



FRRRO for High Recovery: City of Santa Monica

February 29, 2024 / Adam Zacheis

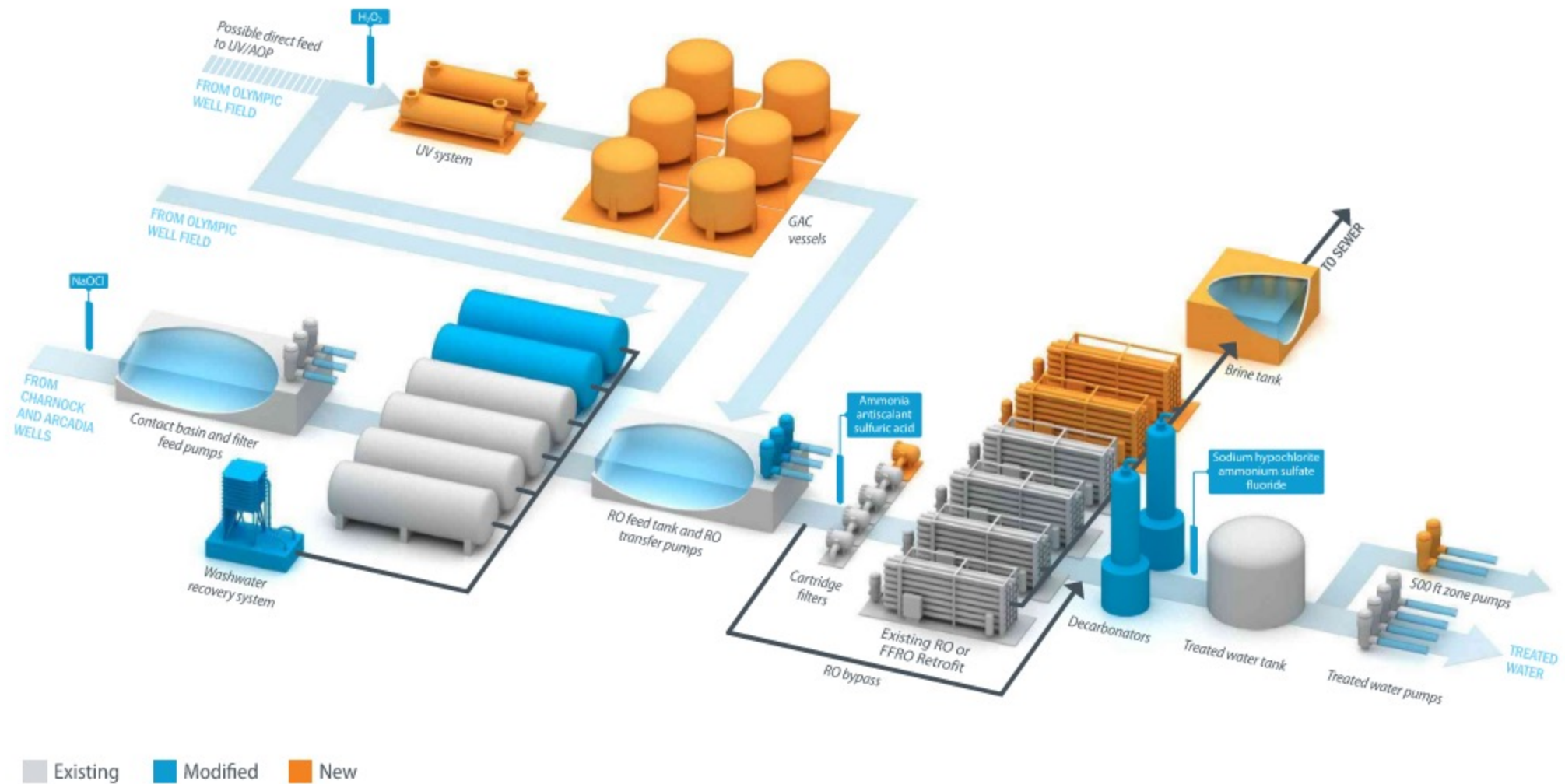


City of Santa Monica aims for water self-sufficiency.

