Using State Point Analysis and Settling Flux Theory to Design and Operate Mine Water Treatment Clarifiers

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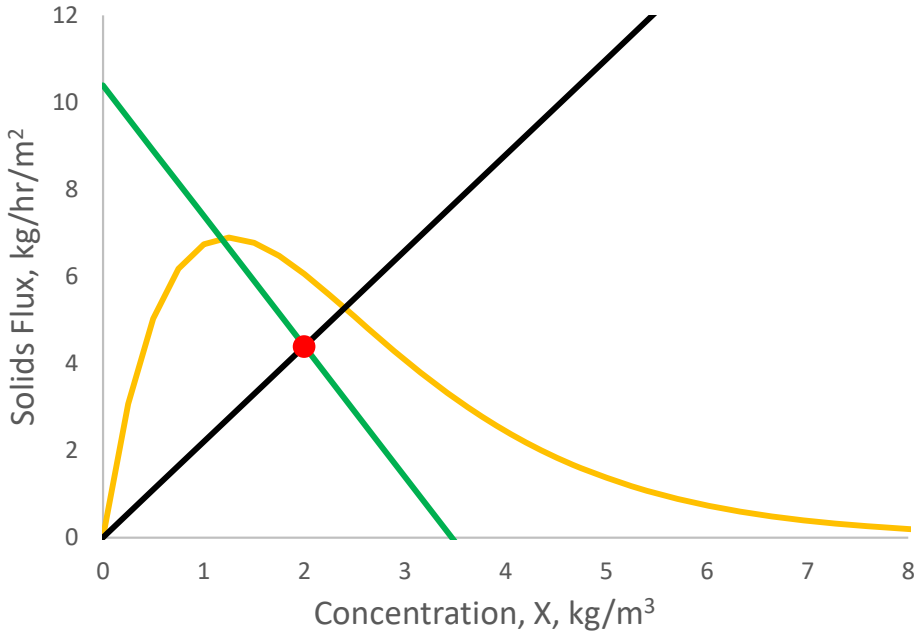
Topics

Explain State Point Analysis

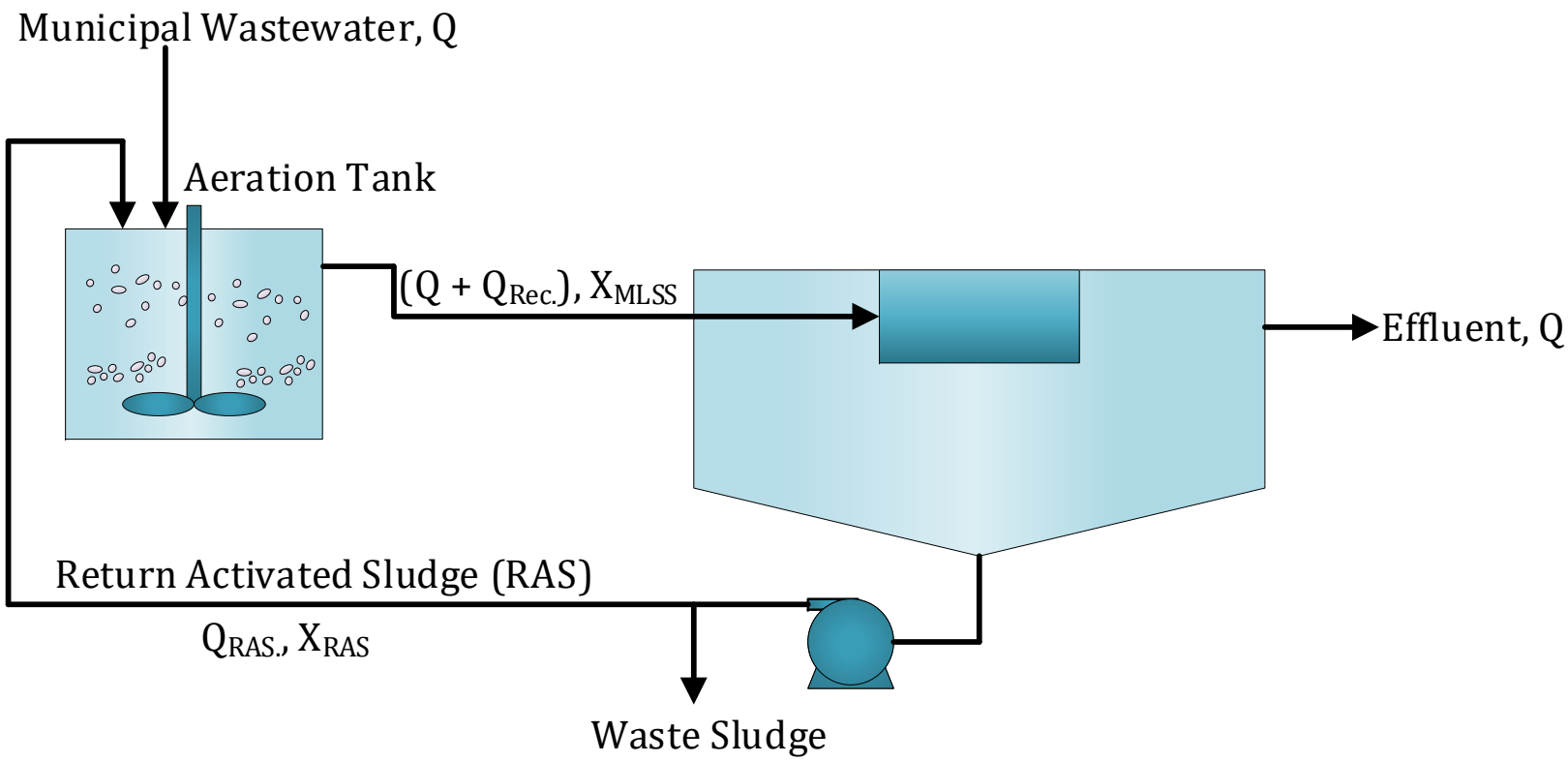
Show application for sizing an aluminum removal treatment process

Use state point to explain operating challenges of an operating iron precipitation process

