Treatment of Dredge Return Water by Electrocoagulation
Lessons Learned: Effective Solids Management and pH Control Optimization

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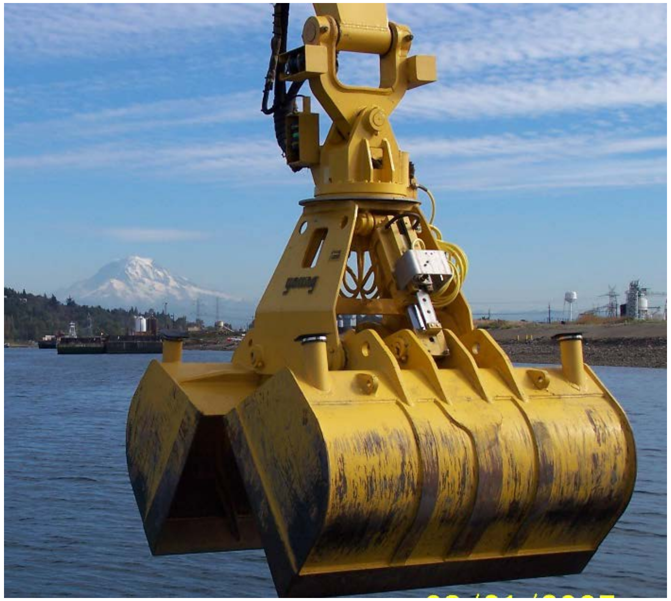
BAKERCORP

PEOPLE. EQUIPMENT. SOLUTIONS.

Overview

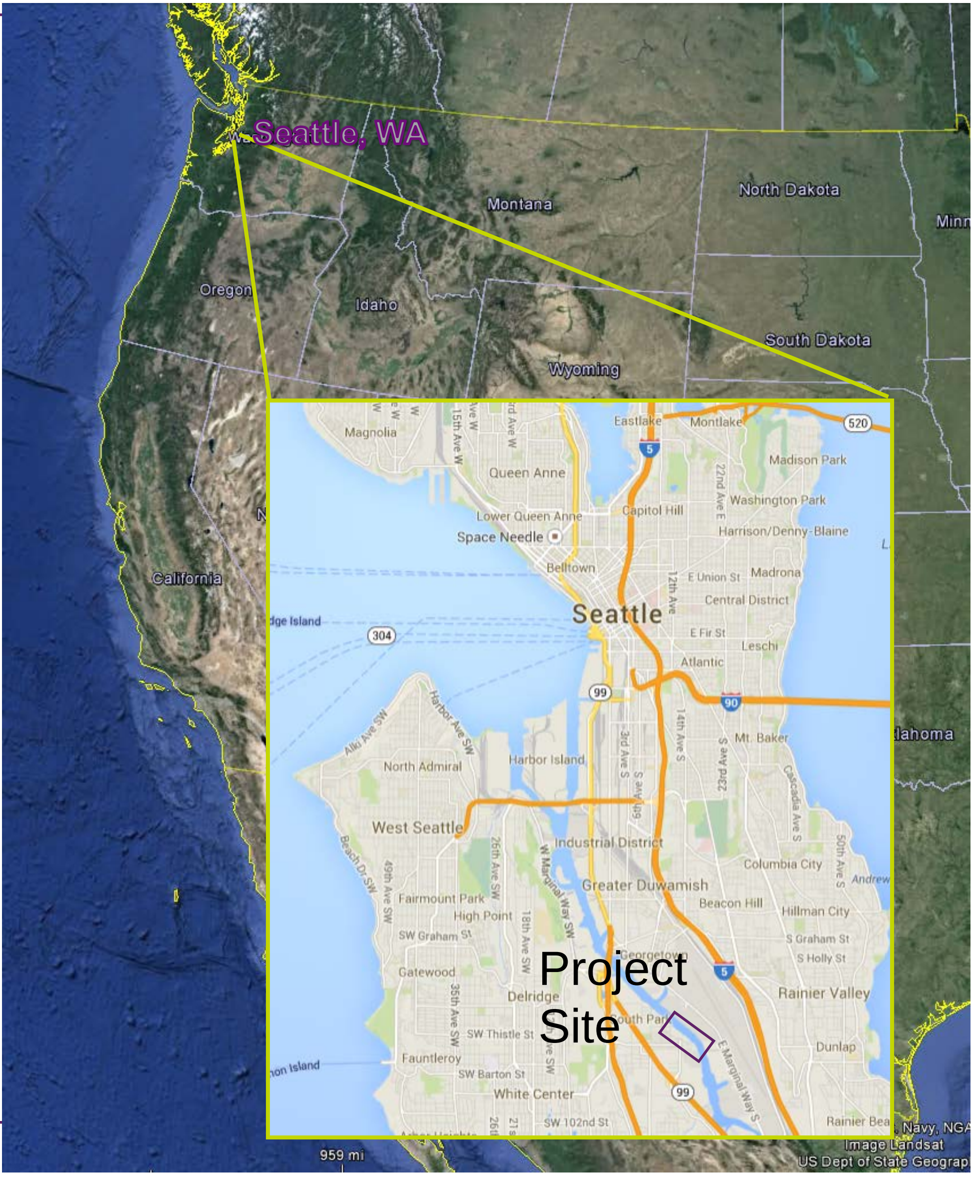
1. Site Background & Project Objectives
2. 2013-2015 Dredge Return Water Treatment System Goals
3. Water Treatment Optimization
    1. Improvement of Floc Formation
    2. Improvement of Clarifier Effectiveness
    3. Optimization of Filtration/Polishing Step
4. Conclusion & Project Completion
5. Questions & Answers



