Local Limits Development Guidance. https://www.epa.gov/sites/default/files/2015-10/documents/final_local_limits_guidance.pdf

Sludge AHL

$$\frac{\frac{lbs}{day} * C_{Limit}}{R_{POTW}} = \boldsymbol{AHL_{Sludge}}$$

No "1-R"!

$$\frac{121\frac{dt}{yr} * \frac{1yr}{365day} * 2{,}000\frac{lbs}{dt} * 4{,}300\frac{mgCu}{kg} * \frac{kg}{10^6 mg}}{.976} = \boldsymbol{2.92\frac{lbs}{day}}$$

Dry Tons per Year

Cu. Conc. Limit

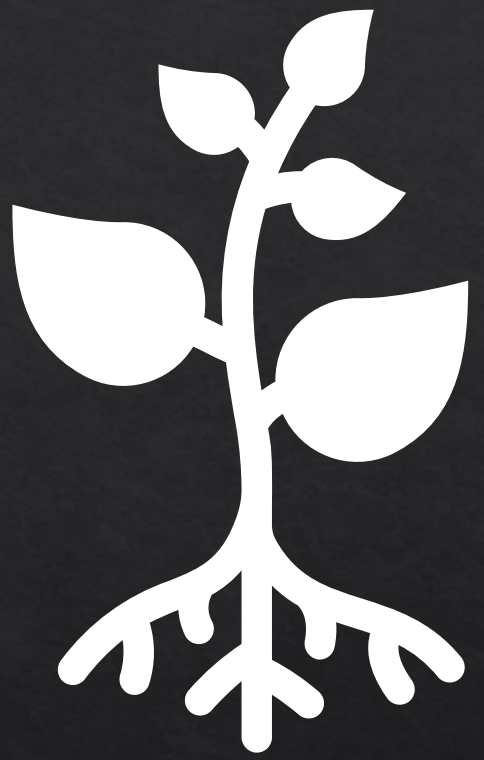
R_{POTW}

Results

AHLs (lbs/day)				
NPDES	Design	WQS	Sludge	Inhibition
0.85	N/A	N/A	2.92	?

Inhibition – Activated Sludge

- Activated sludge inhibition literature value is 1 mg/l.
- Literature primary effluent removal of copper is 22%.
  - No primary clarifiers.



$$\frac{8.34\frac{lbs}{gal} * 0.54\frac{MG}{D} * 1\frac{mg}{l}}{1-0} = \mathbf{4.50}\frac{\boldsymbol{lbs}}{\boldsymbol{day}}$$