- Currently 60% local supply, 40% imported
- Arcadia WTP currently treats groundwater from Arcadia and Charnock well fields
- Groundwater production nearly capped
- New Olympic Wells require VOC and 1,4-dioxane treatment



Arcadia WTP Expansion and Olympic Well Field Restoration Project Process Flow Diagram



Looking Beyond Conventional RO for Higher Recovery

- Increase RO system recovery to 90% to minimize groundwater pumping
- Pilot testing completed
 - Refine design criteria
 - Confirm RO permeate water quality (contaminant rejection and adjustments to post treatment)

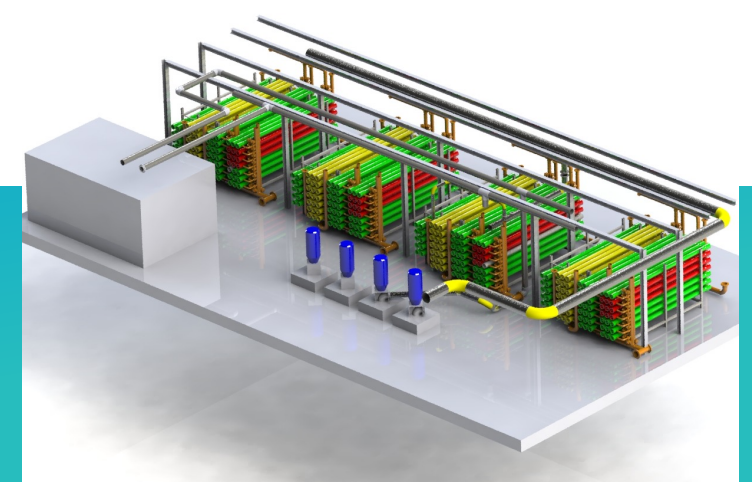
Original RO System



CCRO



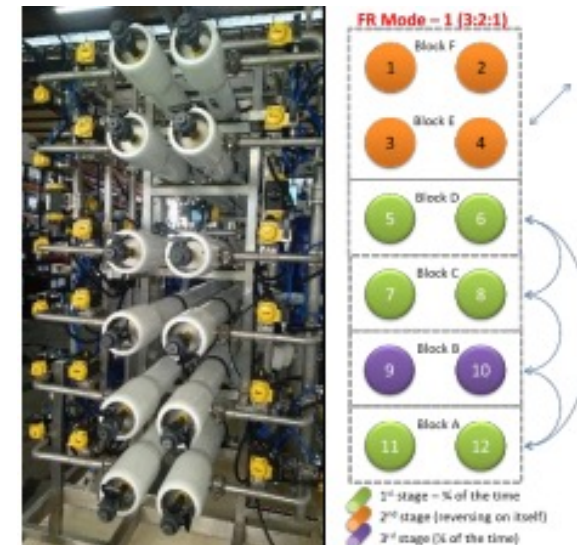
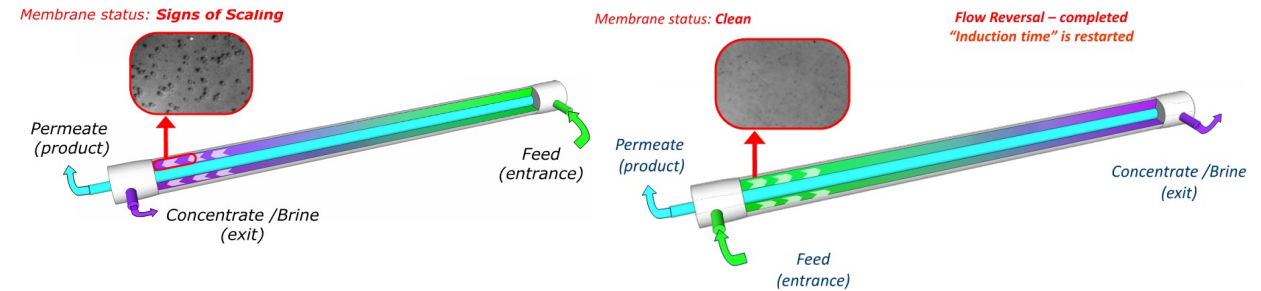
FRRO