Project Site Background & Location

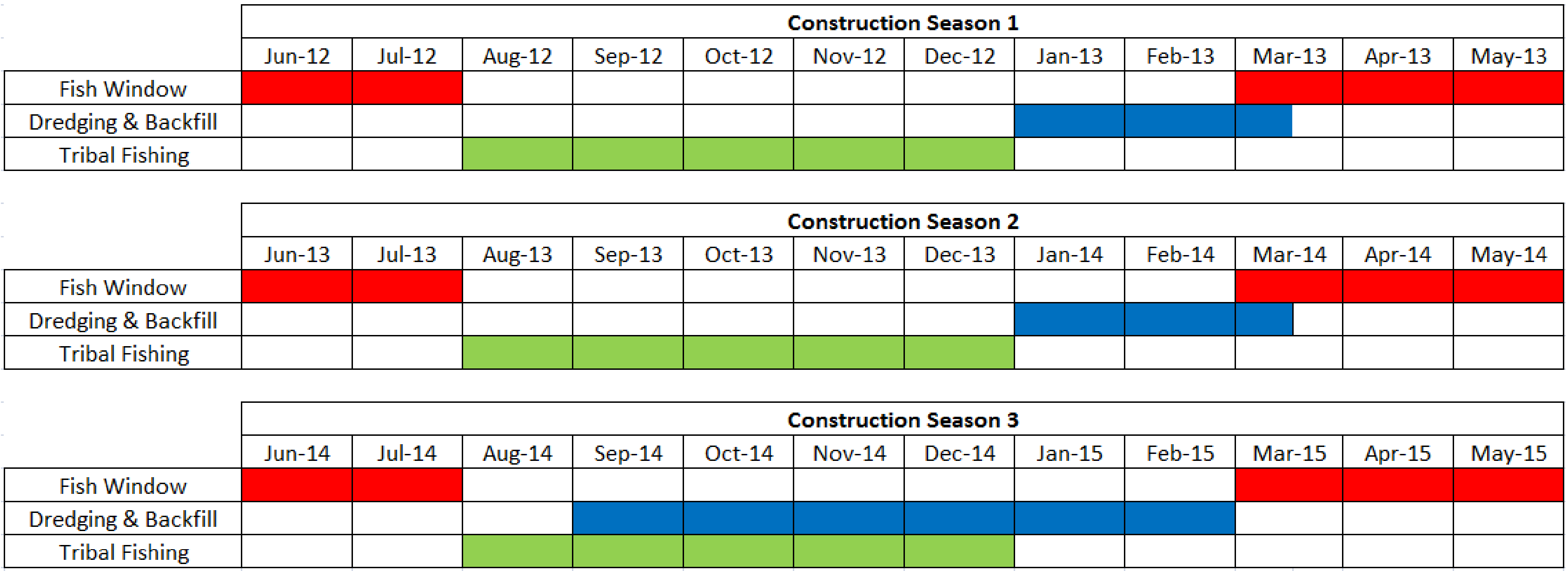
Duwamish Waterway, Seattle, Washington

- ► Former aircraft manufacturing facility established in 1936
  - ► Sediment surrounding parcel was contaminated by heavy metals and polychlorinated biphenyls (PCBs)
  - ► Building demolition in 2011 allowed for the removal of contaminated sediment
  - ► Dredging began in 2013
- ► Project goal: Remove ~160,000 cubic yards of contaminated sediment and restore habitat
  - ► **Dredge water is also contaminated by sediment and must be treated**



Dredge Schedule & Restrictions

River Access Issues



- Tidal influence restricted access for shallow dredging
- Noise permitting considerations with nearby residential areas

Additional Access Issues

High River Traffic

- Active channel with personal and commercial craft navigating the river
- Nearby construction and dredge operations

Selected Water Quality Discharge Criteria

Dredge water quality

Constituent of Concern	Approximate Dredge Water Range
Copper (ug/L)	0.478 – 6.25
Mercury (ug/L)	1.13 – 4.35
PCBs (ug/L)	1 – 6.5
Conventional Parameter	**Range**
pH	7.5 – 8.5
Turbidity (NTU)	250 - >1000

Discharge water criteria

Constituent of Concern	Acute	Chronic
Copper (ug/L)	4.8	3.1
Mercury (ug/L)	1.8	0.025
PCBs (ug/L)	10	0.03
Conventional Parameter	**Range**	
pH	7 to 8.5, and < 0.5 from background	
Turbidity (NTU)	< 5 above background	

