WATER RECYCLE/REUSE IN WOOD PRODUCTS AND BIOENERGY INDUSTRIES

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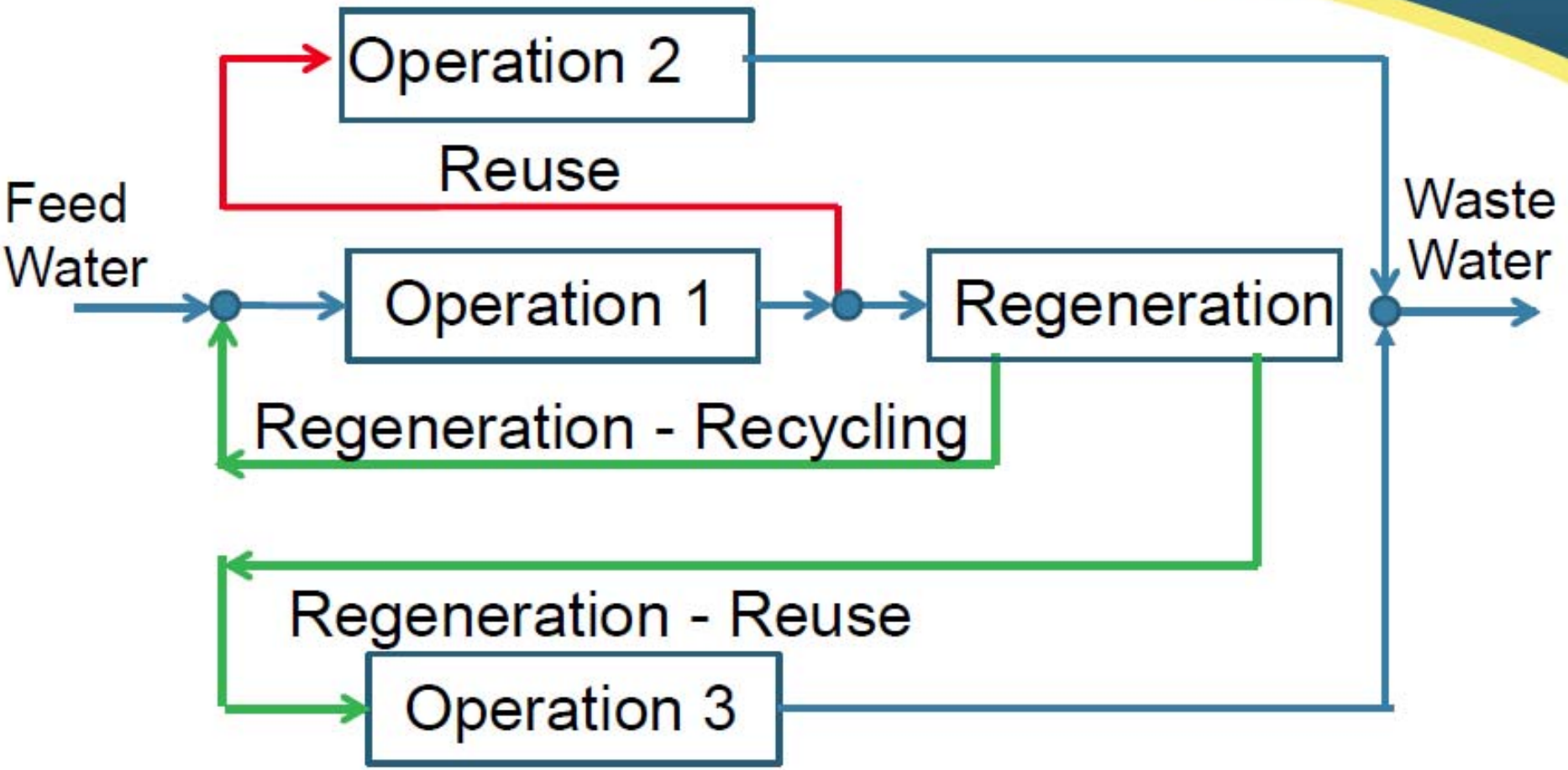
Types of Onsite Water Reclamation



Klemeš, J.J. Industrial water recycle/reuse. Current Opinion in Chemical Engineering (2012), 1:239.

