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Process Modeling and Optimization in RAS Design

Economic Implications for Commercial Operations

Prepared For the Aquaculture Innovation Workshop – Nov 5-6, Comox

Presented by Karl Williaume

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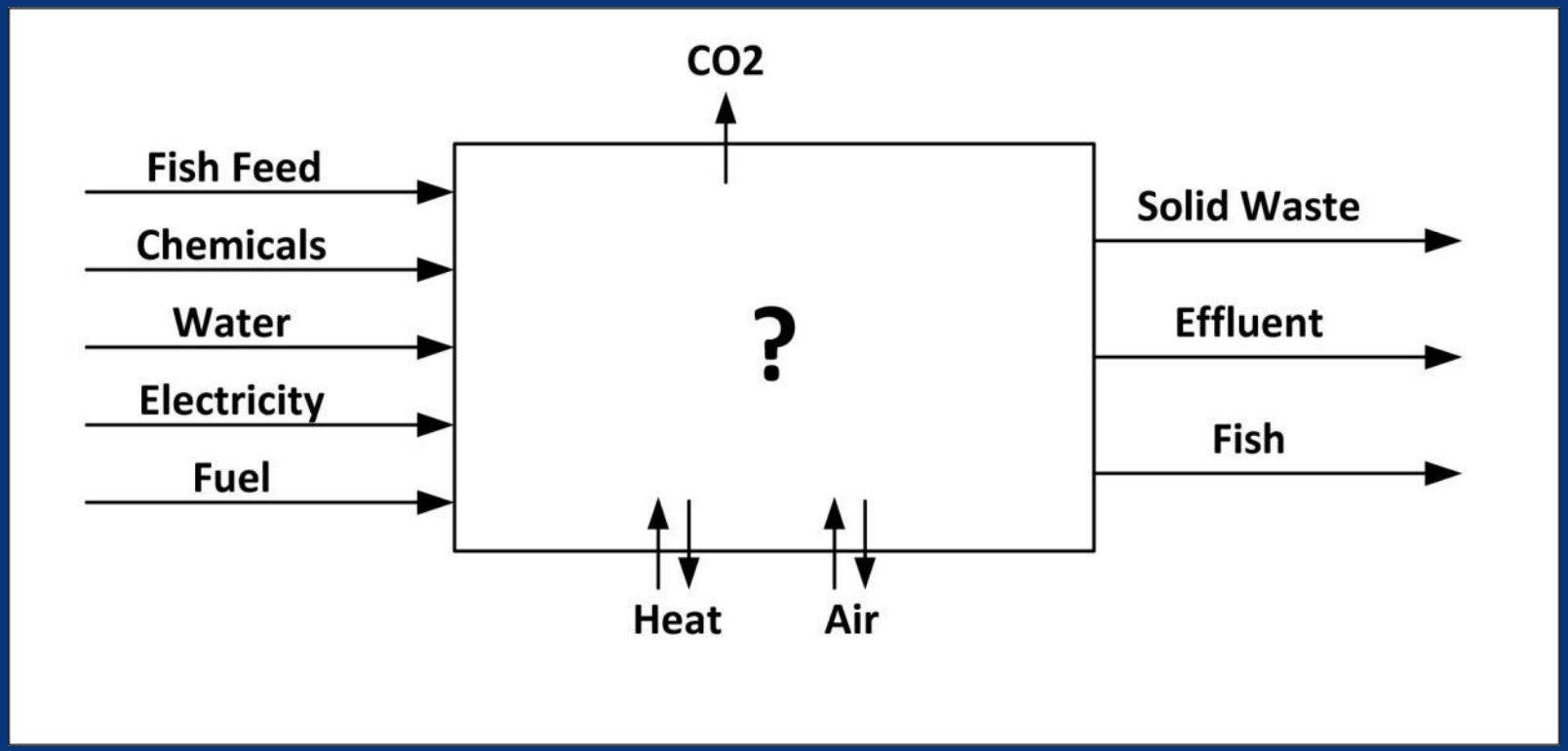
Resource Flow in a RAS Facility



- Challenging economics of commercial-scale facilities require operating costs to be minimized.