Stormwater criteria

WA Industrial Stormwater Benchmarks
14
1.4
Not Applicable
Conventional Parameter Range
Between 5 and 9
< 25 NTU

ug/l = micrograms per liter
NTU = Nephelometric Turbidity Unit

Treatment Considerations for Dredge Water

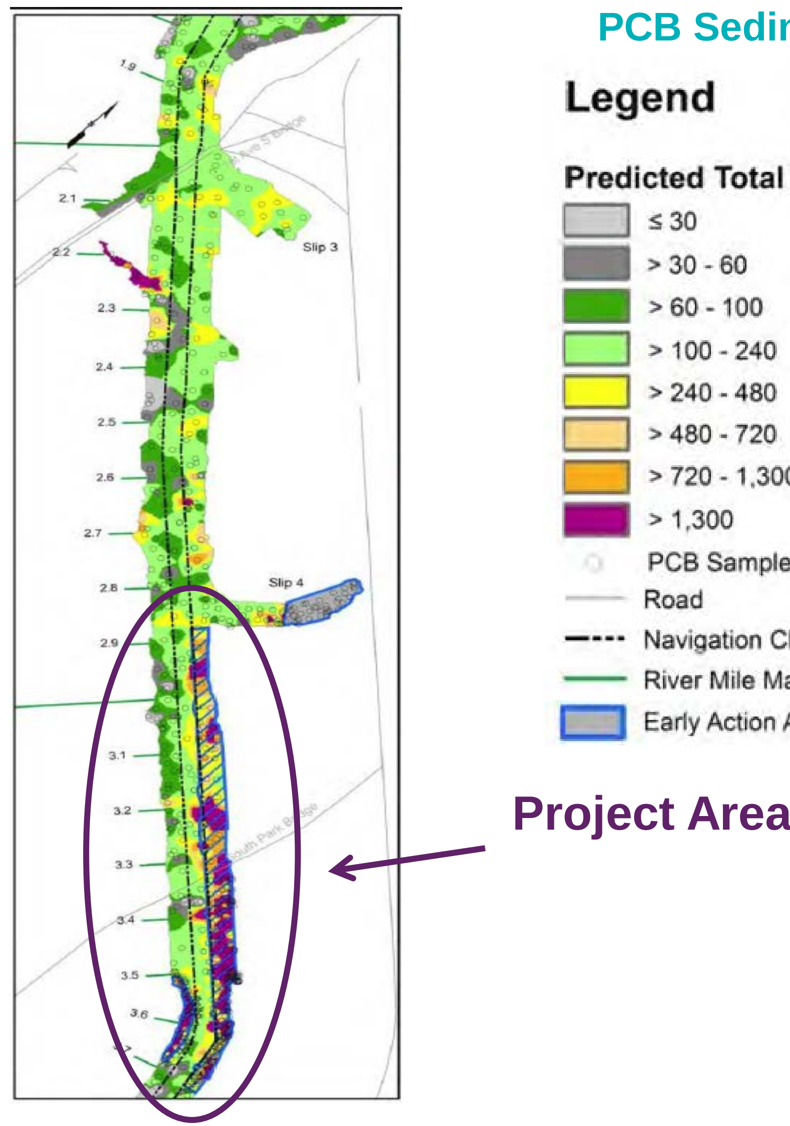