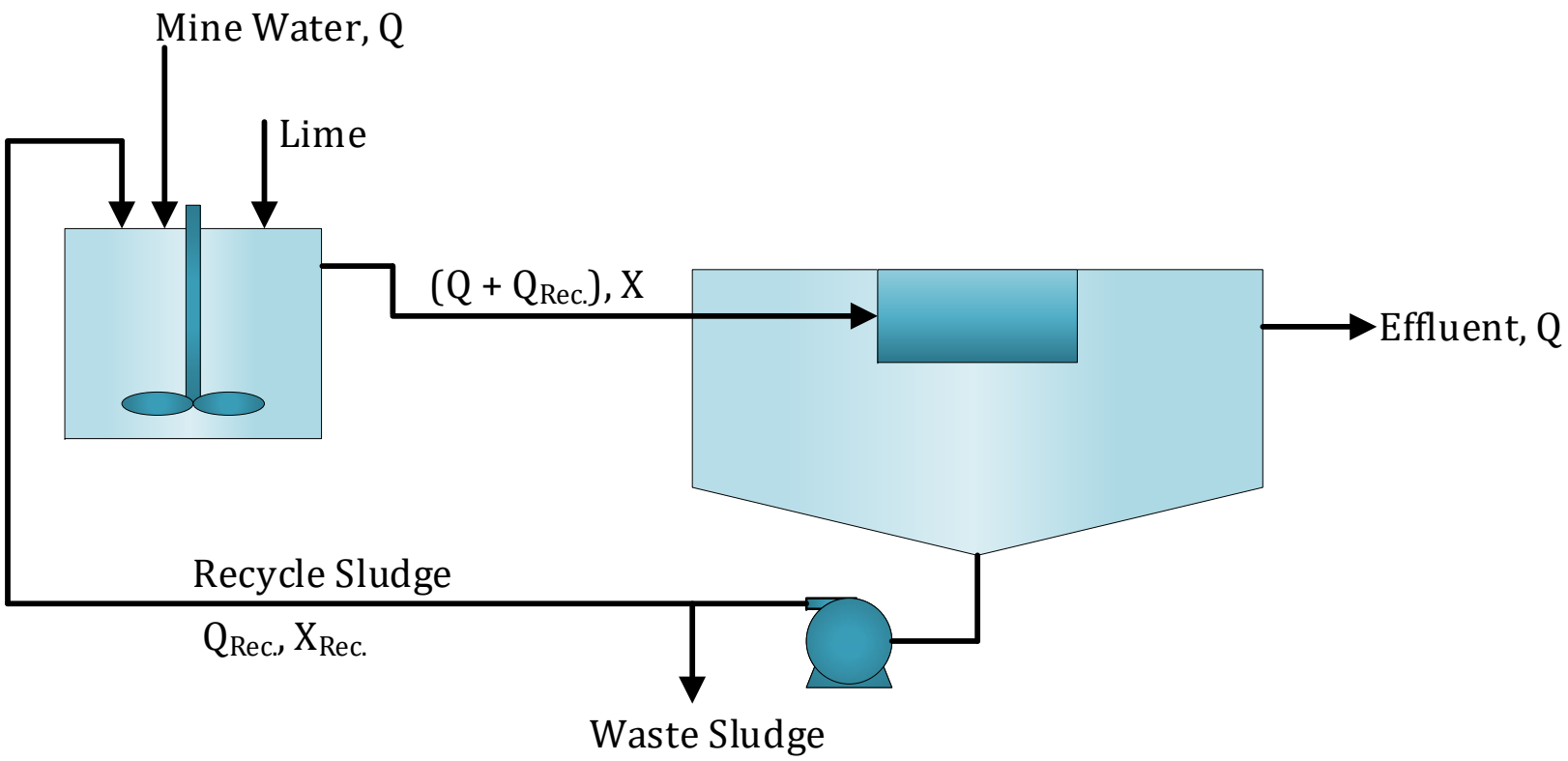
Conclusions – Lessons learned



Municipal Activated Sludge Process



Mine Water Treatment



State Point Development

Solids Flux

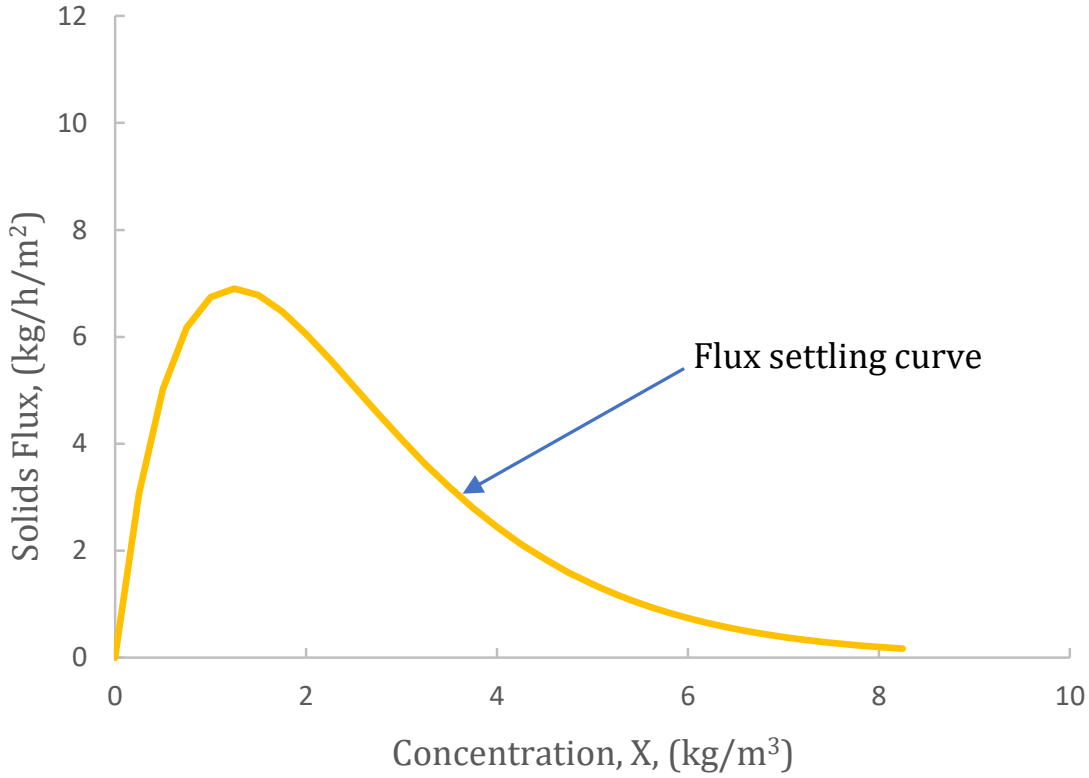
$$Solids\ Flux = \frac{Flowrate(\frac{m^3}{h}) * Concentration(\frac{kg}{m^3})}{Area,(m^2)} = \frac{kg/h}{m^2}$$

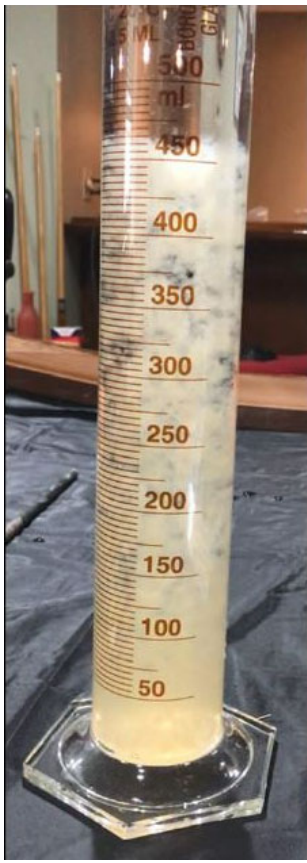
$$Settling\ Flux = \text{Settling Rate } \left(\frac{m}{h}\right) * Concentration(\frac{kg}{m^3}) = \frac{kg/h}{m^2}$$