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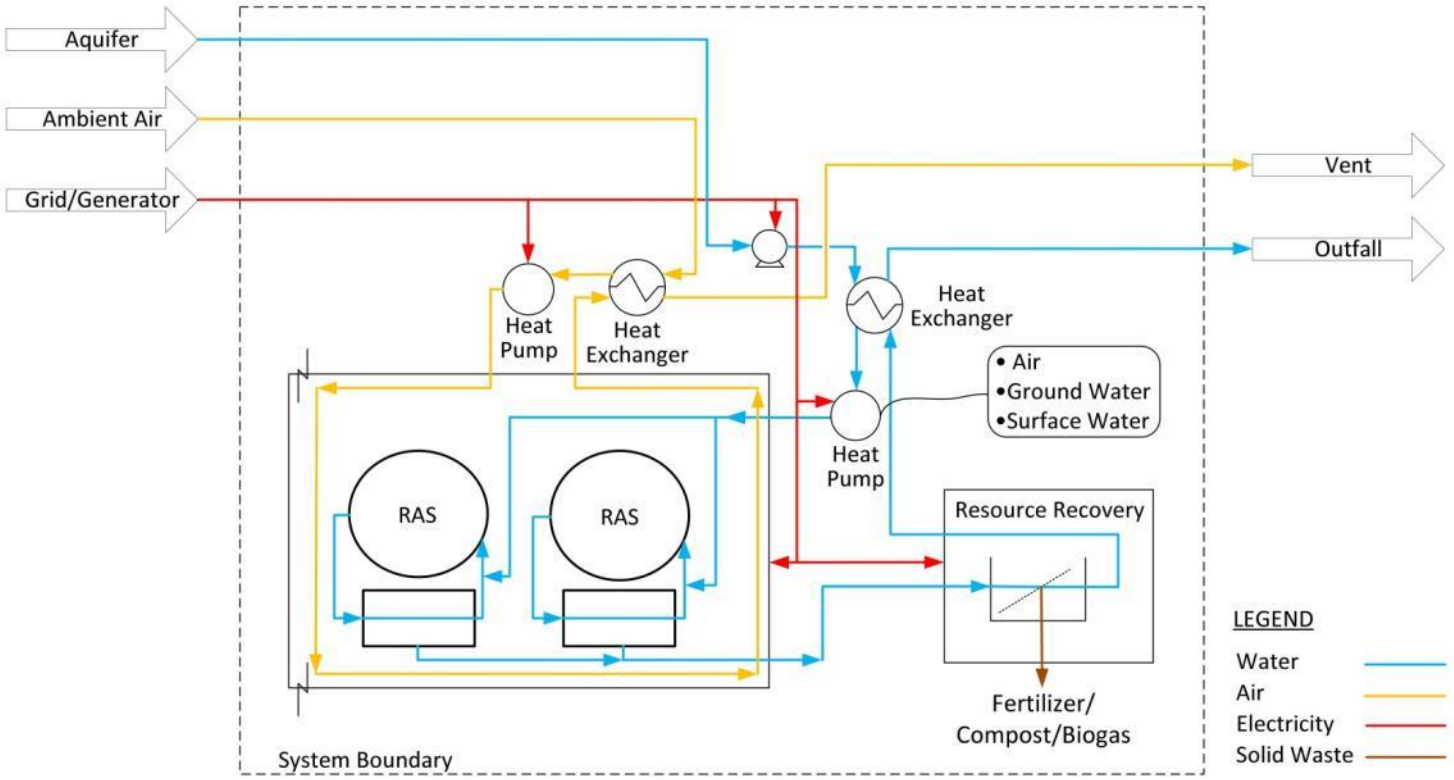
Resource Flow Diagram for RAS Facility



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Key Economic Factors

	Siting	Design
Pumping Energy (process configuration)	√	√
Oxygen source & aeration	√	√
Type of gas transfer device		√
Use of ozone		√
Water heating/cooling	√	√
Biological filtration method		√
Solids removal method		√
Building HVAC	√	√
Alkalinity adjustment	√	√
Biomass density		√
Bioplan and the time dimension		√
Scale	√	√

