

# Progressive Water Use Strategies: Conserve Water and Meet Production Goals



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# Reasons for Progressive Water Use Strategies



Competition for Water



Reduced Power Consumption



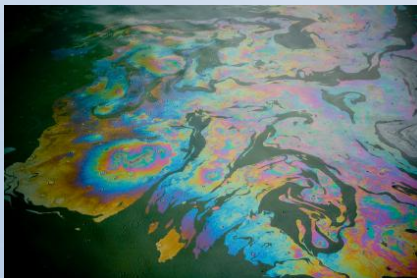
More Control



Water Shortages



Reduced Operating Cost

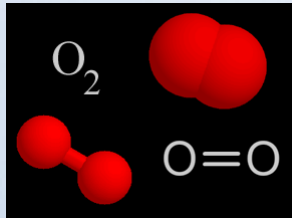


Contaminated Water



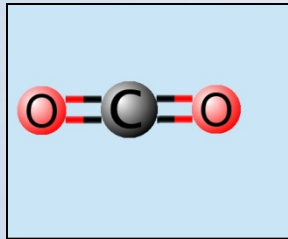
Minimize Effluent Discharge

# Reduced Water Use Results in Water Quality Limitations



Water Quality Parameters Prioritized

1. Oxygen
2. Carbon dioxide
3. Total suspended solids
4. Ammonia nitrogen
5. Etc.



Add treatments for each parameter as that parameter becomes limiting.

# Advanced Strategies for Water Use Improvements

- Influent water conditioning
- Raceway oxygenation
- Serial water reuse
- Partial Reuse Aquaculture System (PRAS)
  - Circular tank partial reuse
  - Raceway partial reuse

# Selection of a Water Use Strategy

Find balance between conflicting objectives:

- Maximize fish quality and health
- Minimize capital cost
- Minimize operating cost
- Minimize risk
- Maximize production

Limit the “Total Cost” which includes:

- Single expenditure capital costs
- Recurring operating costs
- Risk related costs



# Raceway Oxygenation

## State of California: Darrah Springs

- No changes to raceway infrastructure or water use
- Low Head Oxygenators (LHO) installed at equal intervals to boost DO
- Oxygen supply via Oxygen Generators (LOX is good alternative)



# Raceway Oxygenation Results

## Benefits

- Achieve higher densities while maintaining acceptable DO ( $>7$  mg/L)
- 50% increase in production without additional water
- Minimal infrastructure changes required

## Risks

- May result in water level changes in raceway (12-24 inches head required at each LHO)
- Increased complexity and maintenance requirements
- Once using oxygen, are reliant on it; mechanical failure risk.

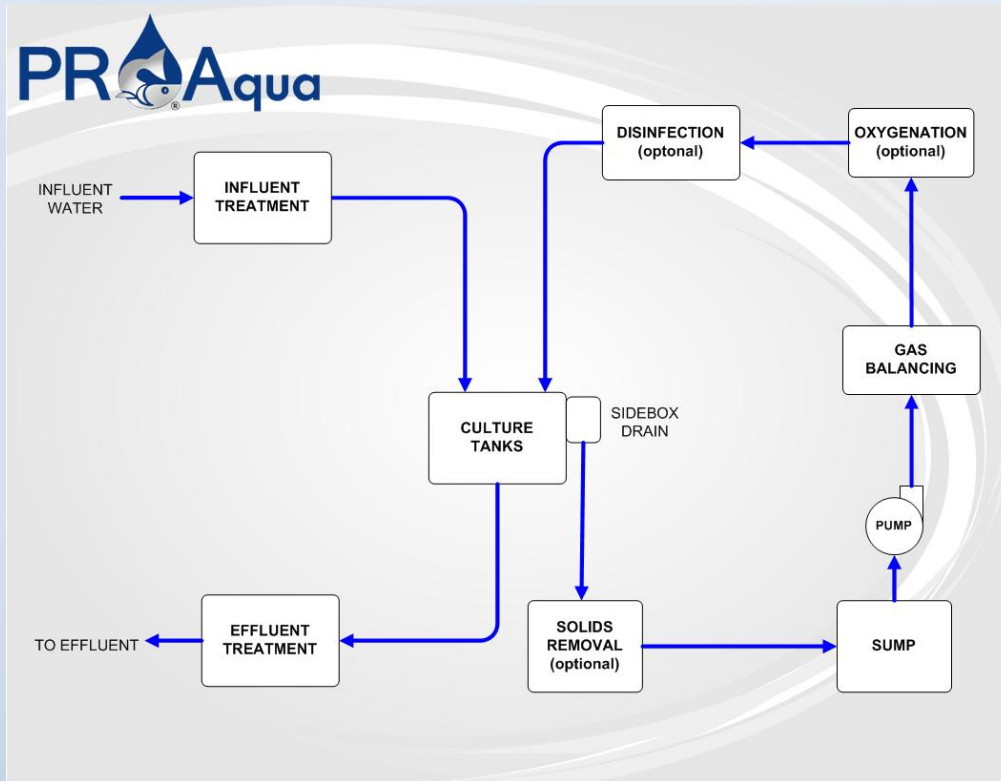
# Partial Reuse Aquaculture Systems (PRAS)

- Use a few, simple water treatment processes to allow a portion of the culture discharge water to be recycled
- Use flushing and water replacement to control parameter for which treatment is not provided





