Biomass Dewatering at Valero Pembroke Refinery's Waste Water Treatment Plant.

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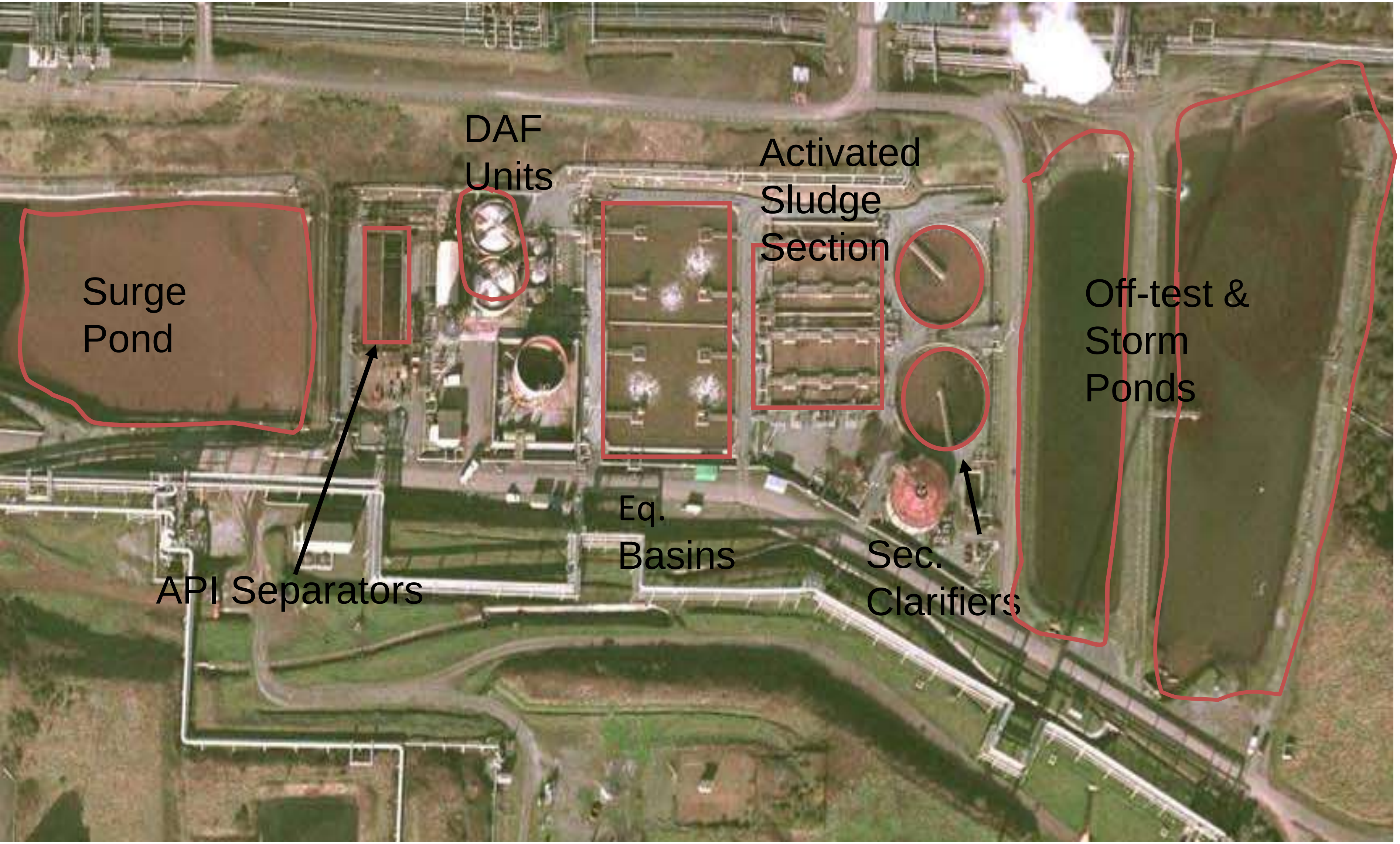
Purpose of Presentation

- Outline the Valero biomass sludge dewatering process.
- Options review from ultra filtration to using classic filter membrane.
- How the plant was designed and why.
- How the plant was commissioned.