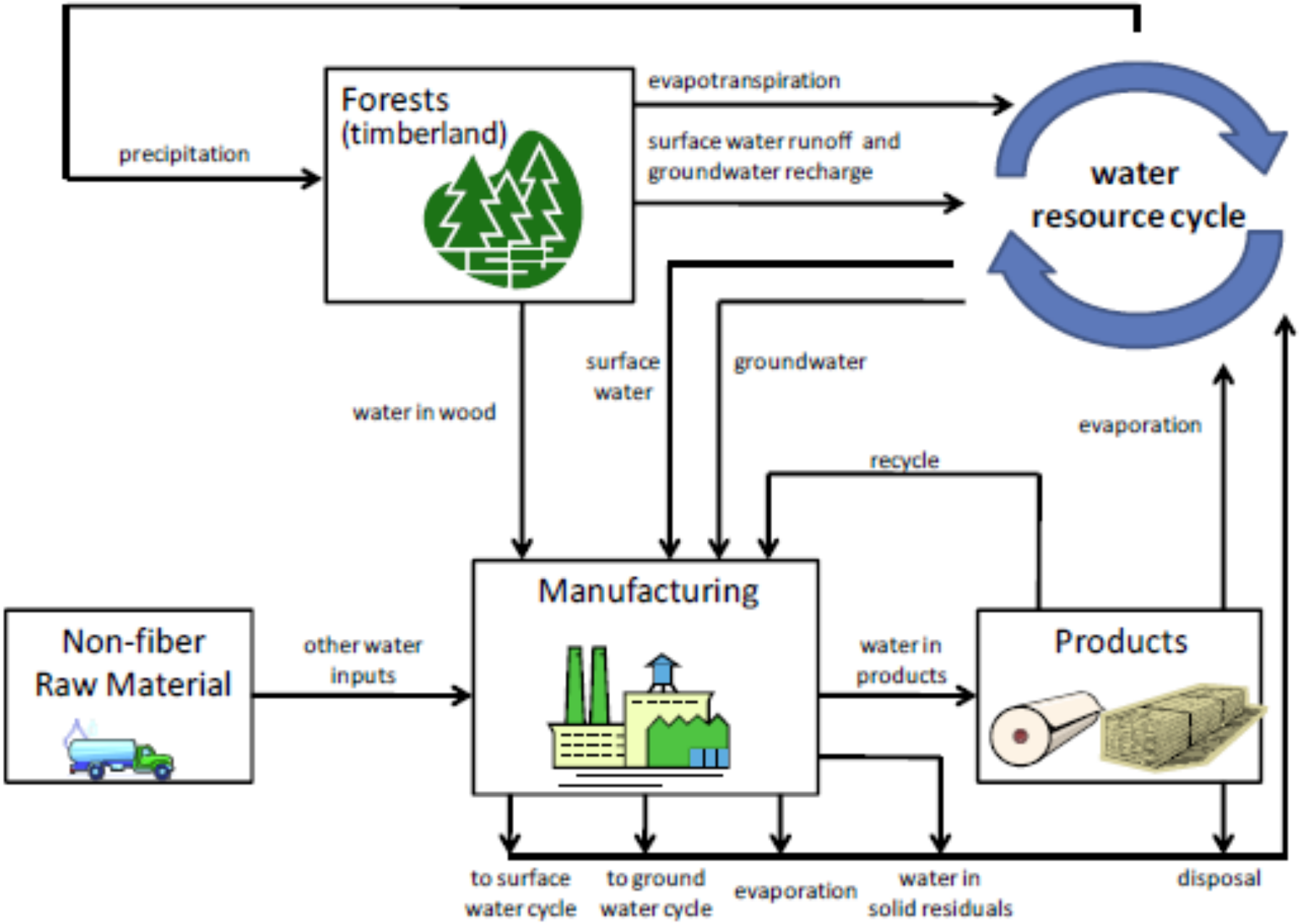
Conservation vs Reclamation

- Cooling Towers recirculate water to cool equipment
  - Evaporation (temp differential)
  - Drift (drift rate)
  - Blowdown or Bleed-off (COC)