# PRAS Treatment Process



## Required Processes

- Pumping
- Gas Balancing (Aeration/CO<sub>2</sub> Degassing)

## Optional Processes

- Solids Removal
- Oxygenation
- Disinfection

# Typical PRAS Water Quality

Design for:

- Steelhead @ 100 g
- 330 m<sup>3</sup> (11,655 ft<sup>3</sup>) tank volume
- 9,000 kg production per crop

Parameter	Units	70% Reuse Rate
Culture flow rate (max, total of all tanks)	Lpm (gpm)	7,571 (2000)
Reuse Flow Rate	Lpm (gpm)	5,300 (1400)
Influent Flow Rate	Lpm (gpm)	2,271 (600)
Maximum temperature	°C (°F)	15 (59)
pH	-	7.3
Salinity	ppt	0.00
Alkalinity	mg/L as CaCO <sub>3</sub>	130.0
Max TAN concentration	g TAN / m <sup>3</sup>	1.32
Max NO <sub>3</sub> -N concentration	g NO <sub>3</sub> -N / m <sup>3</sup>	0.0
Max CO <sub>2</sub> concentration	g CO <sub>2</sub> / m <sup>3</sup>	12.0
Min DO concentration (at culture tanks)	% of sat	70%-100%
Max supply DO concentration	% of sat	<160%
Max TSS	mg/L	<5 mg/L

# Partial Reuse Systems for Raceway Culture



Raceway PRAS are more difficult:

- Plug flow does not provide for rapid mixing of oxygenated water
- Water degrades from one end of the raceway to the other
- Solids tend to remain in the system longer due to low velocities.

However, if **properly applied**, raceway PRAS is possible.



## Raceway PRAS Pilot Freshwater Fisheries Society of BC





# Raceway PRAS Design

- Reuse water pumped from tail end of raceway to treatment system installed at the head of the raceway.
- Maintain high water flows to promote solids movement to tail of raceway. Possibly use baffles to promote solids movement.
- Pumping system designed to minimize turbulence and breakdown of solid wastes. Water drawn from high in the water column.
- Water flows, equipment placement, and equipment size important to ensure adequate mixing of oxygenated water.



# Raceway PRAS Results

- “Pilot achieved a range of 35% to 41% of the electrical energy and associated energy costs of the existing single-pass water delivery system now in place at this hatchery.”
- Anticipated to reduce long term maintenance costs due to the reduction in water withdrawals and pumping needs.
- “No significant differences were noted in the health, mortality or fish culture performance of any of these groups of fish.”
- More comprehensive study of water quality and fish health impacts should be conducted.

# Partial Reuse Systems for Circular Tanks

- Ideal for PRAS
- Excellent mixing of new oxygenated water
- Equal utilization of full volume
- Self-cleaning feed and feces
- Range of swim speeds
- Morts and solids get directed to center of tank



# Circular Tank PRAS: Design and Layout



## Decentralized Treatment Strategy

Treatment of water occurs at each individual culture tank.



## Centralized Treatment Strategy

Water from the culture tank is collected, piped to a common water treatment plant, and then redistributed to the culture tanks.

# Decentralized PRAS



## Advantages:

- Limits piping requirements
- Limits head requirements
- Limits risk of disease transference between tanks
- Modularity limits risk of mechanical failure
- Equipment is small and manageable

## Disadvantages:

- Microscreen filtration for removal of small particles may be cost prohibitive
- More pieces of equipment to operate and maintain
- Requires distribution of power



# Centralized PRAS



(Photos of White River Hatchery PRAS, courtesy of The Freshwater Institute)

## Advantages:

- Economies of scale; reduced capital cost.
- Microscreen filtration is more economical and provides improved water quality.
- Redundancy is more easily provided.
- Fewer pieces of equipment

## Disadvantages:

- Disease transference concerns; disinfection systems required.
- Requires significant piping systems
- Increased head requirements
- Greater susceptibility to mechanical failures if redundancy is not provided.



# Centralized PRAS

## Chelan PUD: Eastbank Hatchery PRAS Pilot



# Chelan PUD: Eastbank Hatchery PRAS Pilot Informal Conclusions

- Excellent survival and fish health
- Returns were quicker and in greater numbers for the re-use group
- “...by study’s end both cohorts were generally comparable in performance, health, and welfare indices, suggesting that partial water reuse technology for rearing juvenile anadromous salmonids can be employed without negatively affecting fish quality.”
- “The results of this pilot study demonstrate that juvenile Chinook salmon can be raised in a partial water reuse system environment with comparable performance and survival to those reared in traditional flow-through raceways.”

# Things to Consider During Planning

- Collect data in advance:
  - Biological data (TUG, K, oxygen consumption)
  - Influent data (Water quality, gas content, and temperature characterization)
- Retrofit or New
  - Sometimes working around existing infrastructure is more costly than removal
- Cover it?
  - Building or tank enclosures are important for biosecurity, exposure to the elements, and better control
- Sludge handling
  - Reduced effluent volumes but at higher waste concentration. Plan for sludge handling capacity.

# Summary: Benefits of Advanced Water Use Strategies

- Significantly reduced water consumption and effluent volumes
- More controlled environment
- Reduced energy consumption
- Site placement is less dependant on water availability
- Improvements in fish health and conditioning
- More economical influent treatment and effluent treatment
- MORE FISH with LESS NEW WATER

# Questions?

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