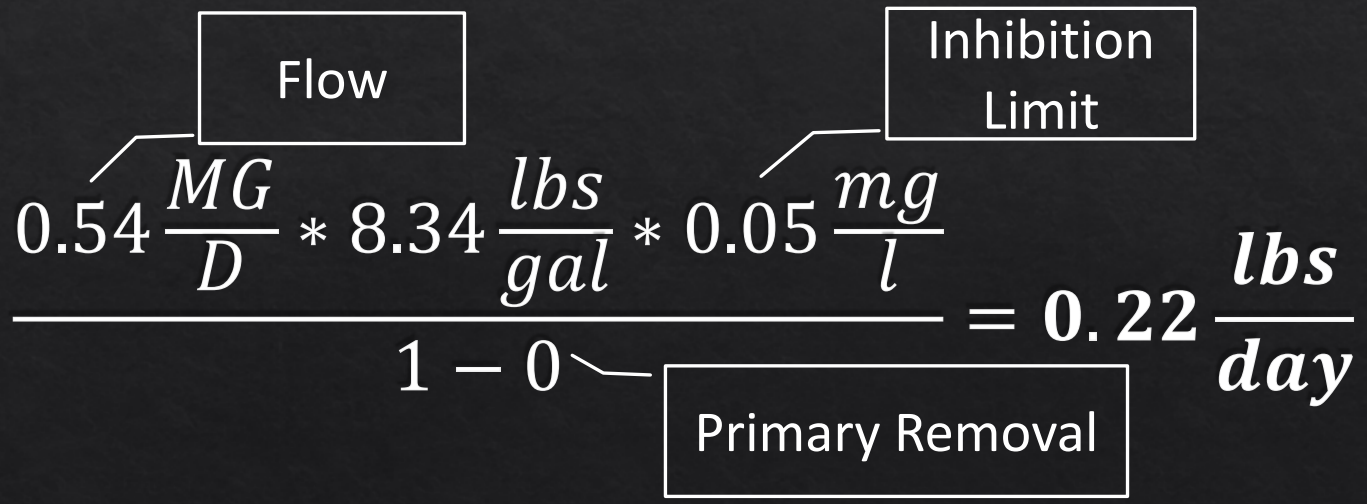
Flow

Inhibition Limit

Primary Removal

Inhibition – Nitrification

- Nitrification inhibition literature value ranges from 0.05 mg/l to 0.48 mg/l.
- No primary clarifiers before nitrification.



Inhibition – Nitrification

- 0.22 lbs/day is very limiting.
- Know the plant has received 0.43 mg/l at 0.36 MGD and no observed issues with nitrification, use this as a ceiling/limit.

Flow

Ceiling

$$0.36MGD * 8.34\frac{lbs}{gal} * 0.43\frac{mg}{l} = \mathbf{1.29}\frac{\boldsymbol{lbs}}{\boldsymbol{day}}$$



- Still low but will not end up being the MAHL.
- No credit for primary removal.

Inhibition

If inhibition is the most restrictive, can consider making it a screening level if it is not a site-specific value.



Results

NPDES is the limiting AHL making it the MAHL.

AHLs (lbs/day)				
NPDES	Design	WQS	Sludge	Inhibition
0.85	N/A	N/A	2.92	1.29

MAHL

Questions?



Domestic Loading

Average Flow | Industrial Flow | Septage | Unregulated Flow (domestic + commercial)

$$0.54\frac{MG}{D} - 0.066\frac{MG}{D} - 0.004\frac{MG}{D} = 0.470\frac{MG}{D}$$

Domestic only result shows 18.5 µg/l for copper.

Unregulated Flow | Domestic Conc.

$$0.47\frac{MG}{D} * 8.34\frac{lbs}{gal} * 0.0185\frac{mg}{l} = 0.073\frac{lbs}{day}$$

Hauled Waste

3,809 gal/day at 9.6 mg/l of copper.

Septage Received

Septage

$$0.003809 \frac{MG}{D} * 8.34 \frac{lbs}{gal} * 9.6 \frac{mg}{l} = \mathbf{0.30} \frac{\boldsymbol{lbs}}{\boldsymbol{day}}$$