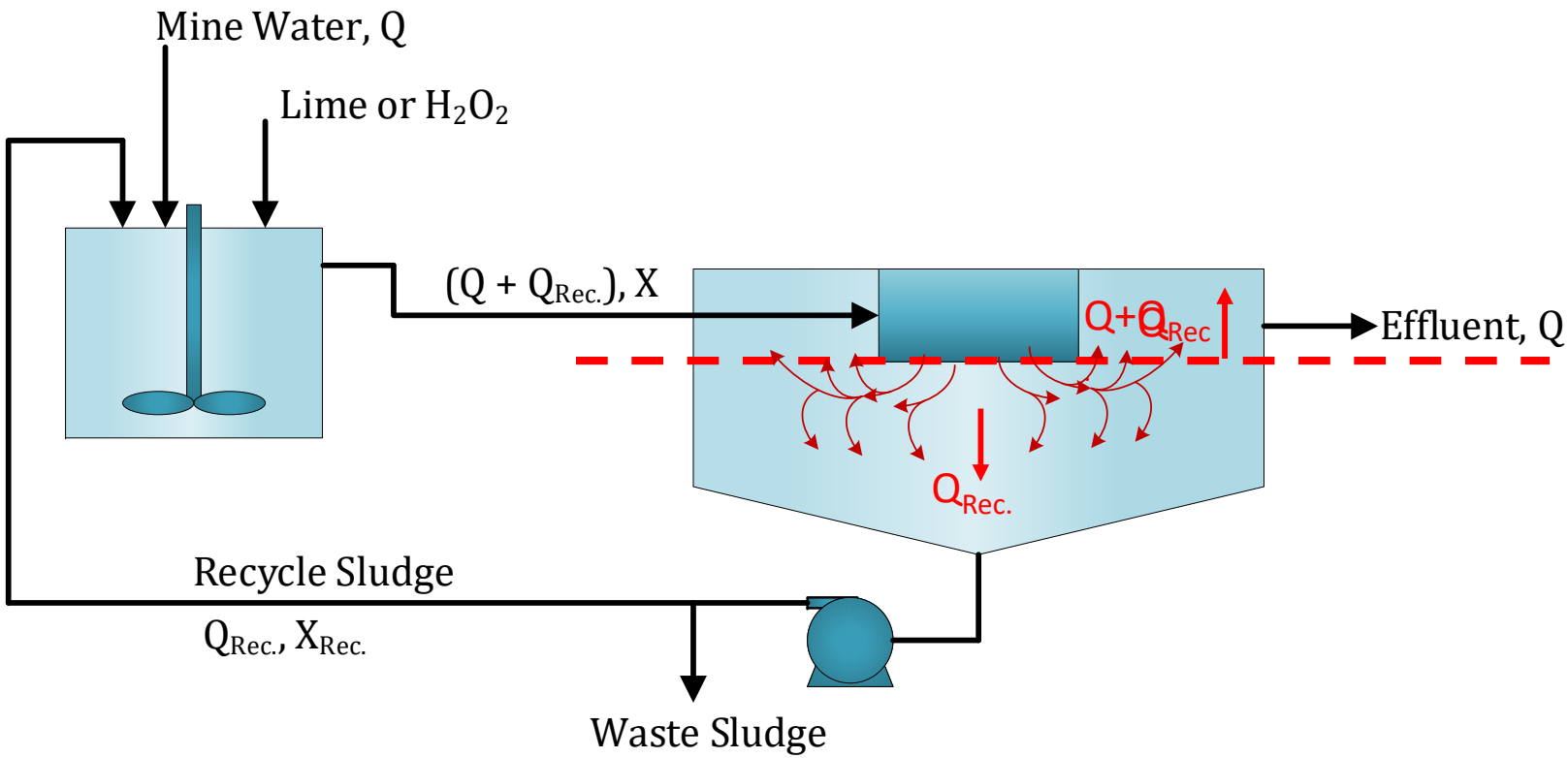
State Point Development

Solids Flux

$$Settling\ Flux = \text{Settling Rate}\left(\frac{m}{h}\right) * Concentration\left(\frac{kg}{m^3}\right) = \frac{kg/h}{m^2}$$