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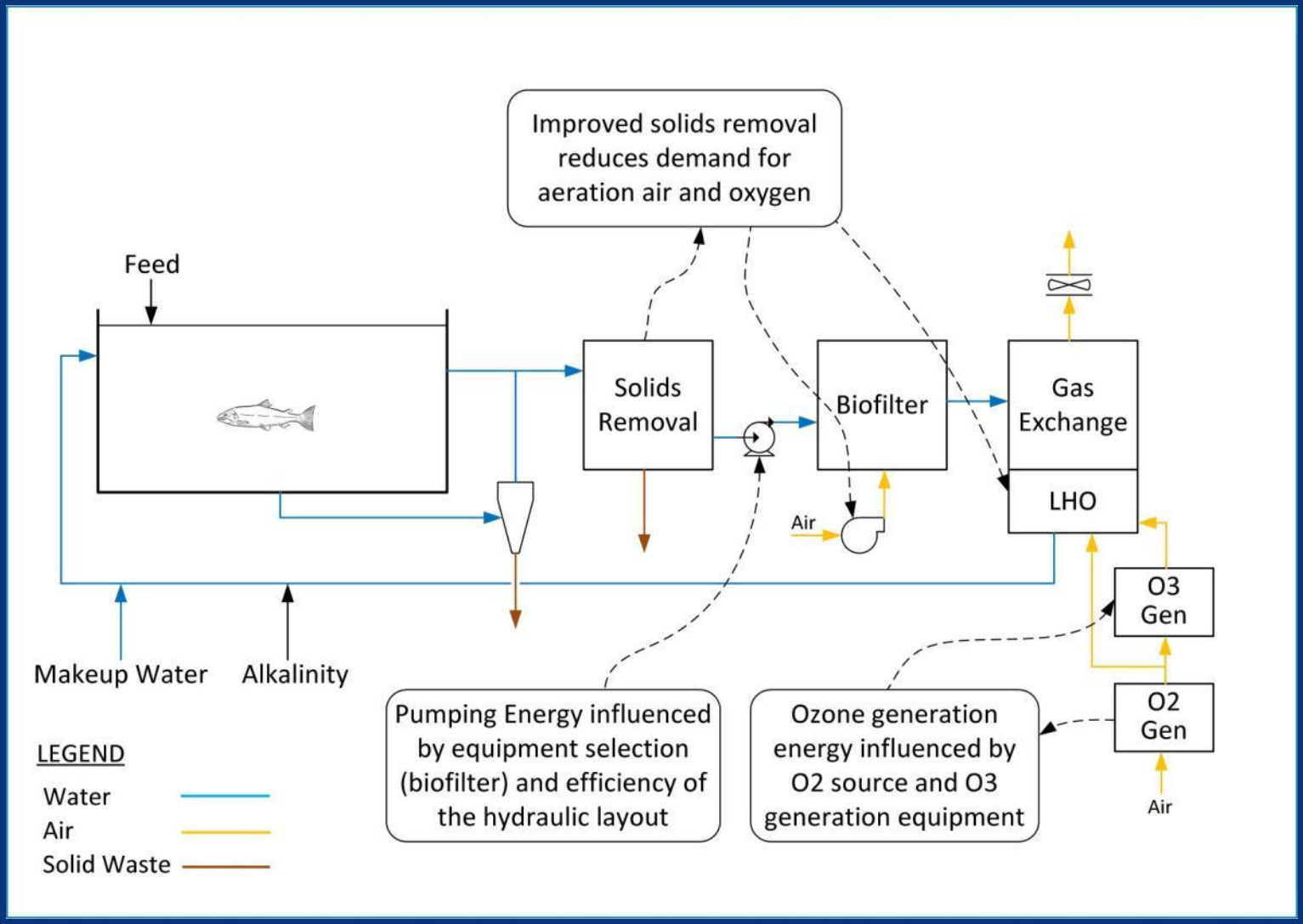
RAS Resource Flow Diagram



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Pumping Energy

- Efficiency of Hydraulic Layout

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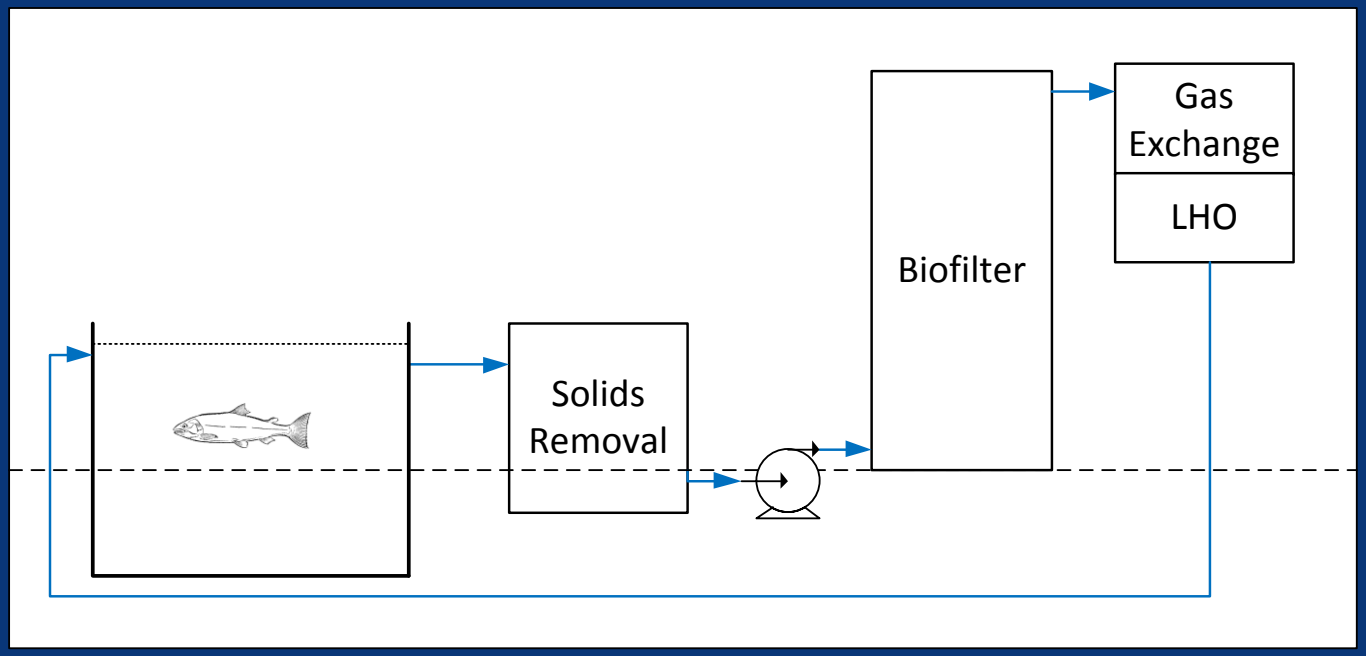
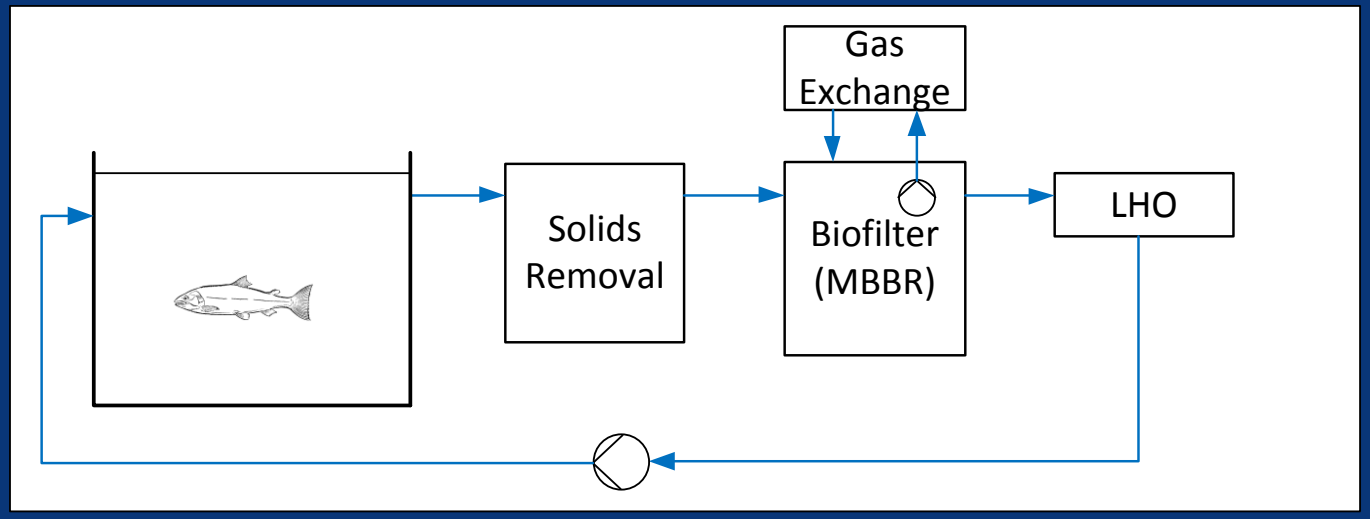
Pumping Energy