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MAIL

MAHL: $0.85\,\frac{lbs}{day}$

Safety Factor: $(1 - .15)$

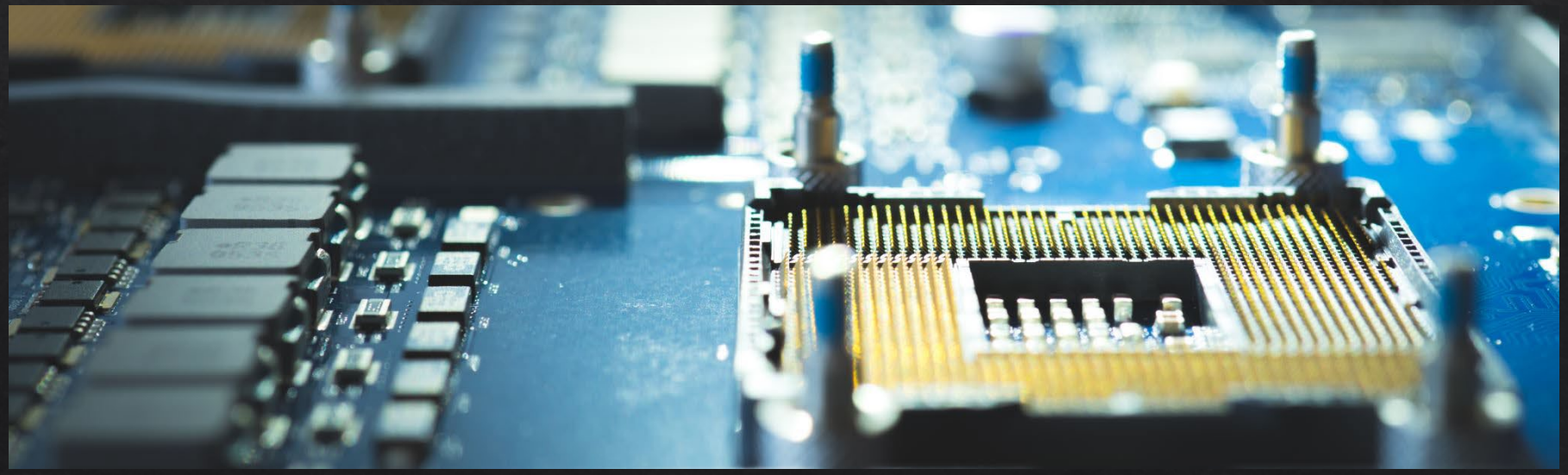
Domestic: $0.07\,\frac{lbs}{day}$

Septage: $0.30\,\frac{lbs}{day}$

Growth: $0.1\,\frac{lbs}{day}$

MAIL/Local Limit: $\mathbf{0.25\,\frac{lbs}{day}}$

$$0.85\,\frac{lbs}{day} * (1 - .15) - \left(0.07\,\frac{lbs}{day} + 0.30\,\frac{lbs}{day} + 0.1\,\frac{lbs}{day}\right) = \mathbf{0.25\,\frac{lbs}{day}}$$



Negative MAIL

What if we used the literature nitrification inhibition AHL of 0.22 lbs/day?

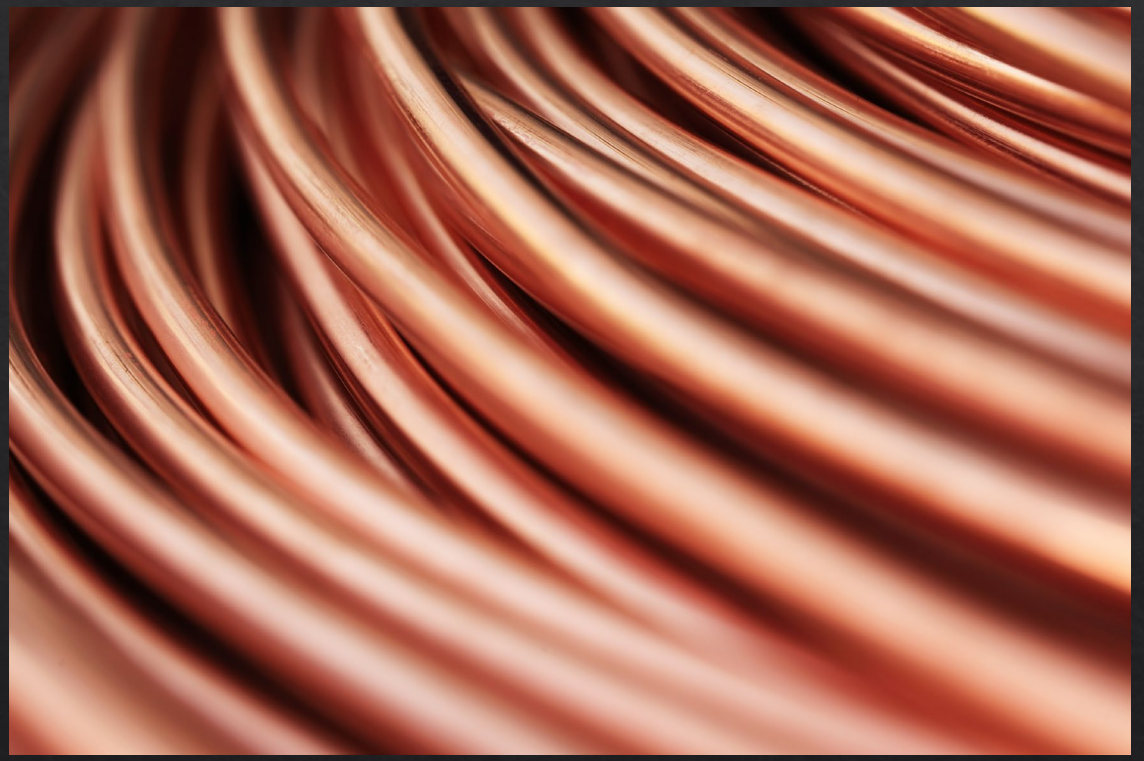
MAHL | Safety Factor | Domestic | Septage | Growth | MAIL