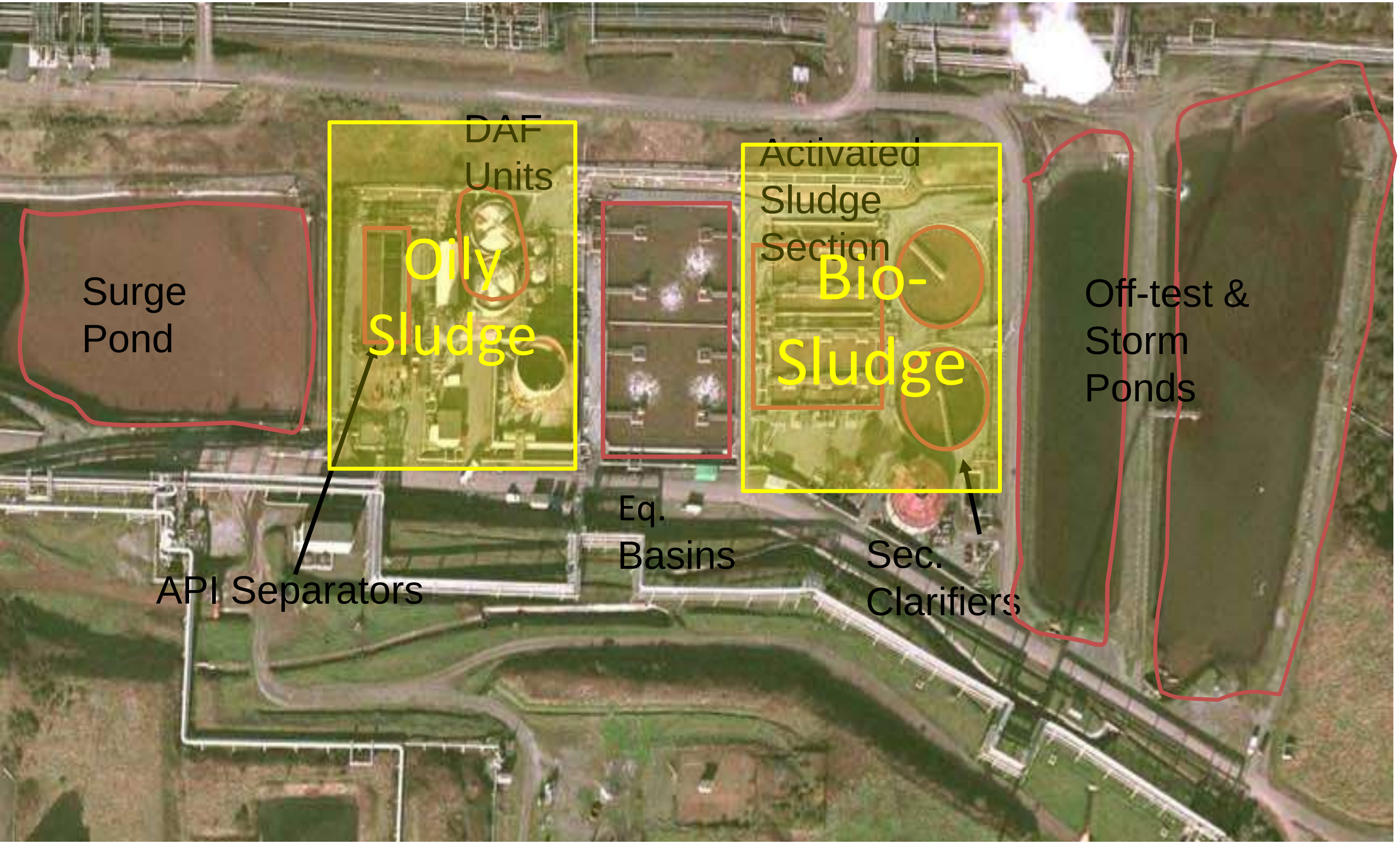
Plan view of the WWTP



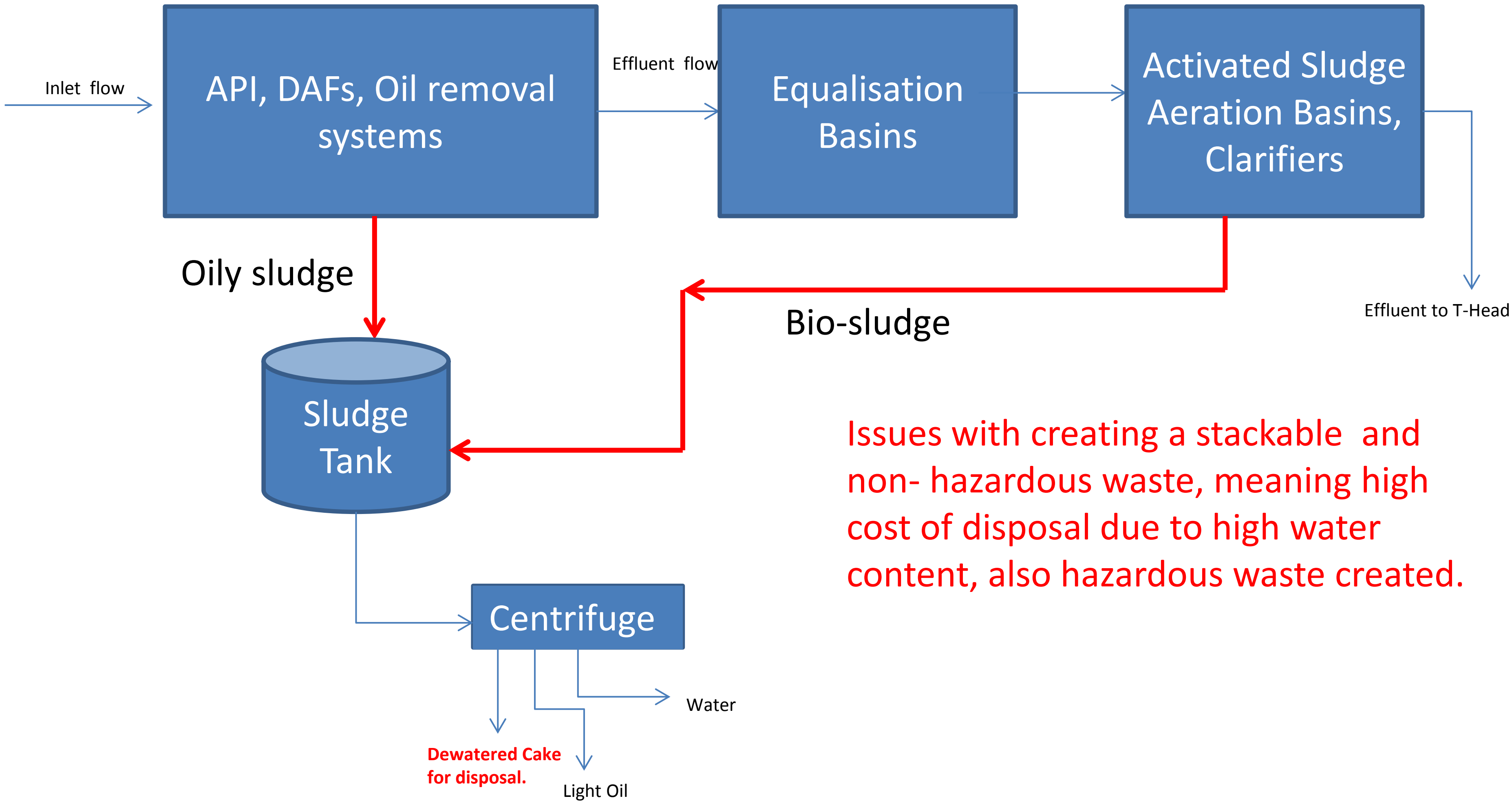
Types of Refinery Sludge

- Oily Sludge
  - DAF (Dissolves Air Flotation) oil floats.
  - API (American Petroleum Institute) Separator bottoms sludge
- Biological Sludge (Bio-Sludge)
  - WAS (Waste Activated Sludge)
  - Secondary Clarifier Scum

Plan view of the WWTP



Previous Pembroke WWTP Sludge Removal Process



Issues with creating a stackable and non- hazardous waste, meaning high cost of disposal due to high water content, also hazardous waste created.

Technical issues with mixing sludges prior to dewatering

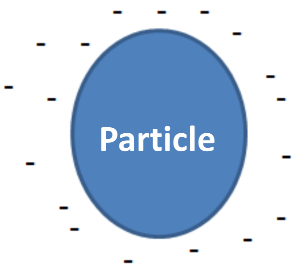
The surface charges on oily sludge and bio-sludge are different:

- charge type differs
- and charge density differs

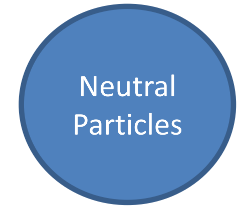
Mixing both sludges together discourages floc formation with polymer addition because;

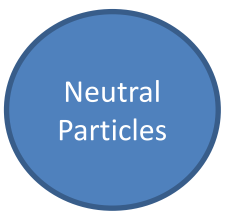
When a constant amount of cationic polymer is added to this mix, it either adds to much positive charge to one type of particle or too little to the other, so a neutral solution cant be formed and no flocs occur.