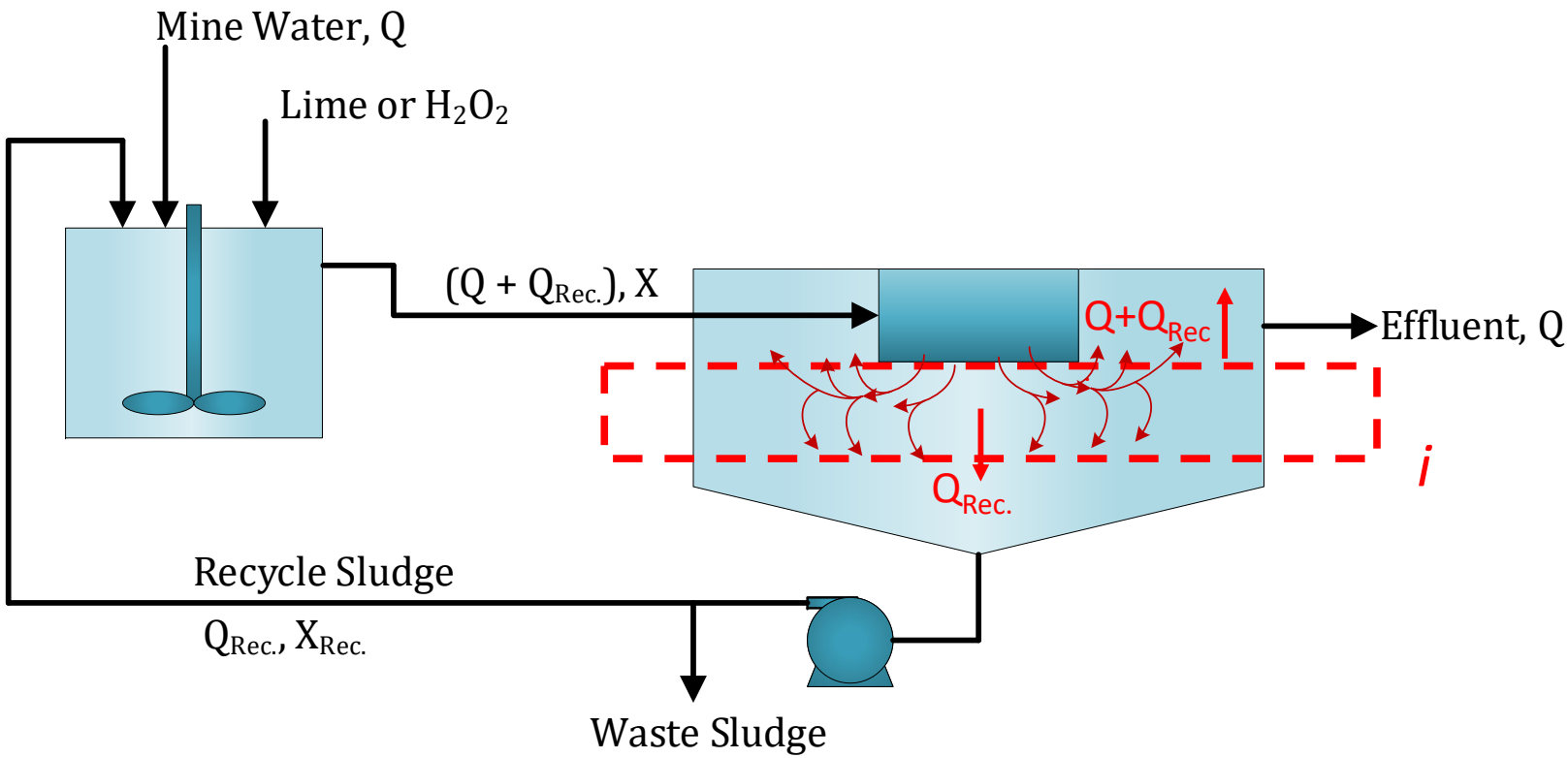






$$Net\ upward\ flux = \frac{Q * X}{A}$$

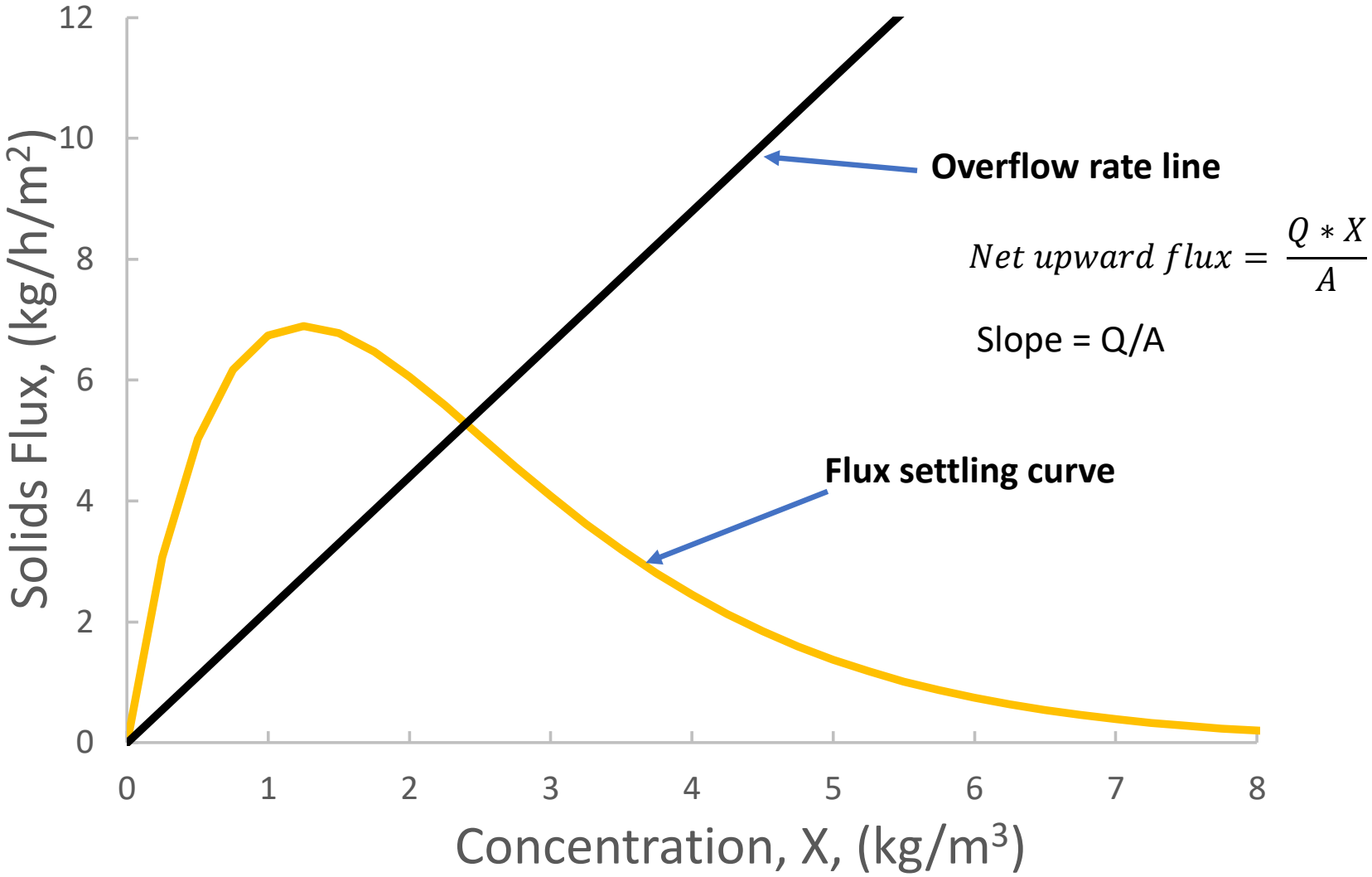
Straight Line passing through the origin with slope = Q/A



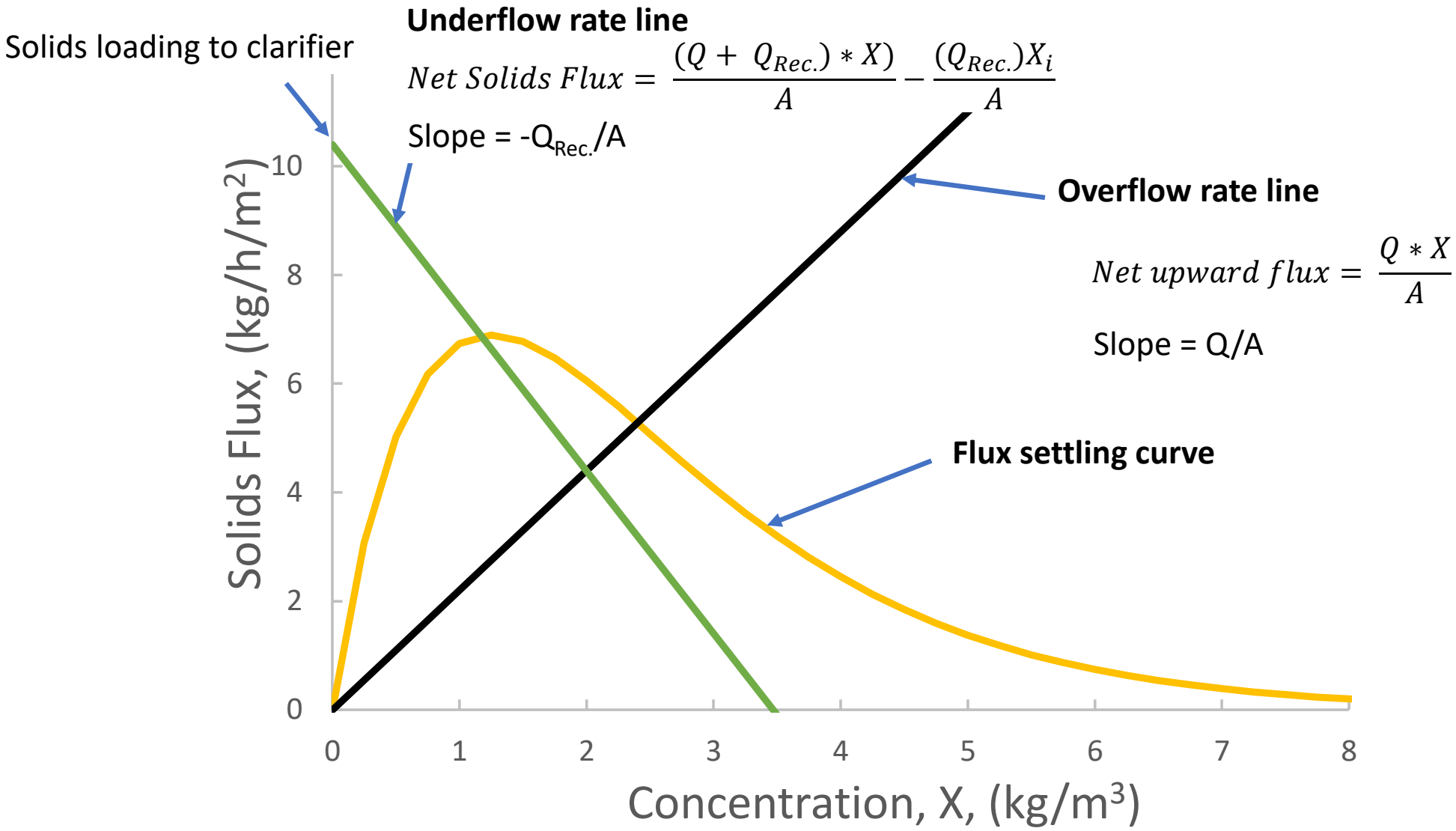
$$Net\ Solids\ Flux = \frac{(Q + Q_{Rec.}) * X)}{A} - \frac{(Q_{Rec.})X_i}{A}$$