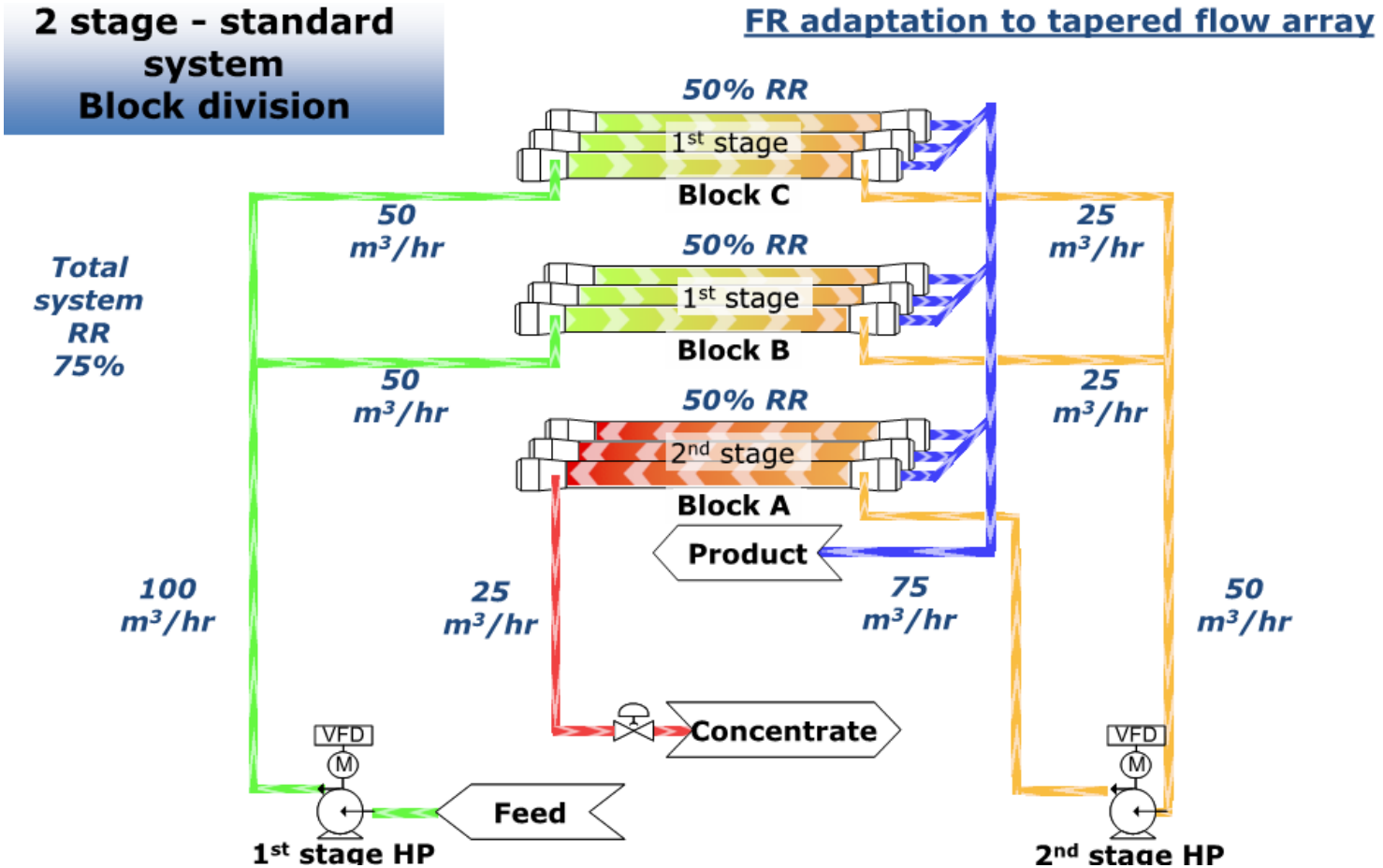
Overview of Flow Reversal Reverse Osmosis