Floc Formation



\+ Cationic (+ve) coagulant =





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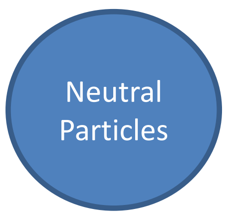
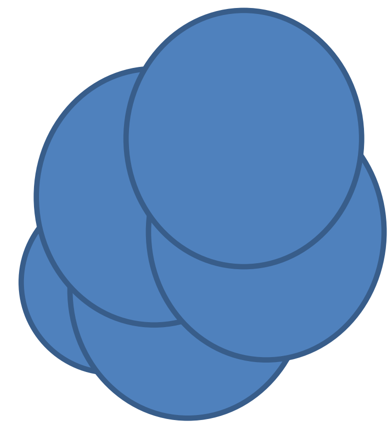


\+ Flocculant = Flocs



Bigger flocs settle faster (Stokes Law). $V_t = (g/18\mu)(\rho_w - \rho_p)D^2$

The vertical velocity of a particle in water under quiescent conditions depends on:

Density of the particle being separated

Diameter of the particle

Viscosity of the wastewater

Temperature of the wastewater

Variables which affect dewatering

Most important

Surface Charge

Charge Density

Particle Size

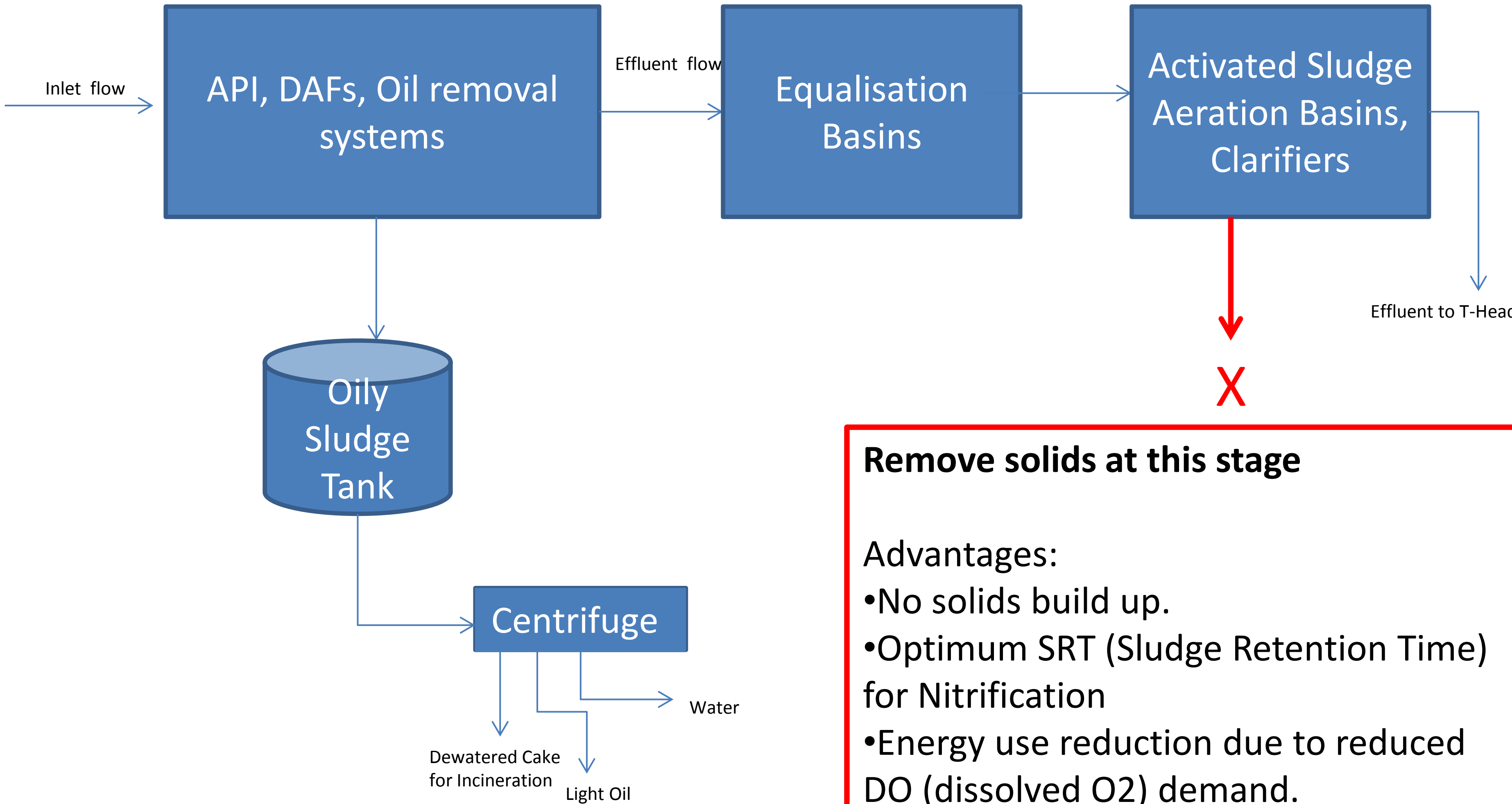
Composition

Particle density

Particle shape

Least important

Solution



Remove solids at this stage

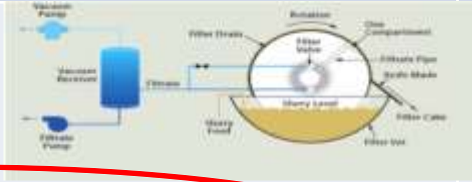
Advantages:

- No solids build up.
- Optimum SRT (Sludge Retention Time) for Nitrification
- Energy use reduction due to reduced DO (dissolved O2) demand.

Bio-Solids Removal Goals

- Need a separate process to dewater biosludge which is independent of oily sludge.
- New process must create sludge within the TPH (Total Petroleum Hydrocarbons) specification.
- Water content of dewatered sludge must be minimised to produce stackable cake.
- Filtrate from dewatering process must be returnable to WWTP.
- Proposed process must be cost beneficial (Cost of installing vs. Savings)
- Minimal operator involvement to run process.

Sludge Dewatering Options Analysis

	Characteristics
Simon Moos Dewatering System and polymer http://www.simonmoos.com/avc-onsite-sludge-dewatering.html	**☺Simon Moos dewatering boxes have associated polymer dosing skid an d pumps** **☺Polymer expertise matched to dewatering technology** **☺Easy implementation** **☺Low capital cost and ongoing operational cost** **☺ Sludge removal is by hooking dewatering box onto vehicle and taking vehicle to disposal location i.e. Minimal handling**