Straight Line → Slope = $-Q_{Rec.}/A$, Y intercept = $(Q + Q_{rec.})/A$ = Total Solids Loading

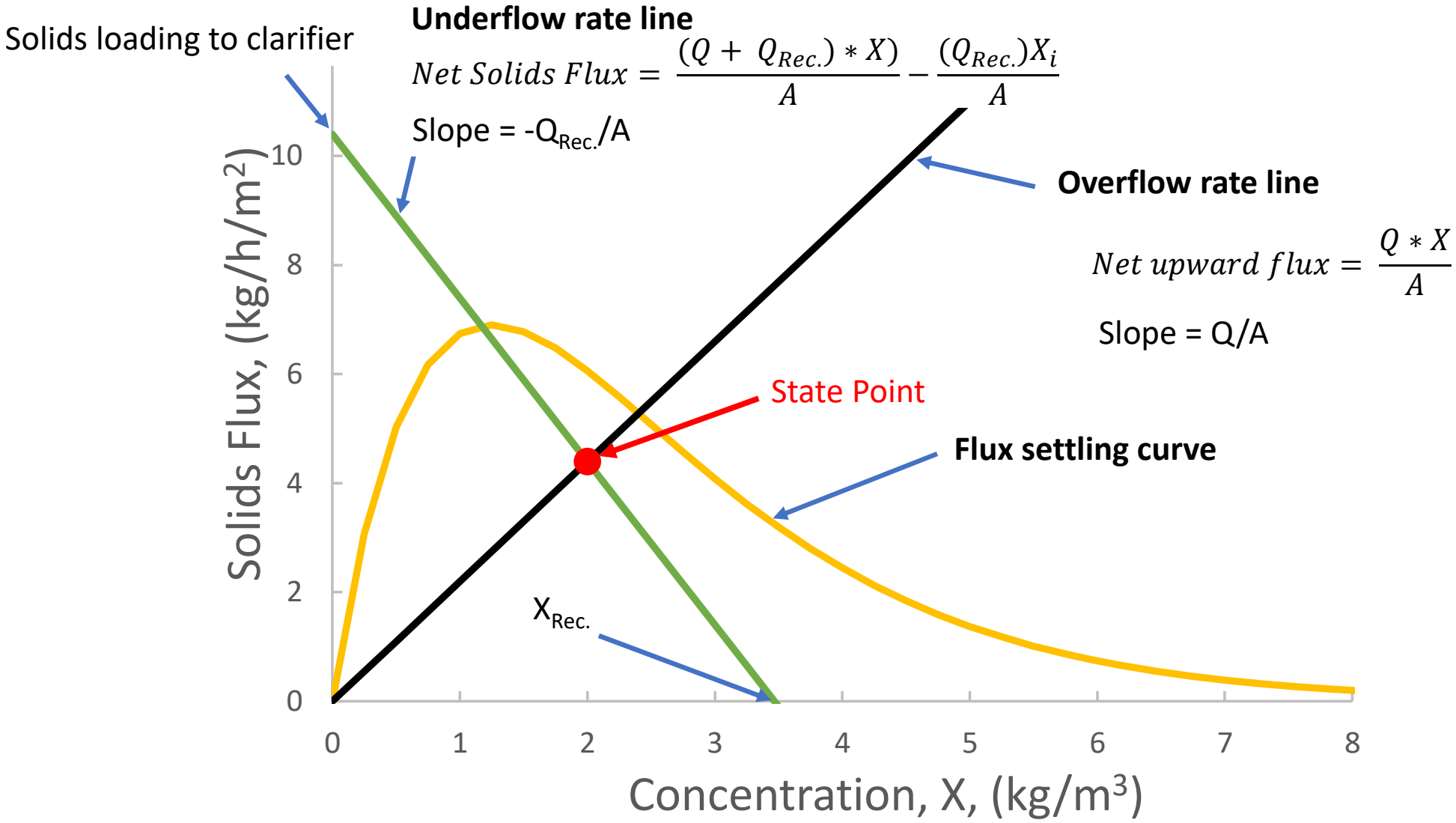
State Point Diagram



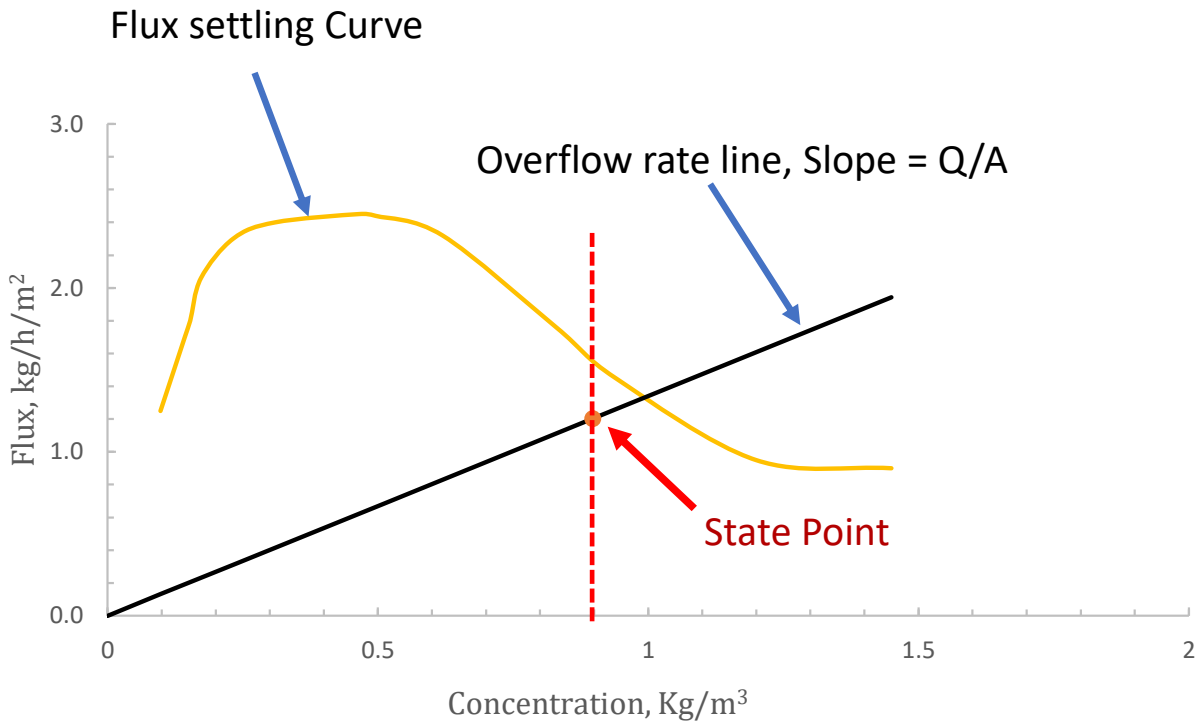
State Point Diagram



State Point Diagram

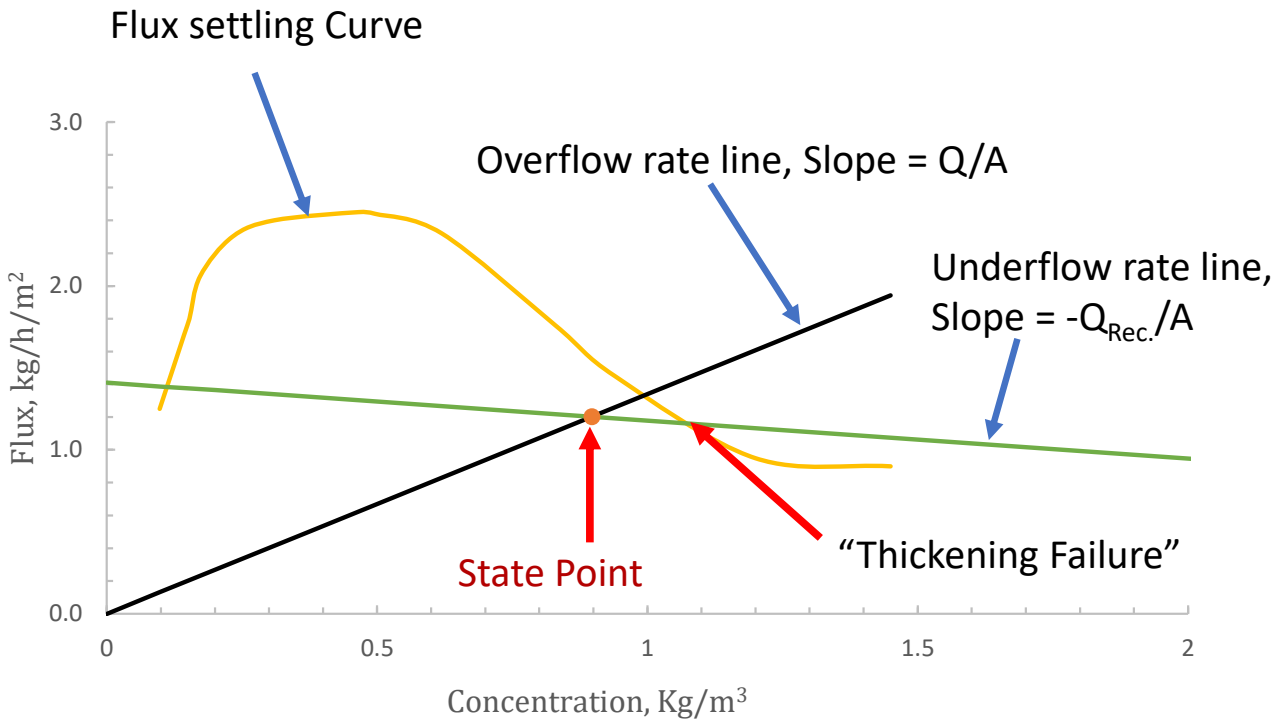