Conventional FSB Configuration



MBBR Configuration



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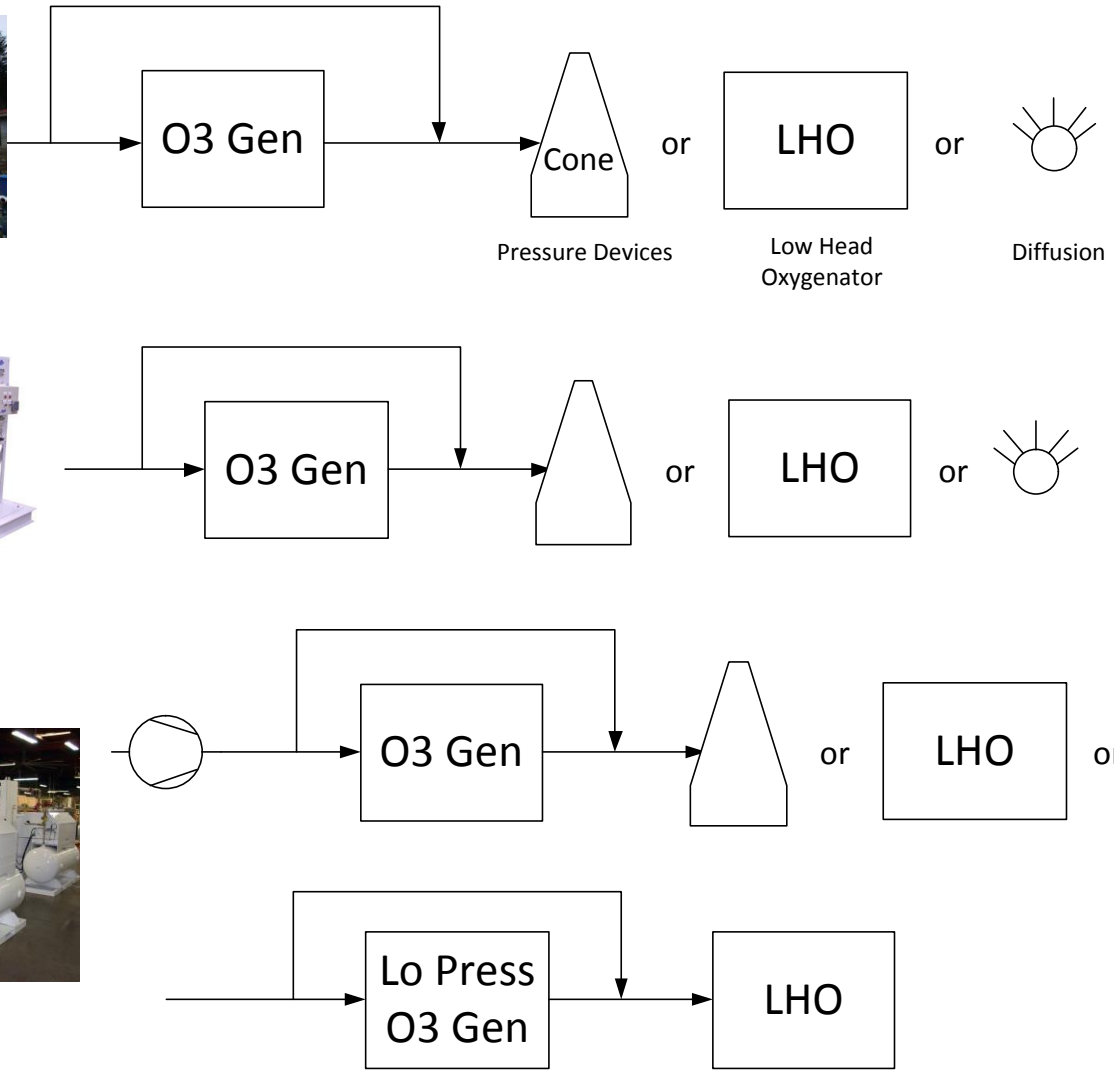
Oxygen / Ozone Supply Choices