Where Cycles of Concentration (COC) = $\frac{TDS_{(Blowdown)}}{TDS_{(Makeup)}}$

Make-up = Evaporation + Blowdown + Drift

So while improving COC is a conservation measure, reuse makeup water can enhance COC

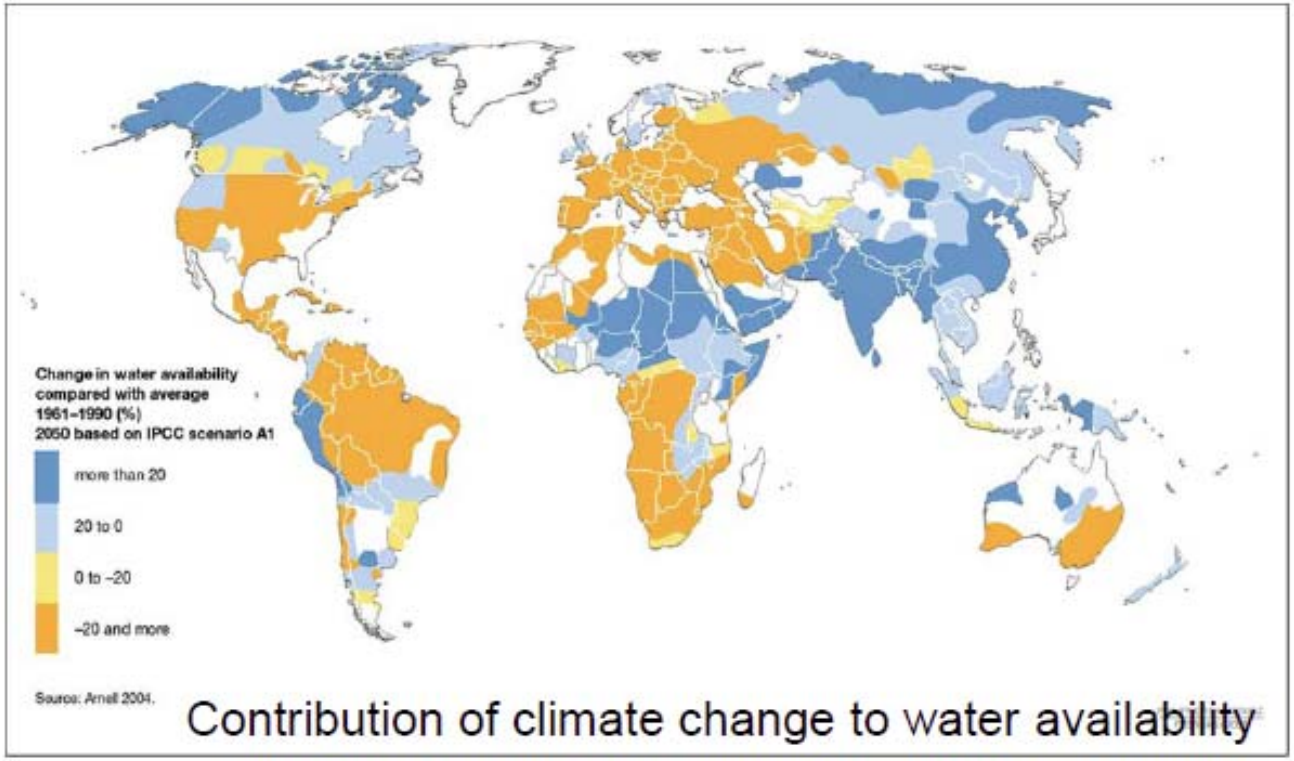

precipitation
Forests
(timberland)
evapotranspiration
surface water runoff and
groundwater recharge
water
resource cycle
surface
water
groundwater
water in wood
evaporation
recycle
Manufacturing
Non-fiber
Raw Material
other water
inputs
water in
products
Products
to surface
water cycle
to ground
water cycle
evaporation
water in
solid residuals
disposal

Industrial Reuse Differs from Municipal Reuse

- Larger diversity of industrial facility processes
- Proprietary nature of industrial corporations
- More diverse and exotic variety of constituents
- Greater need for rapid return on investment
- Historically fewer subsidized economic incentives
- Less technology performance data from installations