Water Treatment Design

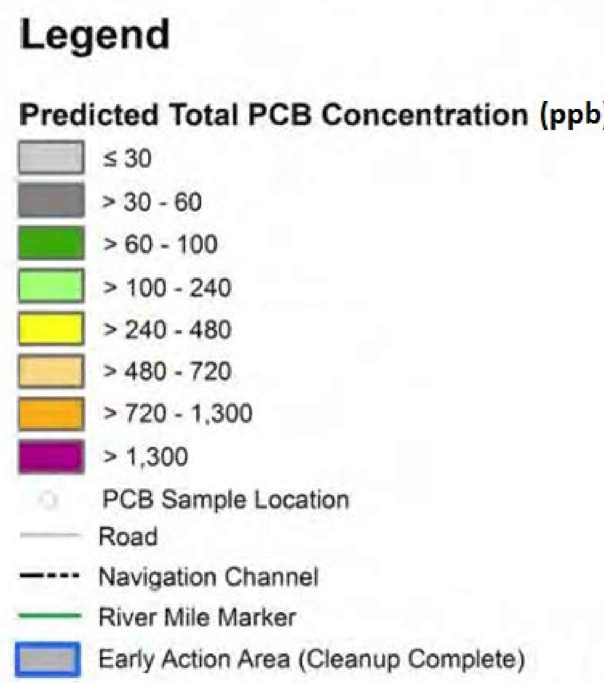
- Variable dredge water production

  (0-1,000 gpm)
- Variable water quality

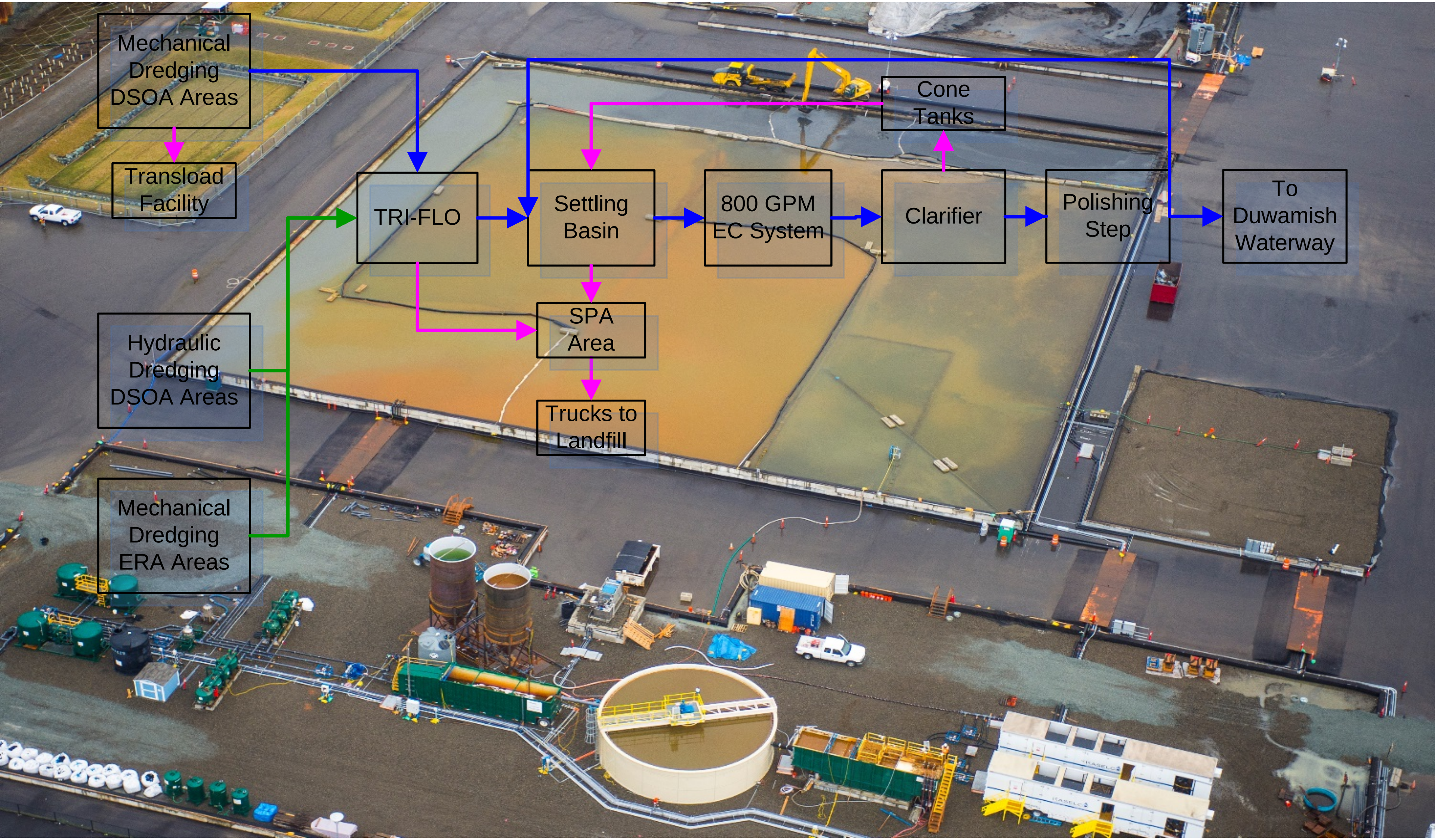
  (0-15% solids, salinity variation from seawater to rainwater)
- Restrictive dredging timeframe