Centrifuge (Hire Centrifuge) or use existing 2-stage centrifuge if not being used for oily sludge) Example: http://www.youtube.com/watch?v=FhS5vN4r5LA	**☺Low capital cost to capacity ratio** **☺Easy to install (or existing)** ☹High maintenance and operator involvement ☹Skilled personnel required for operation
Belt Press Filtration (Hire Equipment) Example: http://www.youtube.com/watch?v=HV6y5bDCJX8	☹Low energy requirements and operator resource intensive. ☹Requires periodic filter media replacement. **☺ Can produce very dry cake.** ☹Sensitive to sludge feed changes and requires sludge grinder in feed system. ☹Requires large capital investment, skilled personnel not required for running
Vacuum Filtration 	☹Very energy and operator resource intensive. ☹Requires periodic filter media replacement i.e. High operational costs **☺ Up to 30% solids content (stackable cake)** ☹Requires large capital investment **☺Skilled personnel not required for running**
Pressure Filtration (Dr. M Technology)  Plate Filter PressExample:http://www.youtube.com/watch?v=g7vump_1zwA	**☺Low suspended solids in filtrate makes it useful for water re-use on other processes** ☹Batch operation (Dr. M filter process can be continuous if multiple filters are used in register arrangement) ☹Skilled operators required ☹Special support structure requirements (Dr M) ☹High Labour cost
Sludge Lagoons	**☺Low energy consumption** **☺No chemical consumption or polymer required.** ☹Low capital cost, only if land is available. ☹Potential for odour and groundwater pollution **☺Least skill required**

Dr. M Fundabac Filtration

- The study was performed on-site at the WWT plant field laboratory.

Aim

- Establish base line for filtration and establish media fouling factor.