LOX

PSA

VSA



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Cost of Oxygen

Source	Operating Cost	Cost with Capital Depreciation	Notes
LOX	$0.35/kg	$0.35/kg	Plus tank rental (minor)
Onsite (Contract) VPSA	$0.22/kg	$0.22/kg	Includes rental
Owned PSA	$0.071/kg	$0.11/kg	Purity 88%
Owned VSA , (low press)	$0.038/kg	$ .094/kg	0.5 kWh/kg @ 93%
Owned VSA , (high press)	$0.045/kg	$0.103/kg	
Owned VSA (supplier 2) (low press)	$0.021/kg	$.062/kg	0.28 kWh/kg @ 93%

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Water Heating/Cooling

- Influent / effluent heat recovery
- Heat Pumps
- Geothermal systems
- Waste heat from nearby industrial facilities

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Comparison of RAS Configurations

- Energy indices such as kWh/kg fish can be misleading
- Operating costs such as Electricity, HC Fuels, Oxygen etc. are interactive and present trade-offs
- E.g. LOX vs onsite O2 generation

	Grid Electricity	Operating Cost
LOX	0.0 kWh/kg O_2	$0.35/kg
Onsite O2 Generation	0.5 kWh/kg O_2	$0.03/kg

- Fair comparison of RAS configurations/facilities should ideally be on a basis of $/kg fish over the entire growth cycle.

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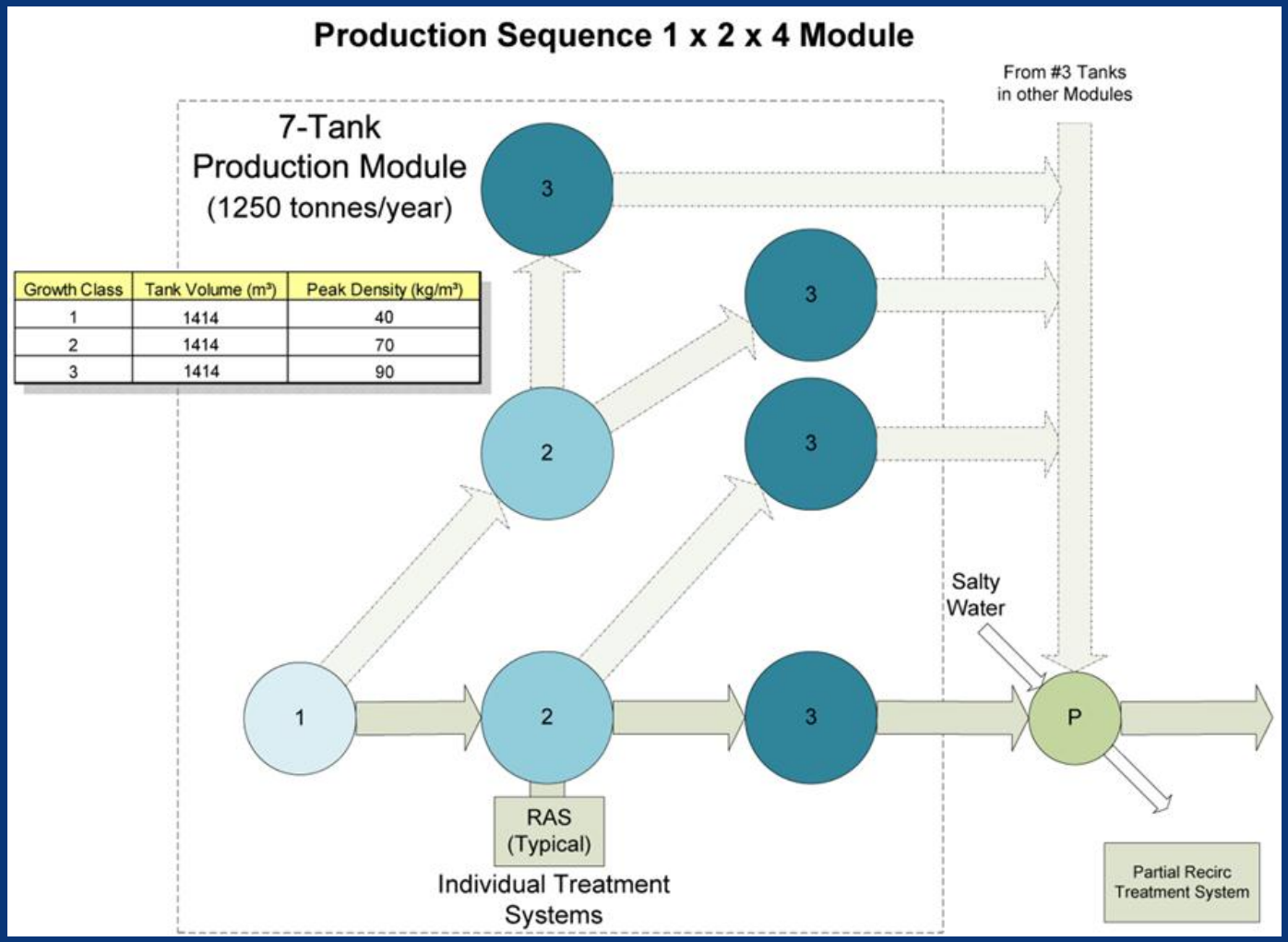
Impact of Bioplan