PCB Sediment Contamination



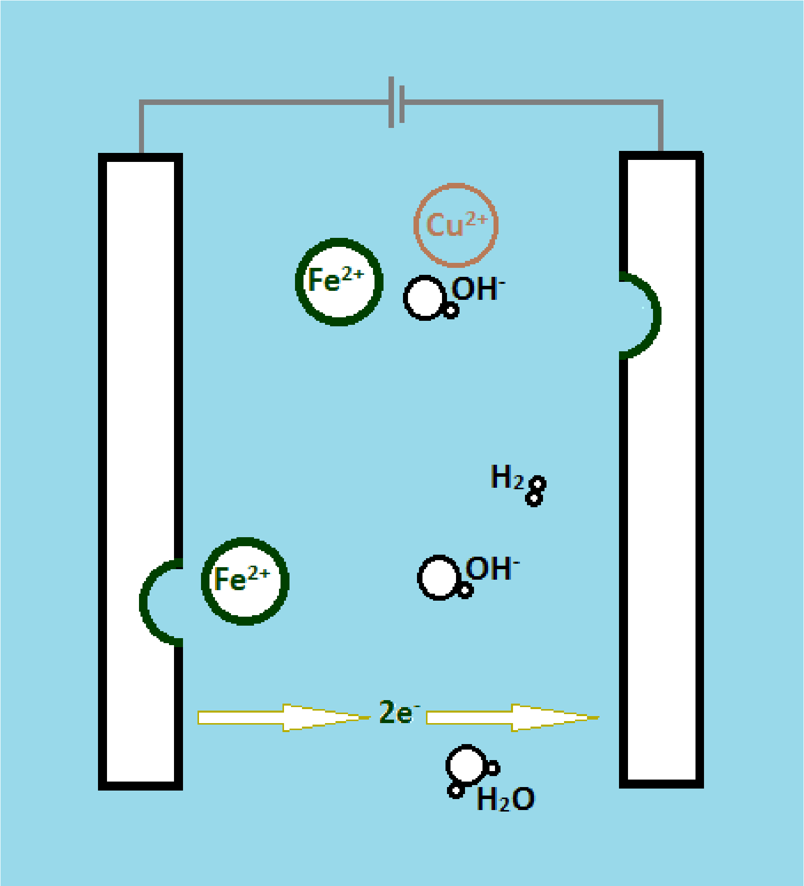


Final Water Treatment Process Design



EC Reaction

$$Fe + 2H_2O \longrightarrow Fe(OH)_2 + H_2$$



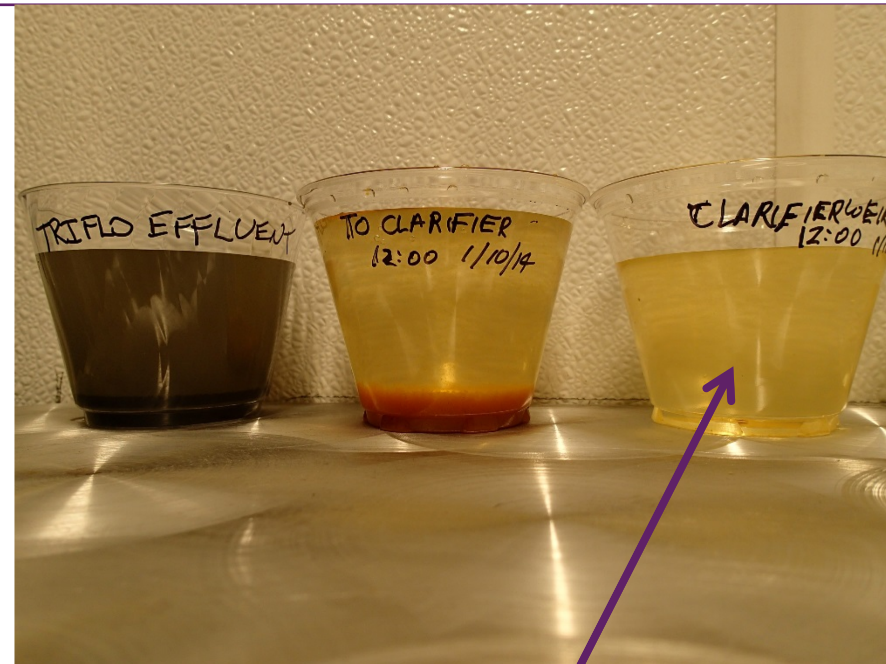
Optimization Target Areas

Improve Clarifier Settlement

- Better floc formation at EC trailers
  - Adjust voltage/amperage
  - Supplementation of solids
- Better floc preservation before clarifier
  - Flocculation tank modification
  - Clarifier modifications

Increase Maintenance Intervals

- Treatment optimization upstream reduces solids loading at filtration



CS2 Post-Clarification Turbidity (average): 85

CS3 Post-Clarification Turbidity (average): 25

Electrocoagulation Optimization

Fine-tuning the Reactors: Improving Floc Quality

Voltage and Amperage Adjustments

- Voltage limiting system – voltage set to defined value and amperage allowed to change
  - Automatic amperage adjustments allowed to change based on influent water conductivity fluctuations
- Power settings changed to adjust iron dose

Reactor Changes

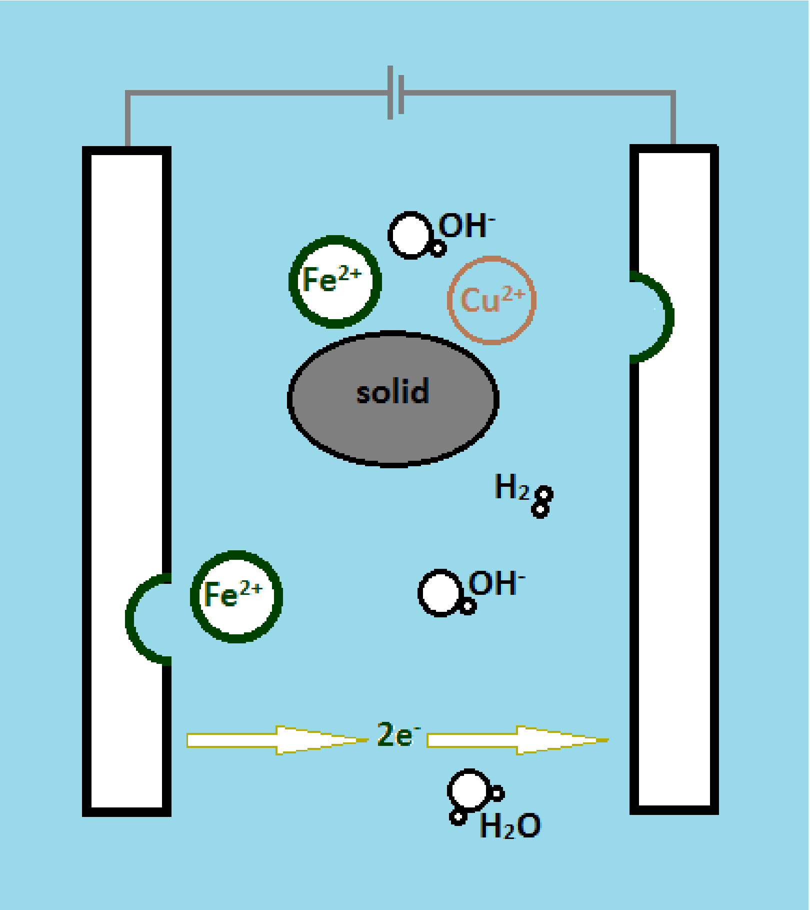
- Patented reactor design
  - Allows for easy removal of reactors for reactor changes to accommodate changing water conditions
  - Multiple reactors used at once
  - In place reactor cleaning