Materials & Equipment

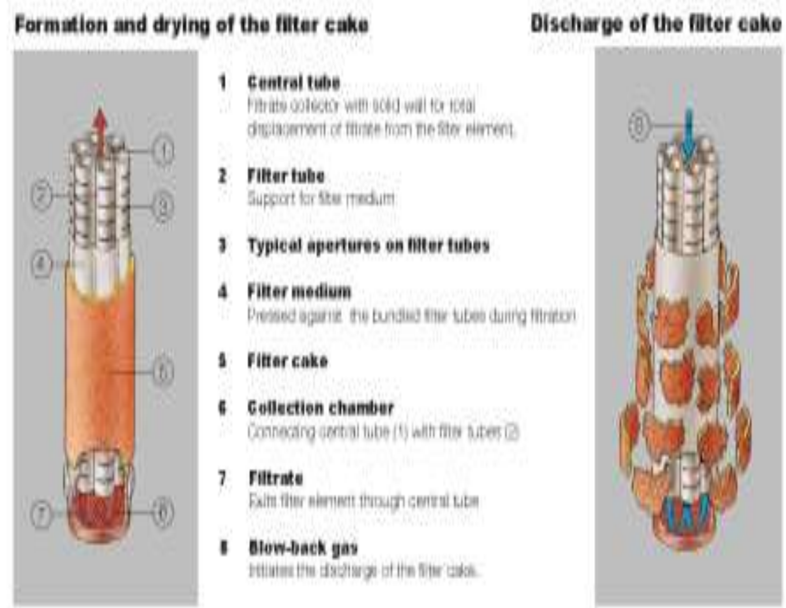
- Dr. M. Nutsche filter unit with a selection of PP filter cloths (2 -100 micron) and a selection of filter aids
- Peristaltic pump

Darcy's Equation

$$\frac{dV_p}{dt} = Q = \frac{\Delta p}{\mu} A \left(\frac{1}{R_m + R} \right)$$

R_m and R are the respective resistances of membrane and growing deposit of the foulants, which we need to minimise


Pressure Gauge
Quick release top feed for pressure pot
Filter holder
Silicone product feed tubing
Variable speed peristaltic pump


Formation and drying of the filter cake
Discharge of the filter cake
1 Central tube
Filtrate collector with solid wall for total displacement of filtrate from the filter element.
2 Filter tube
Support for filter medium
3 Typical apertures on filter tubes
4 Filter medium
Pressed against the bundled filter tubes during filtration
5 Filter cake
6 Collection chamber
Connecting central tube (1) with filter tubes (2)
7 Filtrate
Exits filter element through central tube
8 Blow-back gas
Initiates the discharge of the filter cake.

Results and Insight

- Sludge can be dewatered by filtration.
- At high pressure sludge blinds filter pores due to biosludge rheology – Sludge is non Newtonian fluid: shear thinning at pump pressure. **This means we need passive process.**
- Very high fouling factor without polymer, but worked with polymer addition - **This means we need to use polymer for floc formation.**

Reasons for not using Fundabac

- Would require at least 2 fundabacs working in tandem, possibly more than 2, which is costly.
- Shear stress issues will create future maintenance problems with filters.
- Polymer dosing system will be at additional cost.
- Will require above ground installation to drop dewatered biosludge into tankers underneath the Fundabac - costly

Simon Moos Dewatering Boxes - Lab/Polymer tests

Passive process with integrated polymer dosing system. Sludge and polymer mixing achieved with pipe shape alone.

- We tested 25 different polymers – having established filter dewatering works better with polymer addition.
- Emulsion (oil based) polymers are best but can impact TPH.
- We chose polymer with good floc size i.e. >1mm, but least concentration of TPH from polymer addition.