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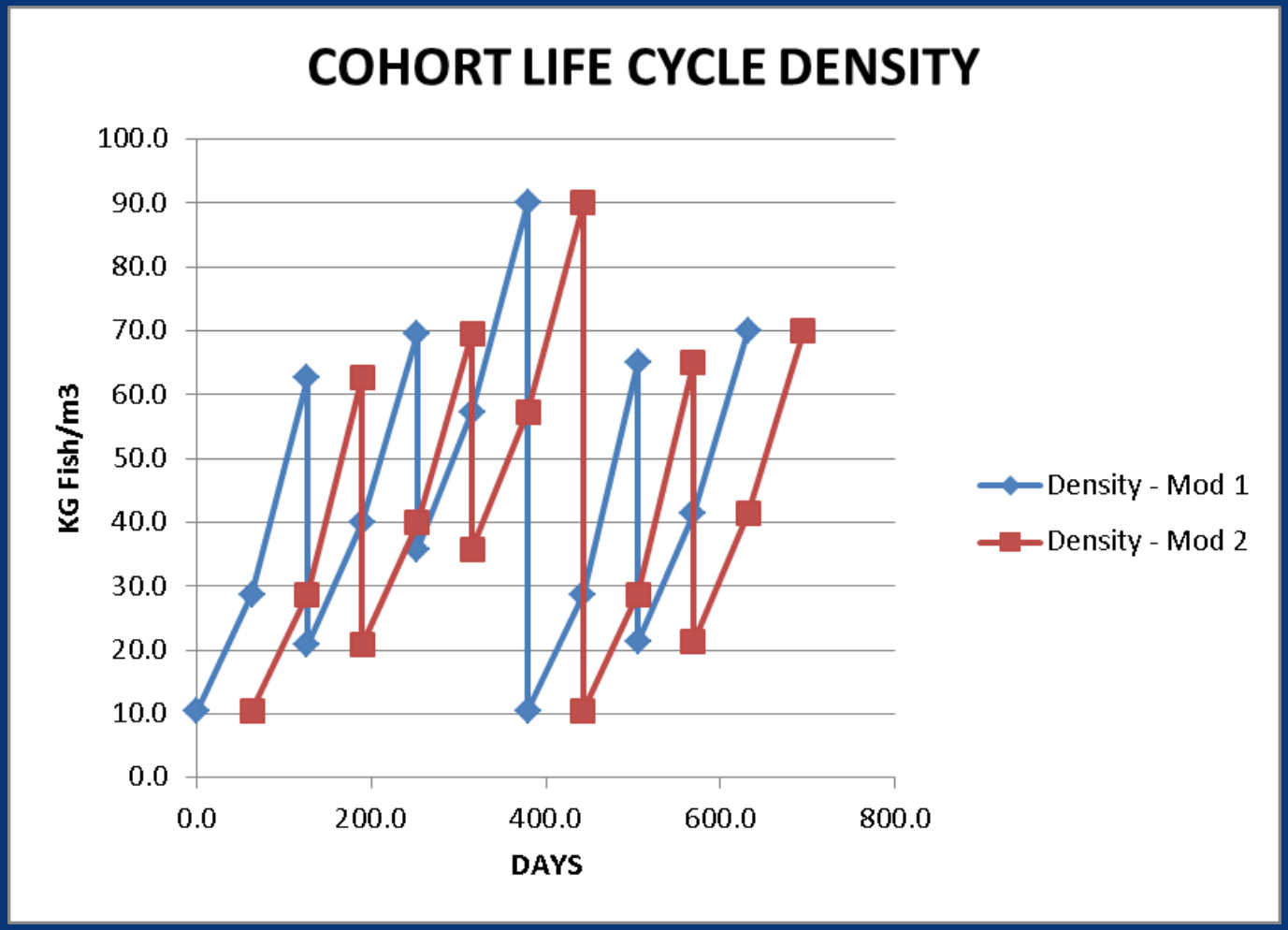
Loading Variability