Electrocoagulation Optimization

Supplementation of Solids at the EC Influent

Addition of Solids to Influent Water at the EC Reactors

- Line to maintain 70-100NTU water at the system influent



Post-EC Aeration Optimization

Floc Oxidation

- Original design included aeration by motorized mixers
  - Mixing sheared floc particulate
- Diesel-powered compressor installed to aerate through sparge manifolds at 375 CFM
  - Operations were costly and caused maintenance downtime for treatment system
- Compressors were replaced by regenerative blowers and fine-bubble diffusers
  - Final configuration providing optimal aeration

Initial CS2 aeration configuration

Floc Transport Improvements
Preserve good floc for clarification/settlement

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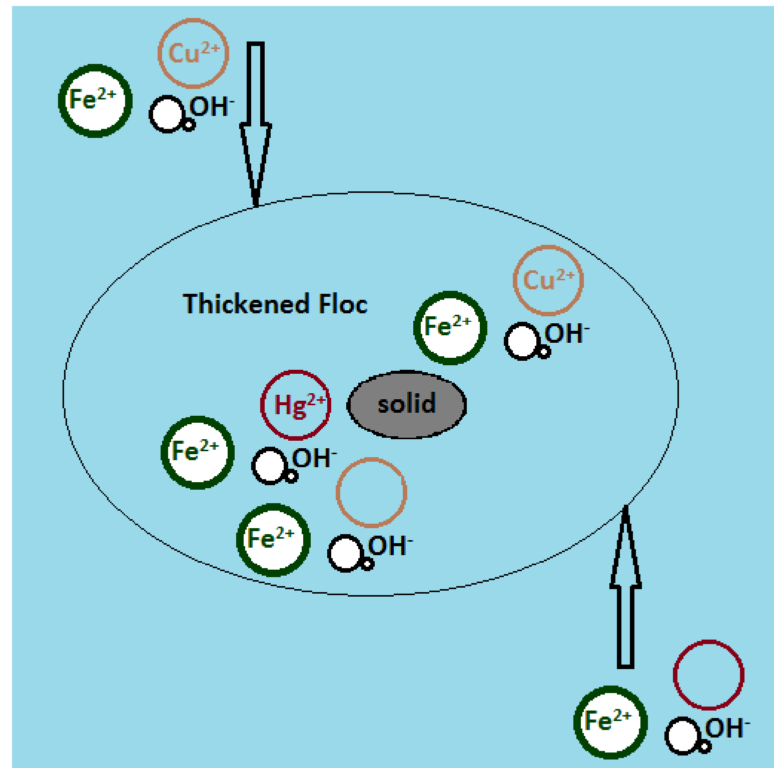
Preserve good floc for clarification/settlement

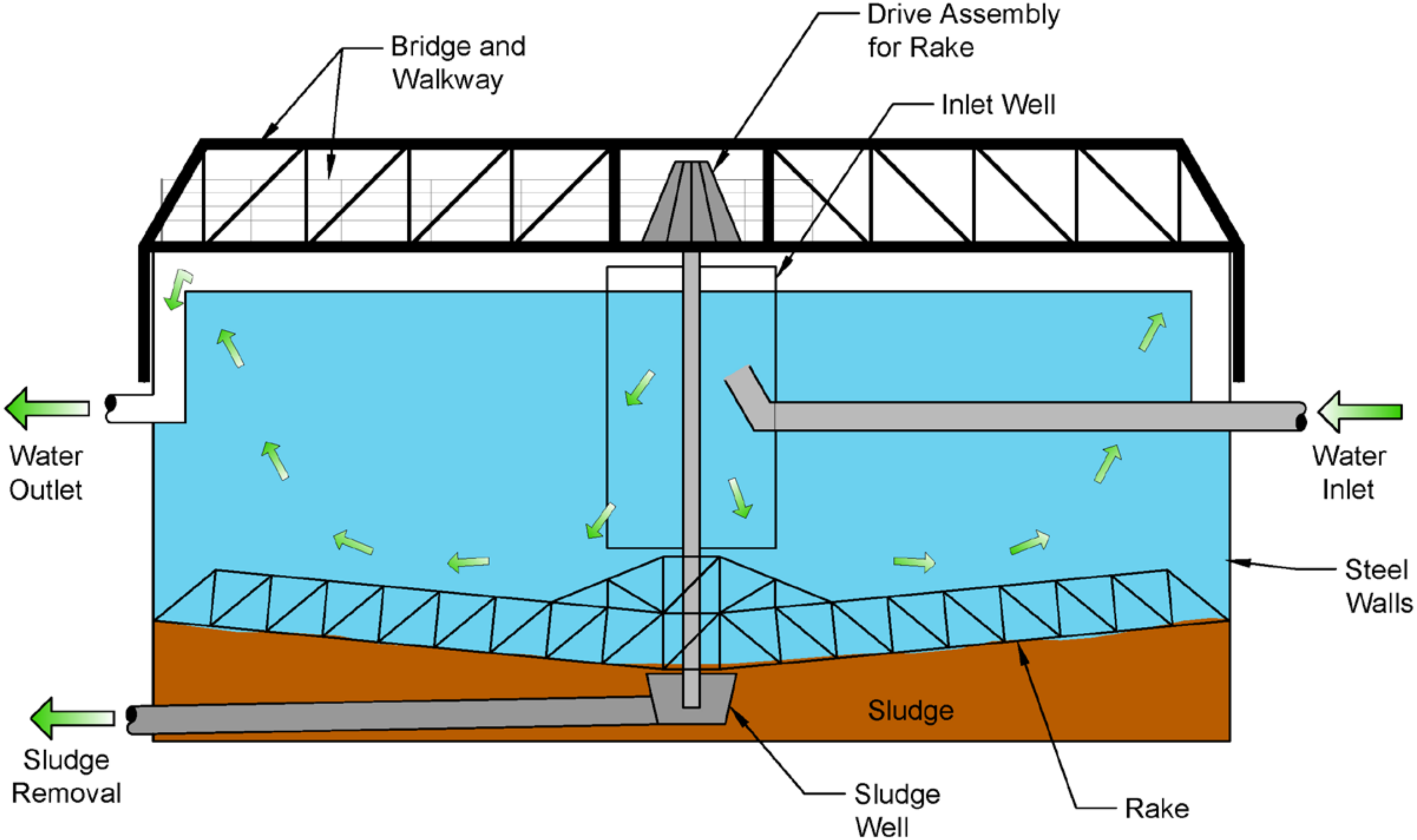
Installed a ramp to decrease shear forces on floc at weir