FRRRO employs two techniques to increase recovery

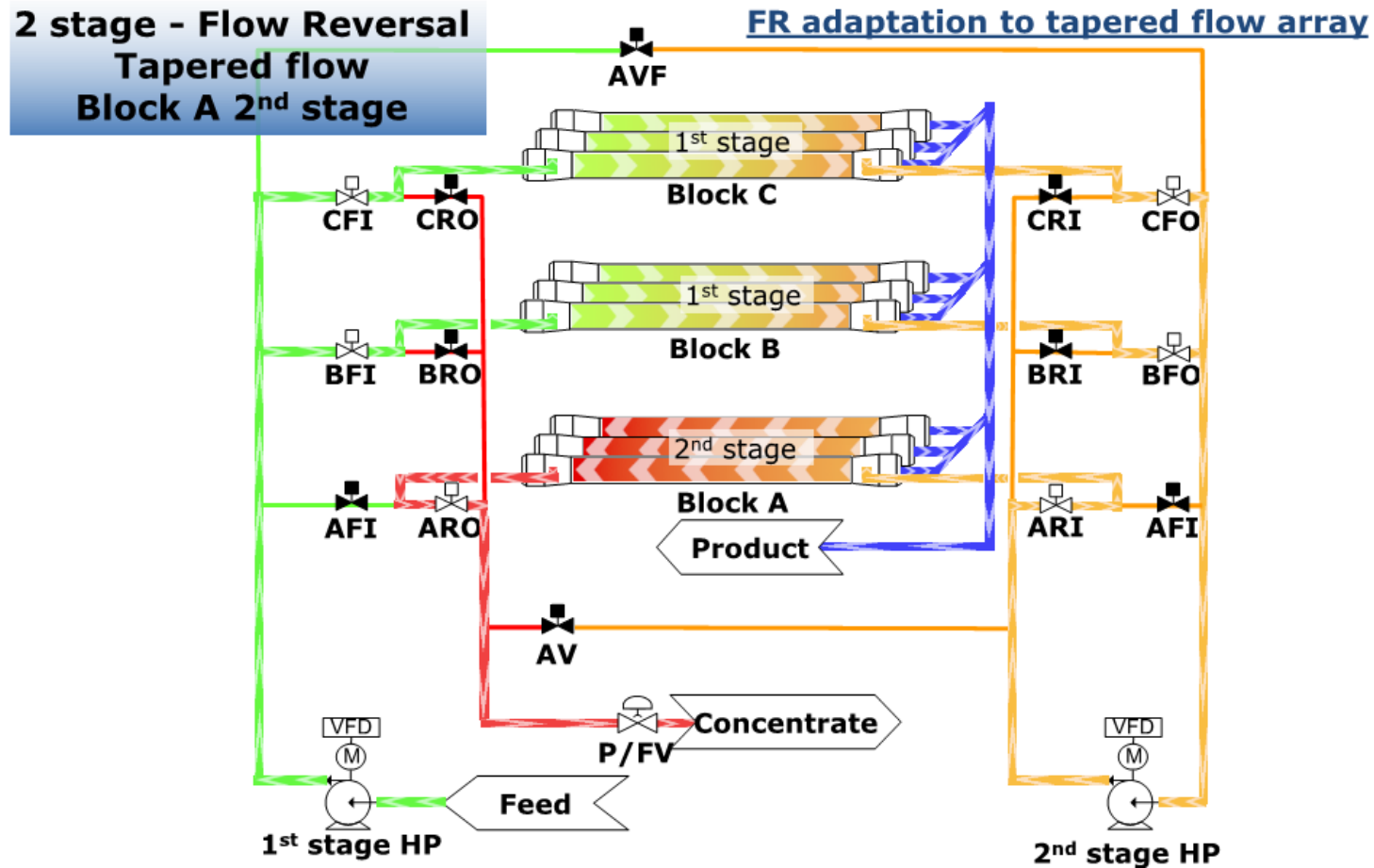
- 1. Flow reversal:** pneumatic valves on each set of pressure vessels occasionally actuate to reverse flow to restart induction time by maintaining under-saturated conditions and sweep away the beginning scale particles in the concentrate before they exceed a critical size to prevent precipitation
- 2. Stage rotation:** each flow reversal cycle also rotates the last stage, which typically treats the most challenging water quality, within first stage of pressure vessels to reduce the load on any given set of pressure vessels