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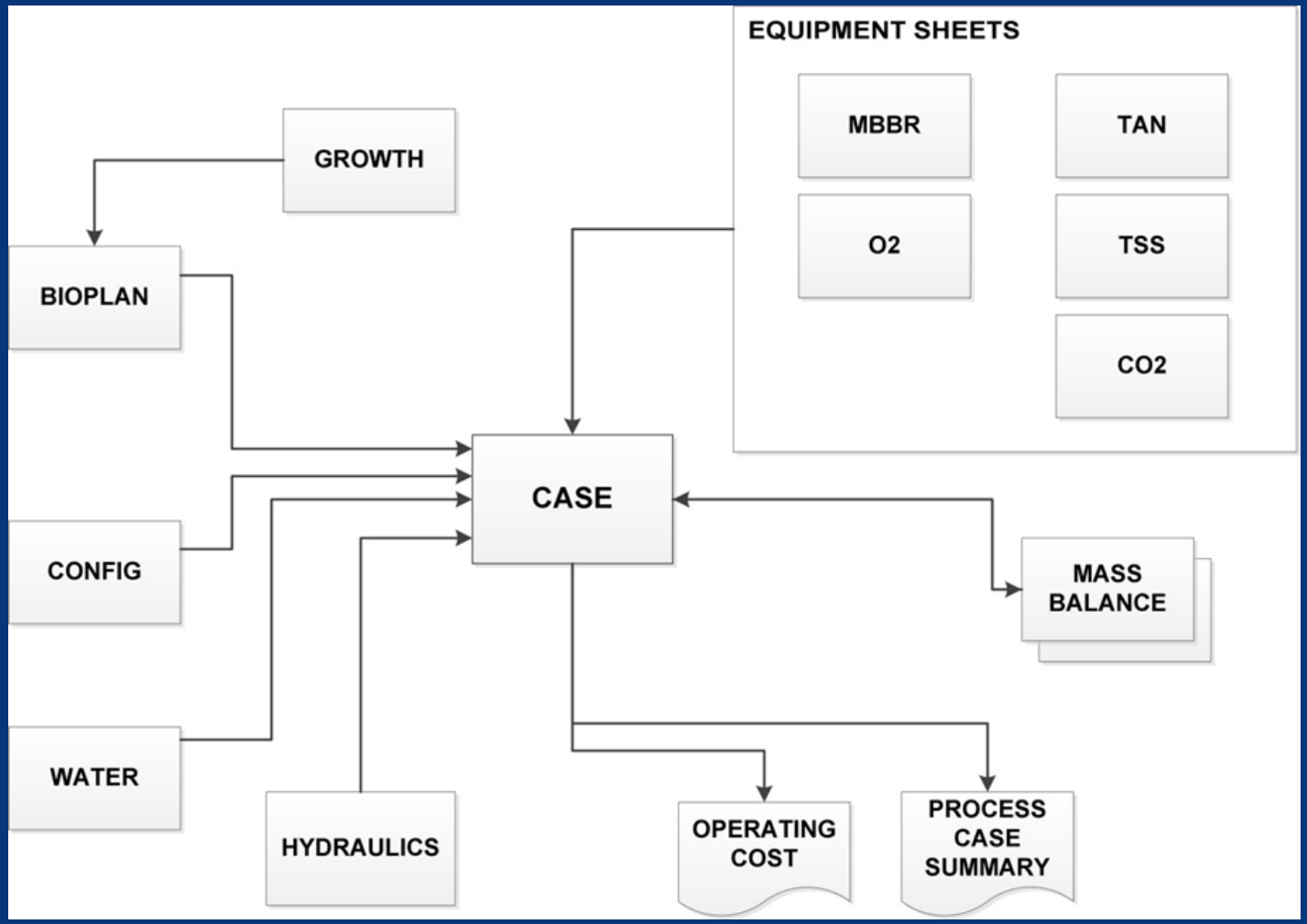
Process Modeling with RASbook