Case 1- Aluminum Removal from Mine Water



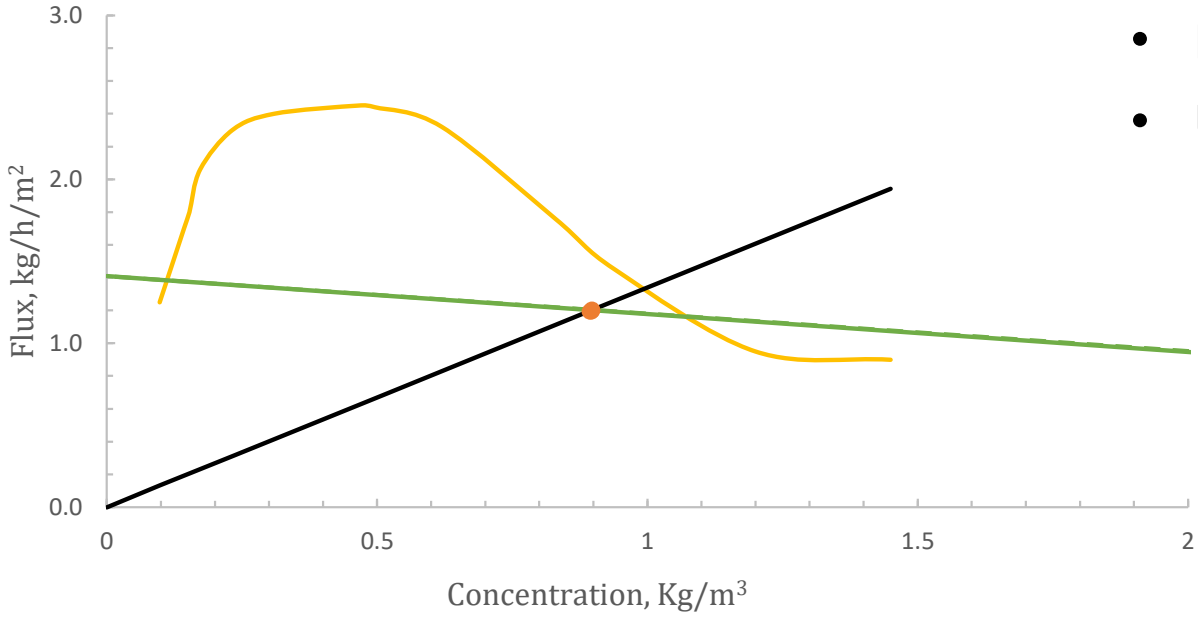
- Precipitation of about 15 mg/L of Aluminum hydroxide
- Scale-up factor of 0.5 applied to flux settling curve
- Good supernatant clarity at 0.9 kg/m^3 feed concentration