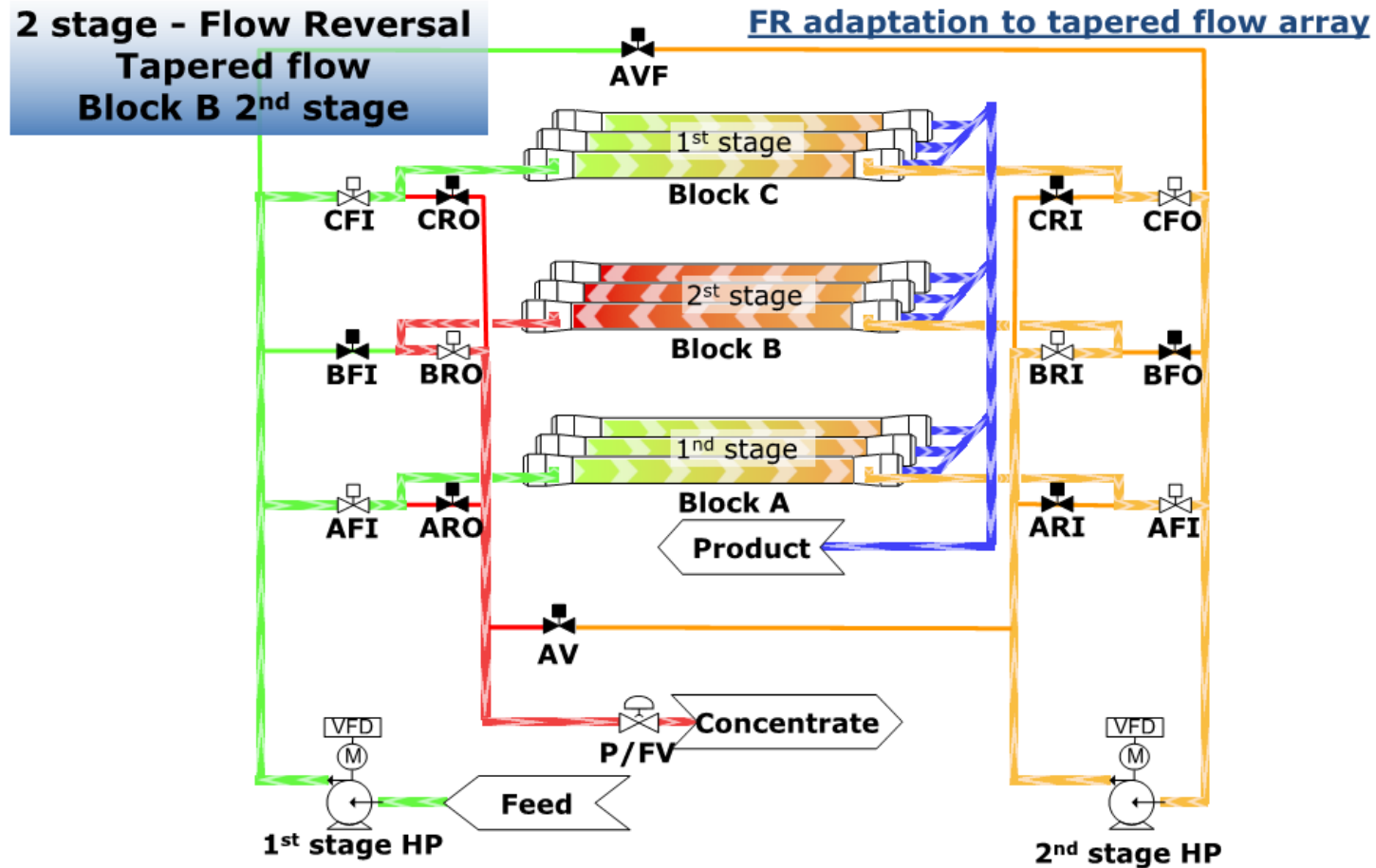
Conventional RO System



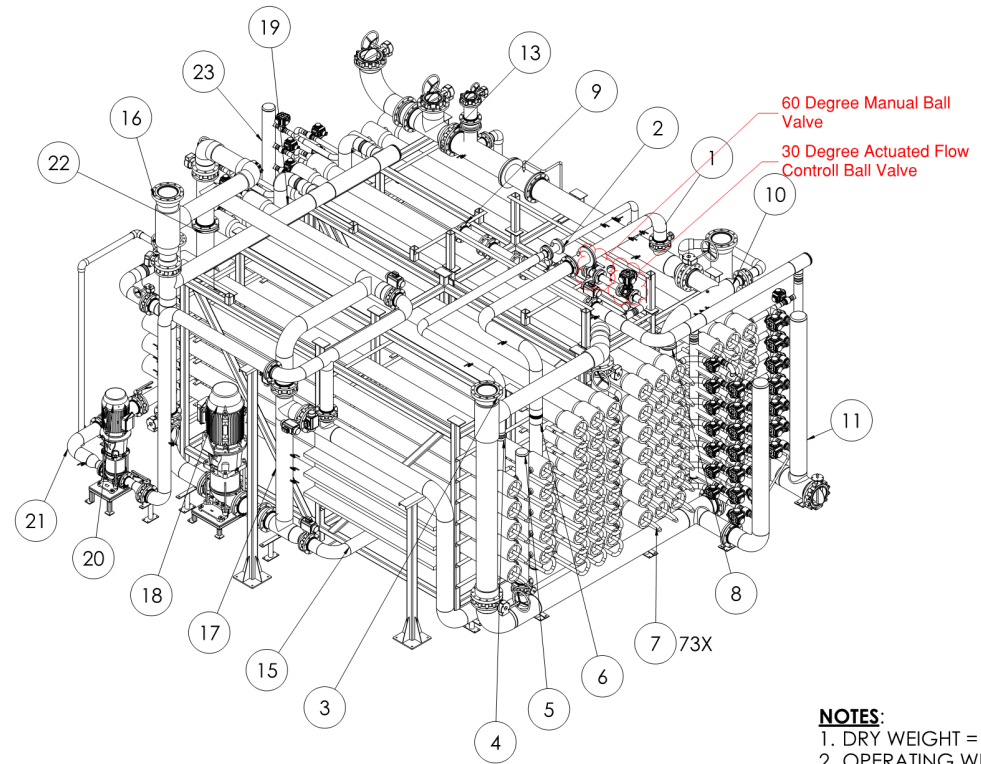