$$0.22\frac{lbs}{day}(1-.15)-\left(0.07\frac{lbs}{day}+0.3\frac{lbs}{day}+0.1\frac{lbs}{day}\right)=\mathbf{-0.28\frac{lbs}{day}}$$



Potential Steps

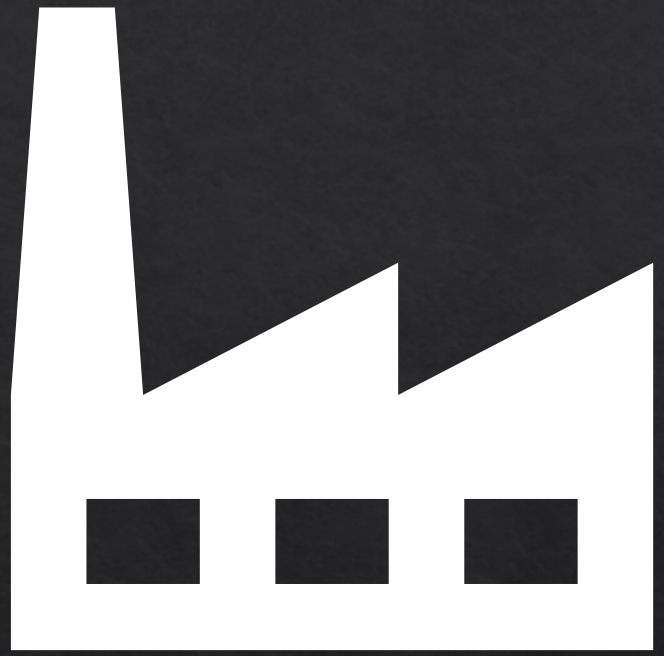
- Limit septage.
- Make IUs treat to domestic.
  - LL may get challenged in court.
  - They could also treat their drinking water if no copper is added.
- Undertake a study on nitrification inhibition.



IU Loading

IUs have dissimilar needs.

	Avg. Flow	**Conc.**	**Load**
	MGD	mg/l	lbs/day
IU 1	0.005	0.20	0.008
IU 2	0.061	0.06	0.029
		Total	**0.037**



IU Allocations

- Load available to industry is 0.25 lbs/day.
- No need to change allocations as 0.24 < 0.25 lbs/day.

	Avg. Flow	**Actual Load**	**Current Limit**
	MGD	lbs/day	lbs/day
IU 1	0.005	0.008	0.068
IU 2	0.061	0.029	0.167
	Total	**0.037**	**0.235**



SUO and IDPs

- Municipality decides current LL is protective and declines to update SUO and permits.
- Municipality assigns 0.01 lbs/day to GF or separate reserve.
- Changes in a LL may require federal/state approval and public notice.



No Allotment

- Consider making a “none added” prohibition in the SUO.
- Difficult for copper as it is in piping.
- Go back and look at assumptions.
- How low is low enough, could a limit of not higher than influent water be appropriate?
- If a limit of zero is selected, add a foot note for a detection limit and/or method.

Questions?

- Scan the code to the right to fill out the survey.
- Any remaining questions or scenarios?