Case 1- Aluminum Removal from Mine Water



"Thickening Failure" will occur

Case 1- Aluminum Removal from Mine Water

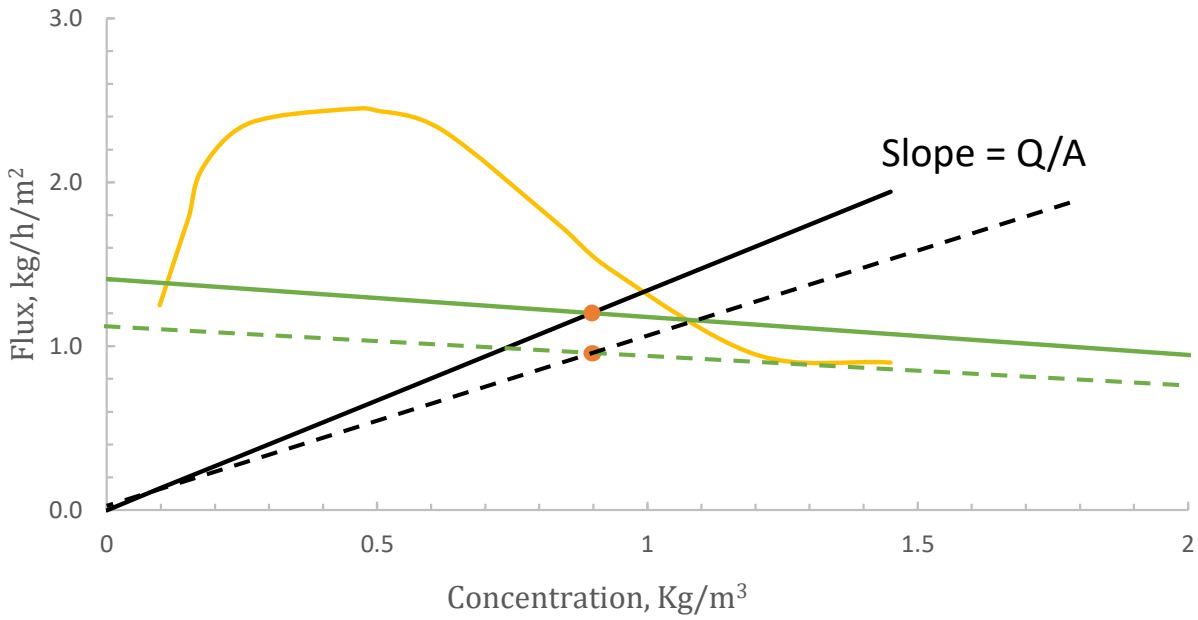


"Thickening Failure" Corrective Options

No Corrective Action

- Feed concentration decreases
- Underflow concentration decreases

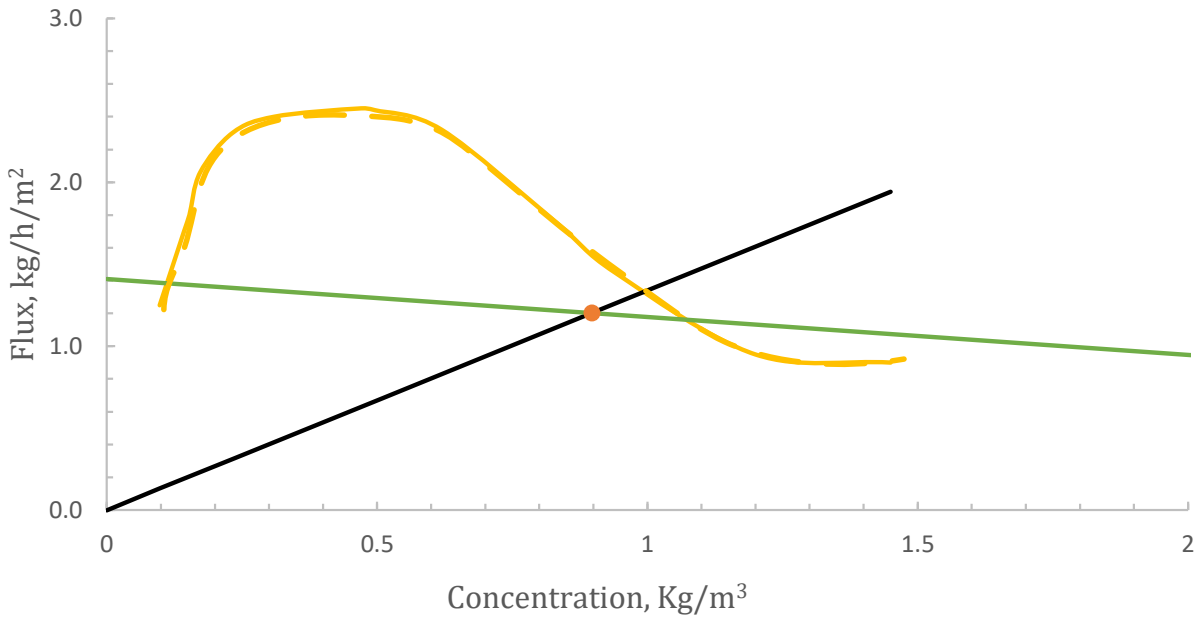
Case 1- Aluminum Removal from Mine Water



"Thickening Failure" Corrective Options

1. **Increase Clarifier Diameter**
   - State point and underflow concentration unchanged
   - Capital cost increases

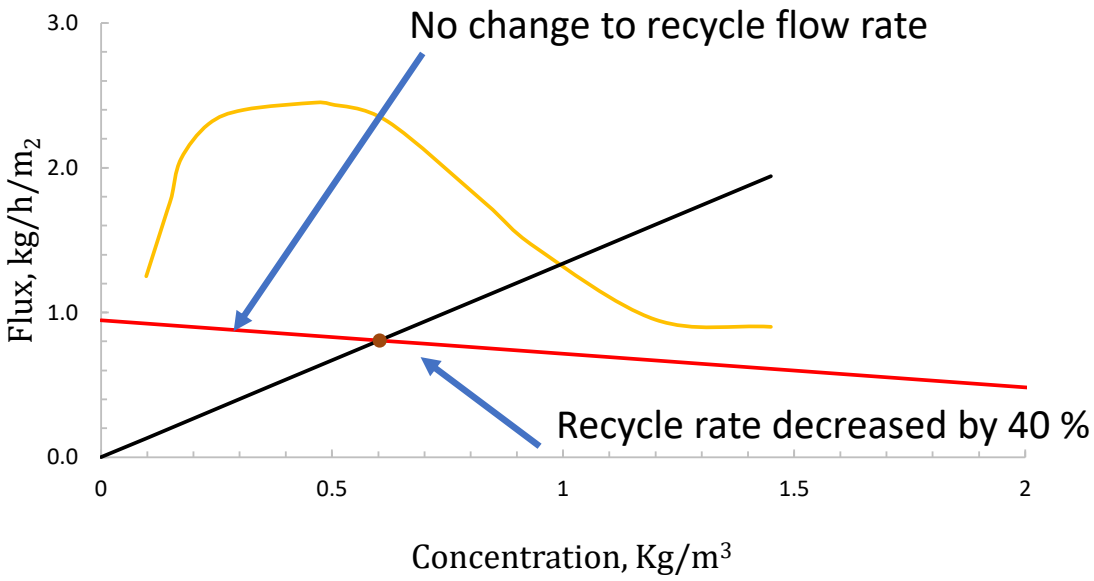
Case 1- Aluminum Removal from Mine Water



"Thickening Failure" Corrective Options

2. **Increase flocculant dosage**
   - State point and underflow concentration unchanged
   - Operating cost increases