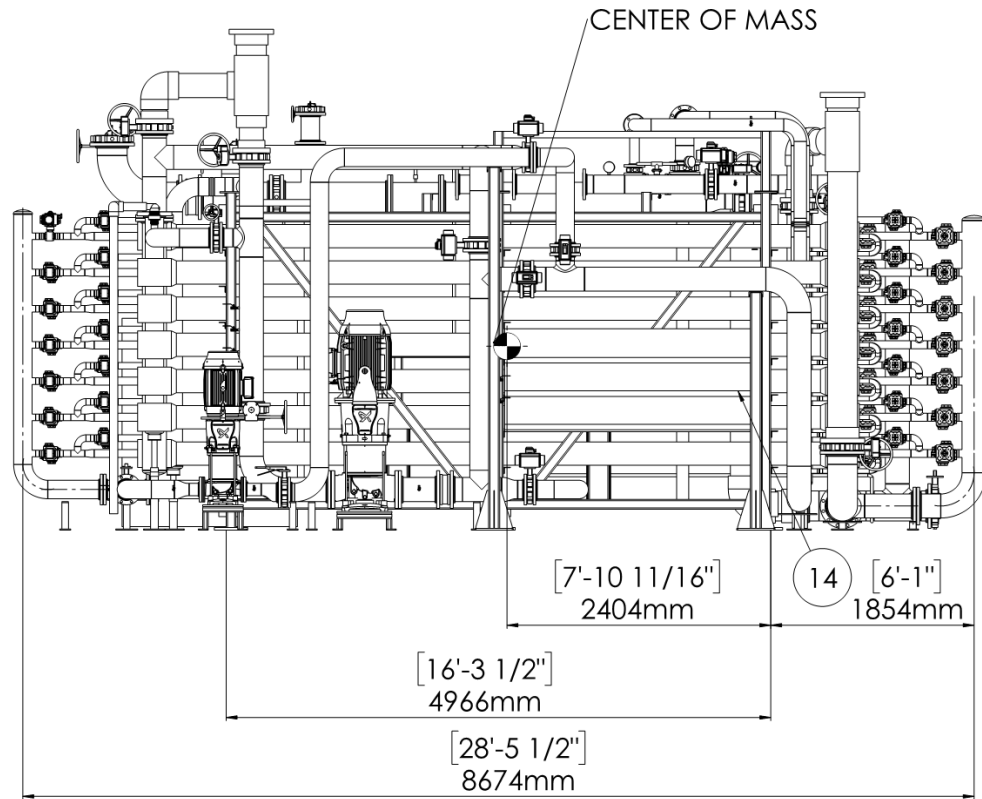
FRRRO System - 2 Stage