Simon Moos filter lab test -Pictures

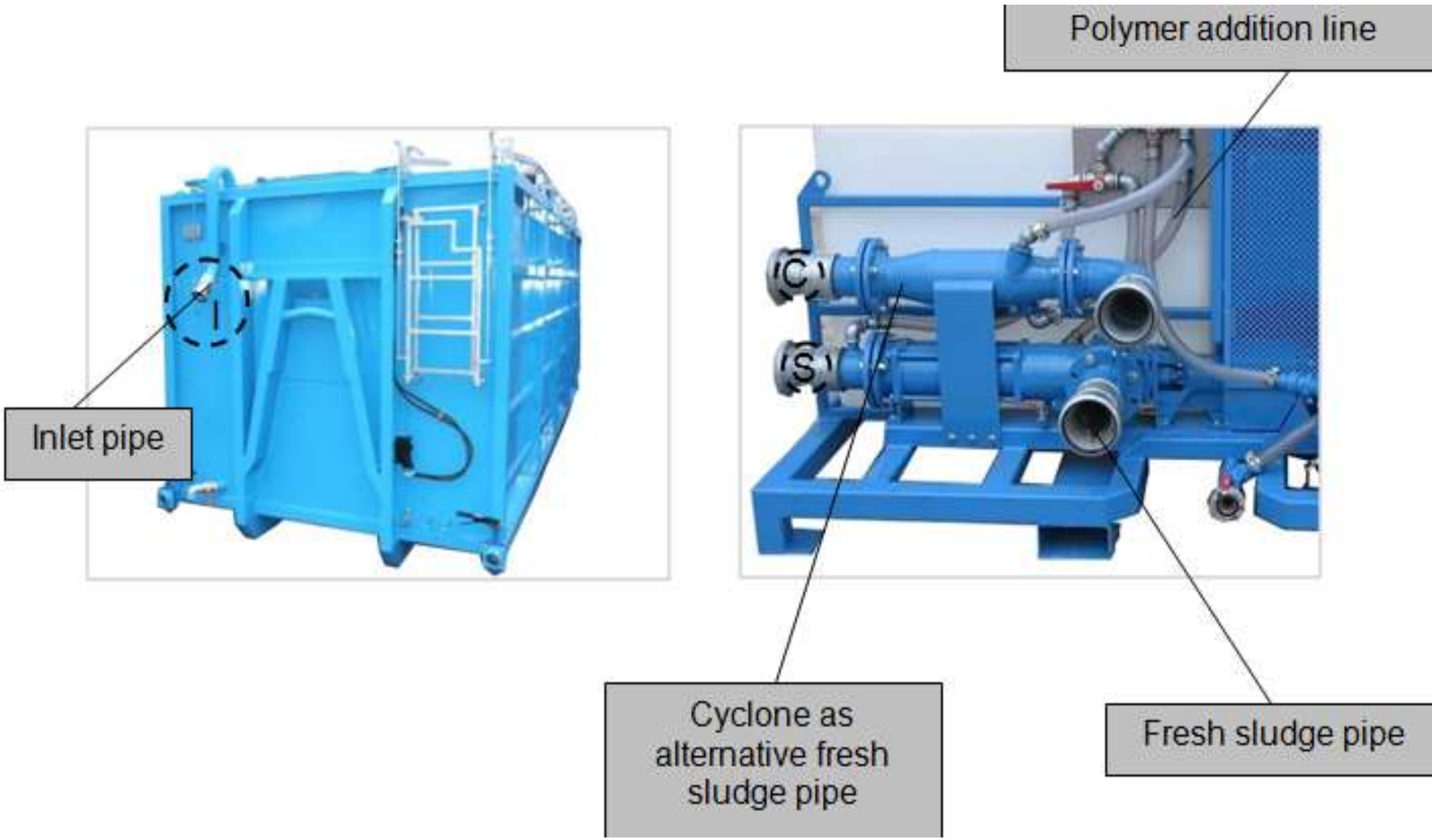
Results

- Sludge can de dewatered with filter, **no filter fouling**.
- Good size flocs with several polymer options.
- TPH <1000ppm i.e. acceptable at non hazardous landfill.

Reasons for using Dewatering Boxes

- Will only need one box on line at any time.
- Passive process requiring minimal process adaptation.
- Box can be filled in situ, sealed, transported away for sludge disposal and returned back to site.
- Low maintenance and minimal operator intervention.
- Filter is cleanable in situ and can be patch repaired.
- Low cost of scaling up and installation.

Dewatering Box Process




Side net
Central net
Side net


Inlet pipe
Top hatches
Ladder

Front

Vent valve

Flocculated Sludge Inlet pipe

Ladder

Manual pump (Opening / closing of the rear hatch)