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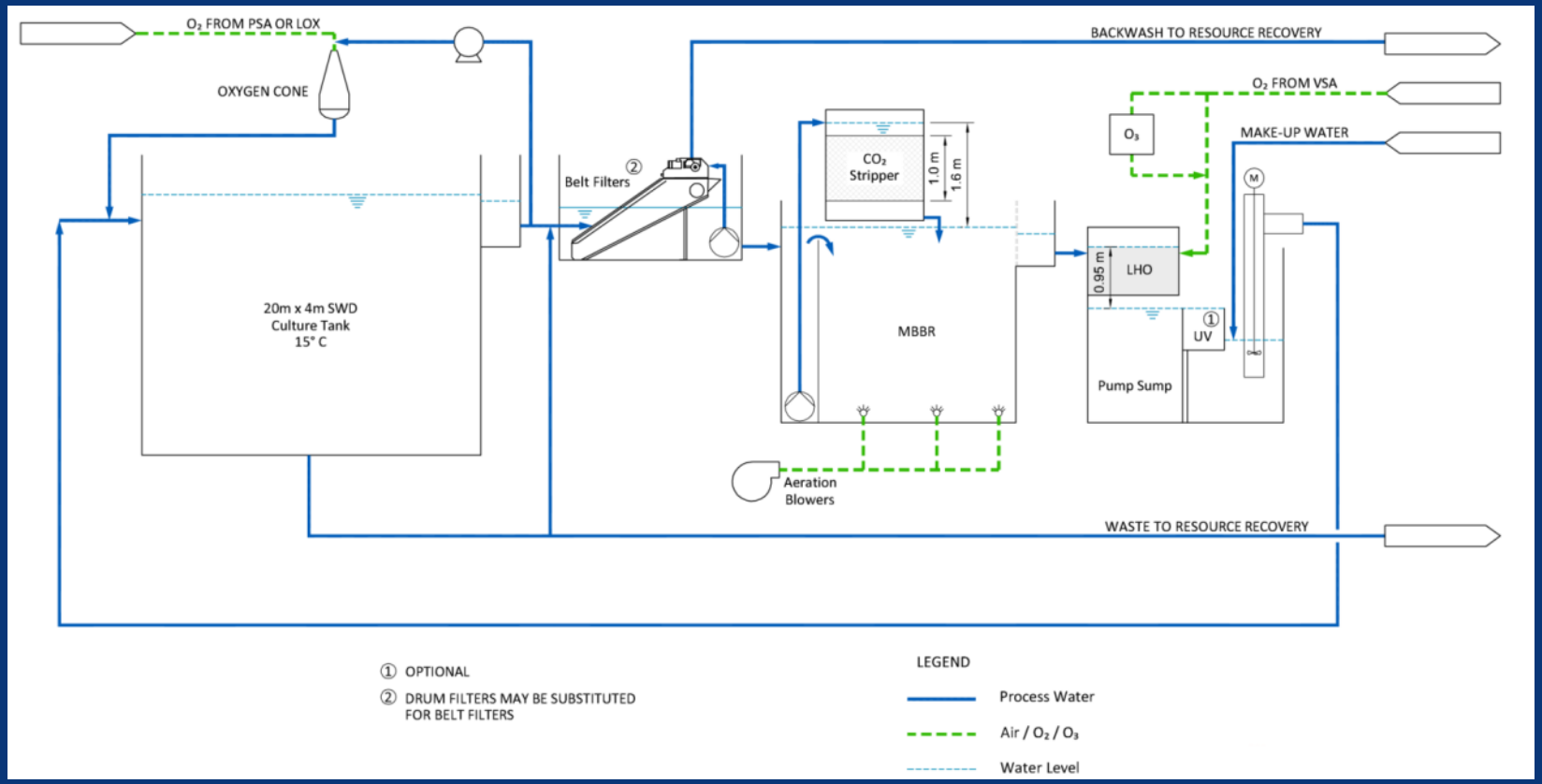
WP Preferred Configuration for Atlantic Salmon Production



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Operating Costs – Optimized Configuration

Component	$/kg Fish (HOG)
Smolts	0.45
Feed	1.96
Oxygen (LOX)	0.01
Electricity	0.22
Fuels	0.00
Chemicals	0.13
Repair & Maintenance	0.39
Labour	0.36
Other	0.30
Subtotal	3.82

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Comparative Impacts

Parameter	Comparison Case	Optimized Case	Impact ($/kg HOG)
Oxygen Supply	LOX + LHO	VSA + LHO	- 0.32
CO2 Stripping	Diffused Air (MBBR)	Packed Tower	- 0.05
Biomass Density	Nom 60 kg/m3	Nom 90 kg/m3	- 0.52
Power Source	$0.12/kWh	$0.06/kWh	- 0.22
Biofilter Type	Conventional FBR	Optimized MBBR	- 0.05

Other impacts of note: Alkalinity, temperature, enhanced solids removal, use of ozone

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Conclusions

- Challenging economics of land-based production requires careful consideration of certain key cost factors
  - At the site selection stage (power cost, alkalinity, etc)
  - At the design stage (scale, biomass density, O2 source, process configuration)
- The only way to do a “fair” comparison of alternatives is to estimate the $/kg fish impacts for the site in question, considering day by day operation over complete cycles.