FRRRO System – Block Rotation



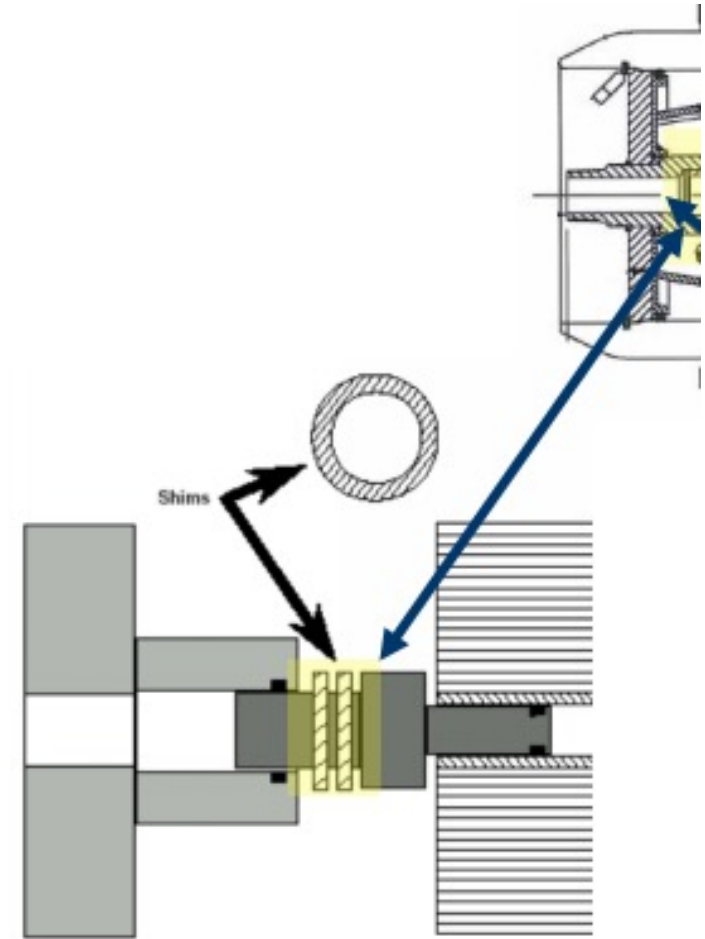
FRR0 System Full Retrofit of Existing System



NOTES:
 1. DRY WEIGHT = 43000 LBS
 2. OPERATING WEIGHT = 73000 LBS

Membrane Element and Support Considerations

- Thrust cones on both ends of vessel
- Proper shimming
- Comments from Membrane Vendors
 - Toray – patented "bi-directional" split-ring brine seal required (e.g., TMG20D-400SR)
 - Hydranautics – any membrane element is acceptable but patent-pending support system is required



Acknowledgements

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