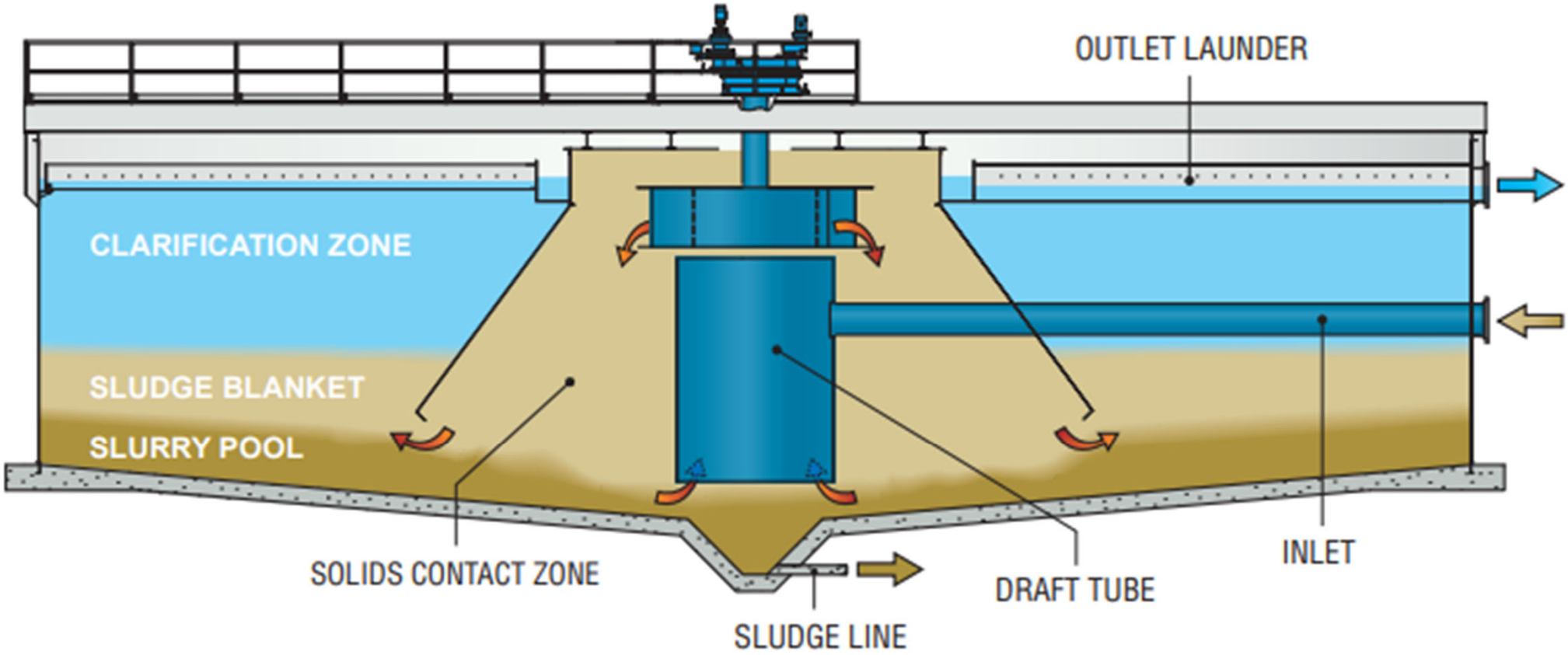
Case 1- Aluminum Removal from Mine Water



"Thickening Failure" Corrective Options

3. **Reduce recycle flow rate**
   - Underflow concentration unchanged
   - Reduced recycle pumping costs
   - Minimal change in state point

Case 2- Iron Removal from Mine Water with Solids Contact Clarifier



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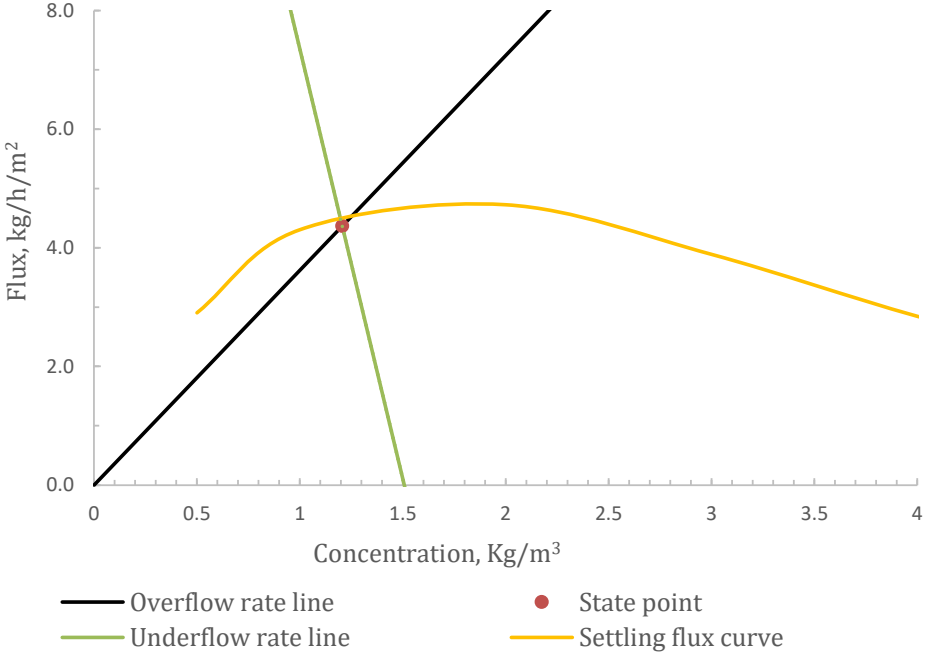
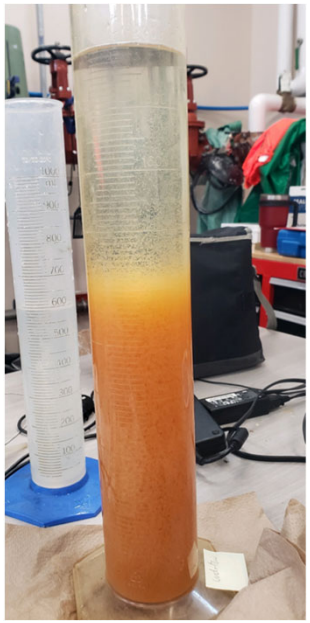
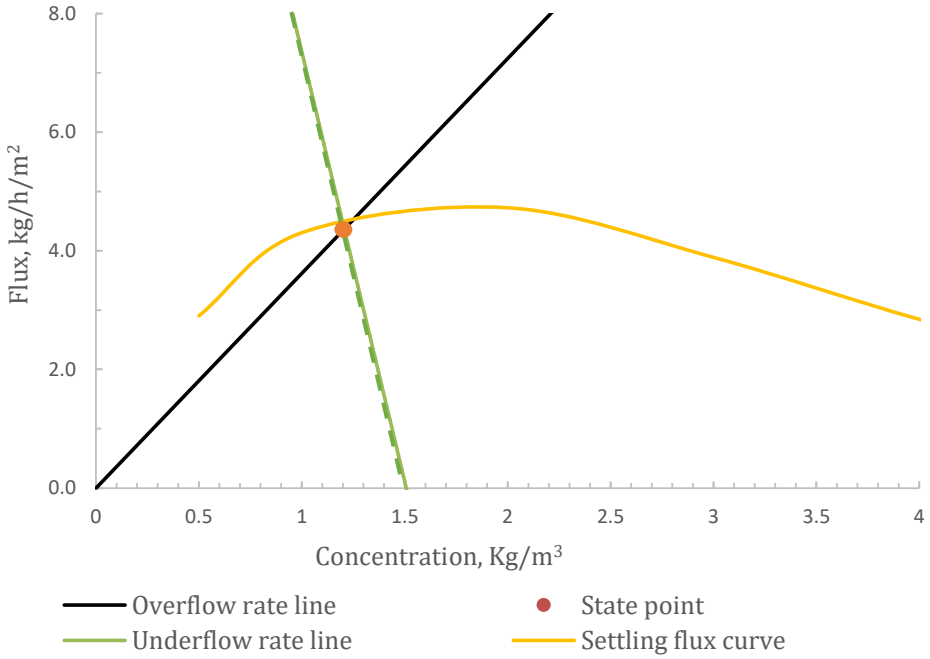




- Aggressive sizing results in State Point close to flux settling curve (0.75 scale-up)
- Low wasted sludge concentration
- Careful attention to flocculation required

Case 2- Iron Removal from Mine Water with Solids Contact Clarifier



What happens if sludge inventory is not controlled

- Underflow/Recycle concentration increases
- State point shifts upward along same overflow rate line
- Clarification failure. Solids rise to effluent

Conclusions

- Clarifier sizing needs to look at solids loading rate as well as hydraulic capacity
- Gives guidance for adjusting recycle flow rate to ensure good flocculation without excessive solids loading
- Shows how recirculation pumping rate can affect wasted [illegible] concentration

Thank You

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