Seeding of the Flocculation Tank

- Introduction of settled and semi-compressed floc from the sludge thickening tanks into the flocculation tank



Clarifier Flow Diagram



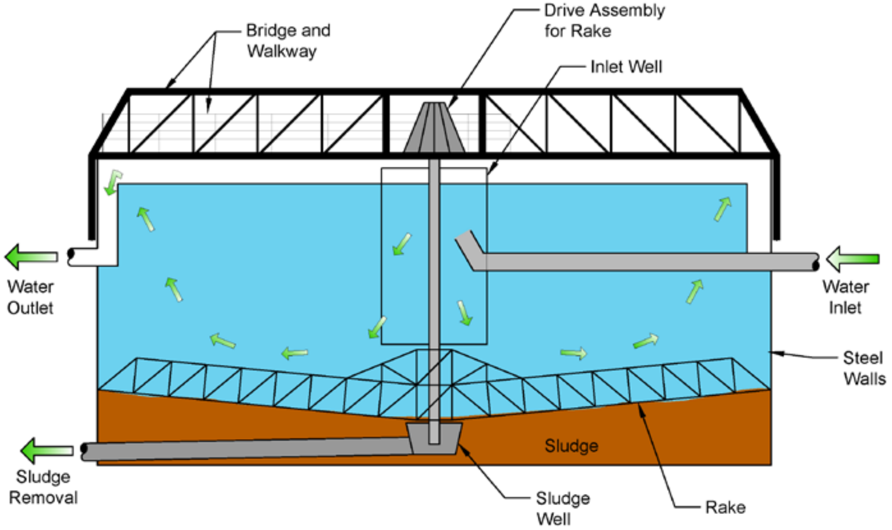
Improve Clarifier Effectiveness

Management of Settled Solids

- Variable influent water quality and changes in EC settings resulted in highly variable sludge production at the clarifier
  - Consistent monitoring of sludge levels and production rates informed solids removal rates
  - A high sludge bed at the clarifier contributed to floc destruction and poor settlement for incoming particles due to decreased retention time

Addition of a variable frequency drive to the clarifier rake

- Enabled control to optimize clarifier performance



Modification Logistics

Decrease Solids Loading at Filters

Cost savings due to reduced consumables

Low Turbidity at the Clarifier Effluent means Less Filtration

- Reduced the solids loading at the sand filters
- Increases the life of the filters
  - Allowed for scheduling of sand filter and GAC filter backwashing
  - Reduced the frequency of bag filter replacement
    - ~$800/day in CS2 on bag filter maintenance
    - ~$200/day in CS3 on bag filter maintenance

Other Lessons Learned

pH Probe Issues

CO_2 Dosing

- EC technology raises the pH of water
- CO_2 dosing used to create carbonic acid to lower the pH
  - Early on, large amounts of CO_2 were used for pH adjustment
    - CO_2 mixing pipe was inadequate for reaction time
  - This became a problem for rainwater, which already had a LOW pH
    - Had to use the Kaselco EC units to raise the pH of rainwater before discharging

Turbidity Recirculation at System Effluent

- Added controls to recirculate based on high turbidity at system effluent

Redundancy & Spare parts

- Two EC trailers run in parallel
  - Option for maintenance while continuing to treat water with single trailer
- Spare transformers, instruments, pumps, impellers, valves, screens as well as standard parts kept onsite