Drain valve for draining filtered water - Filtrate

Sample outlet to test clarity of filtrate

Drain valve for draining filtered water - Filtrate

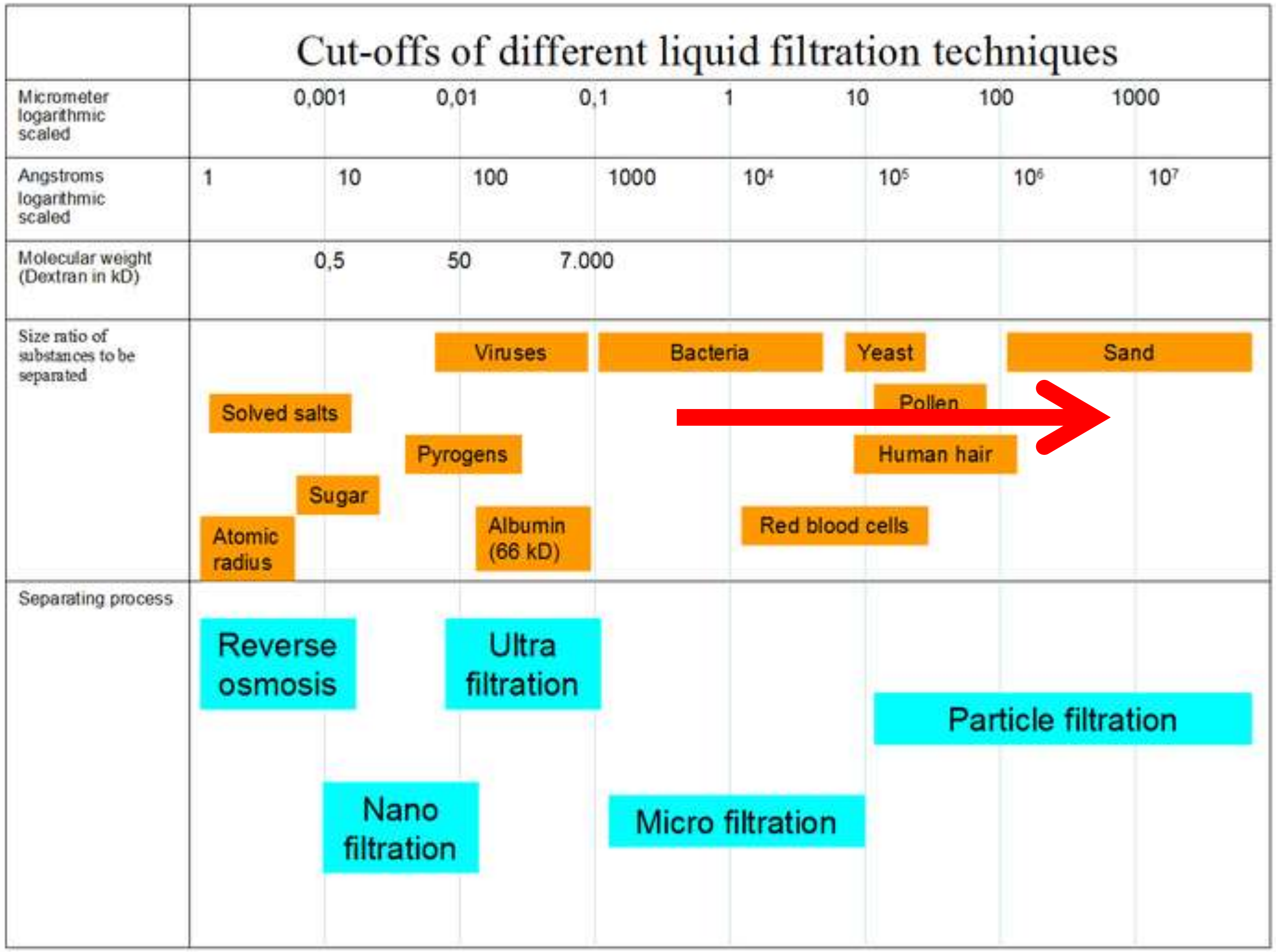
Our Boxes!

Our two boxes

Why does the filter membrane work?

- The pore size is 600 microns and the material is made from woven polyester.
- There is no special coating on the material, but epoxy coating in the box walls.
- It is a classic filter membrane, however **it is woven in a way that it is very smooth in one direction i.e. If you were to run your finger nail from top to bottom you wont feel any resistance. But if you went the opposite way you would feel a resistance.**
- **Filter is set up within the box at a particular tension.**

Hence filter cake peels easily off the filter from top to bottom and self dewaters.



Filtration requirement was moved to the right, which meant:

- **cost reduction**
- **ease of implementation**
- **and reduction in expertise requirement.**

Additional (Pre) commissioning activities

- Document preparation PFD, P&ID generation, SOP (Standard Operating Procedures).
- HAZOP and Risk Assessments
- Scaling up polymer addition rates
- Contractor approvals and engagement
- Construction and Installation (Boxes and Utilities)
- Punch listing – Check P&ID vs. actual build
- Training

Start up and Testing

- Verification against original goals
- Testing filtrate quality for TSS (Total Suspended Solids) and COD (Chemical Oxygen Demand)
- Testing product quality for non hazardous landfill acceptance – TPH WAC (Waste Acceptance Criteria) testing

Disposal

Transport & emptying

Transport of AVC container.

Emptying of AVC container.

Conclusion

Did we achieve our initial goals?

- -Remove bio-solids from the Aeration lanes as WAS - **YES**
- Ensure dewatered WAS is non hazardous – TPH <1000ppm – **YES ~ 200ppm**
- Create stackable cake with low moisture content – **YES <30%**
- Ensure polymer addition : MLSS concentration is minimised – **YES - <45ppm polymer addition to MLSS**