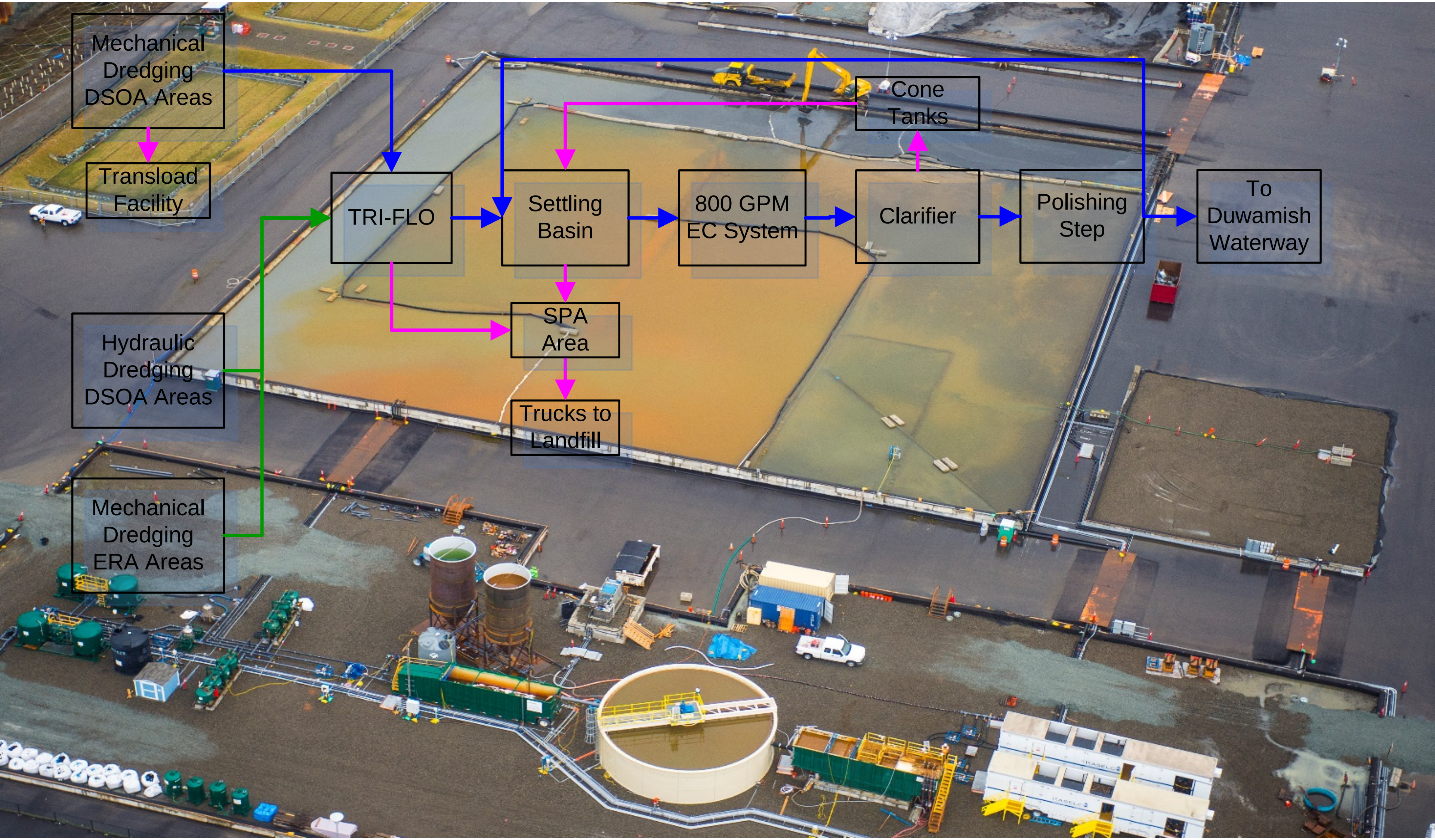
Tuning a Dynamic System

Summary of Water Treatment Optimization Parameters

Modification/Parameter	Pros	Cons
Reduce EC power settings to reduce iron dose	-Reduce dissolved iron -Minimizing pH rise (eliminated need for CO_2)	-Reduced floc size
Raise influent turbidity to 70-100 NTU	-Increase floc density	-Increase cleaning frequency at EC influent -Increase solids loading at the clarifier -difficult to maintain consistent solids loading
Use of fine bubble diffusers instead of sparging pipes	-Increase oxidation rate at the flocculation tank -Reduce maintenance	
Stopped mixer operation at the flocculation tank Installed a ramp at the flocculation tank weir Installed a variable frequency drive at the clarifier rake Cut clarifier inlet from 90º elbow to 45º elbow	-Reduced shear forces on the floc and prevented good floc from being broken up before it reached the clarifier	
Add cone tank sludge to head of basin	-Improved solids settlement in the basin	

Tuning a Dynamic System

Many Possibilities for System Feedback



Key Lessons Learned

Importance of optimizing the treatment system

- Proper solids management
- Controlled solids separation
- pH control

Importance of redundancy

- Ability to maintain or replace system components while minimizing downtime

Conclusion

ZERO delayed dredging shifts due to DRWS

Total Solids Removed: 160,000 cubic yards

Total Volume Treated & Discharged: 47,000,000 gal

- Met Washington State acute and chronic water quality criteria with ZERO discharge exceedances

Essentially all optimization was done while the system was running!

Season and Duration	Cubic Yards Removed	Gallons of Water Treated & Discharged
CS2 (2 months)	48,500 CY dredged	18 million gallons treated and discharged
CS3 (5 months)	75,000 CY dredged	45 million gallons treated 29 million gallons discharged

Acknowledgements

Hsieh, P., Lesikar, B.J., Webb R., and McCormack, D.C. "Lessons Learned: Electrocoagulation Treatment of Dredge Return Water to Acute and Chronic Water Quality Criteria for Dissolved Metals, Total PCBs, pH and Turbidity," ***Proceedings of the Western Dredging Association and Texas A&M University Center for Dredging Studies' "Dredging Summit and Expo 2015",*** **Houston, Texas, USA, June 22-25, 2015.**

Questions & Answers

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