Physical Water Risk – Regional Stress

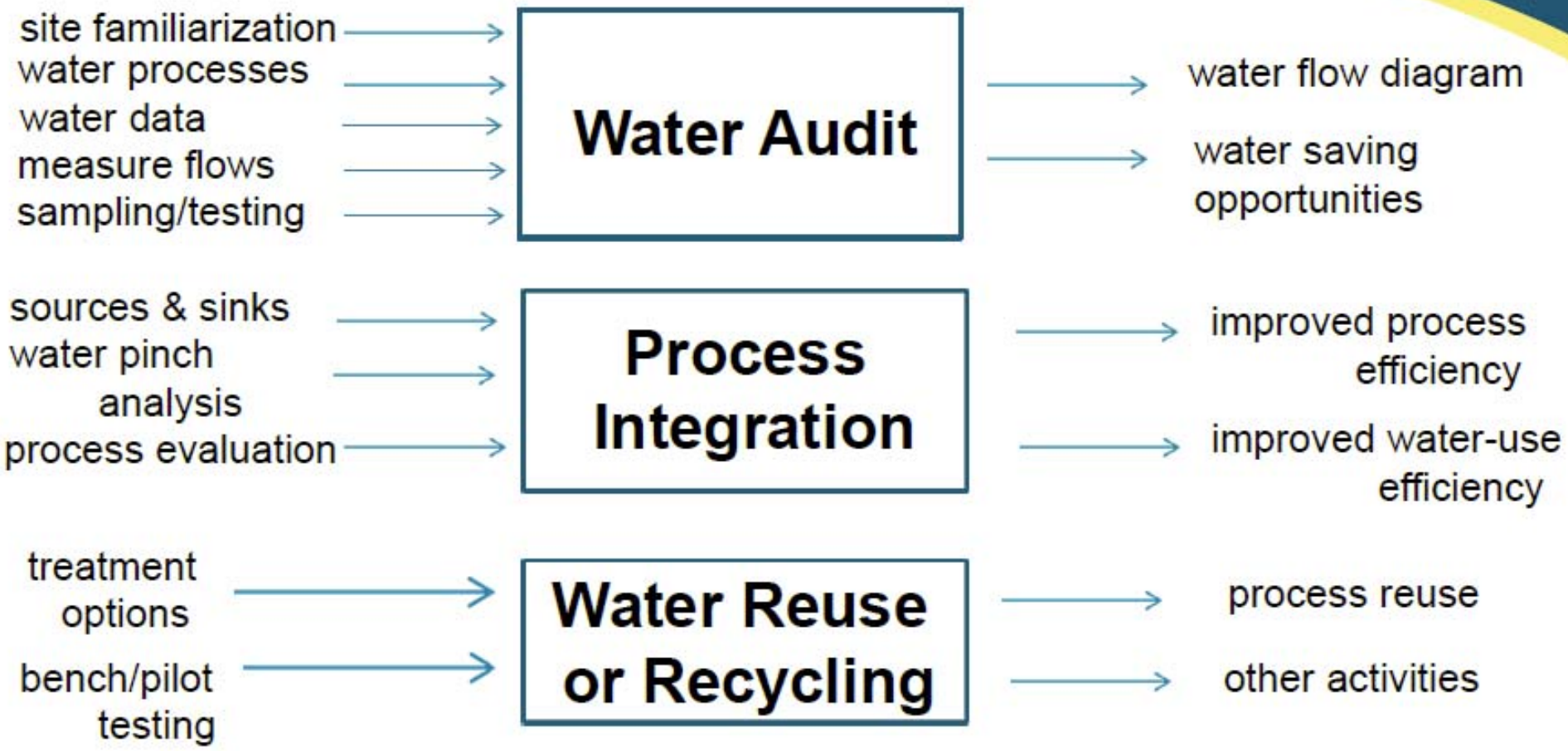
- Inadequate Local Supplies
  - Increasing population / community development needs
  - Climate change altering regional distribution
  - Pollution



Contribution of climate change to water availability

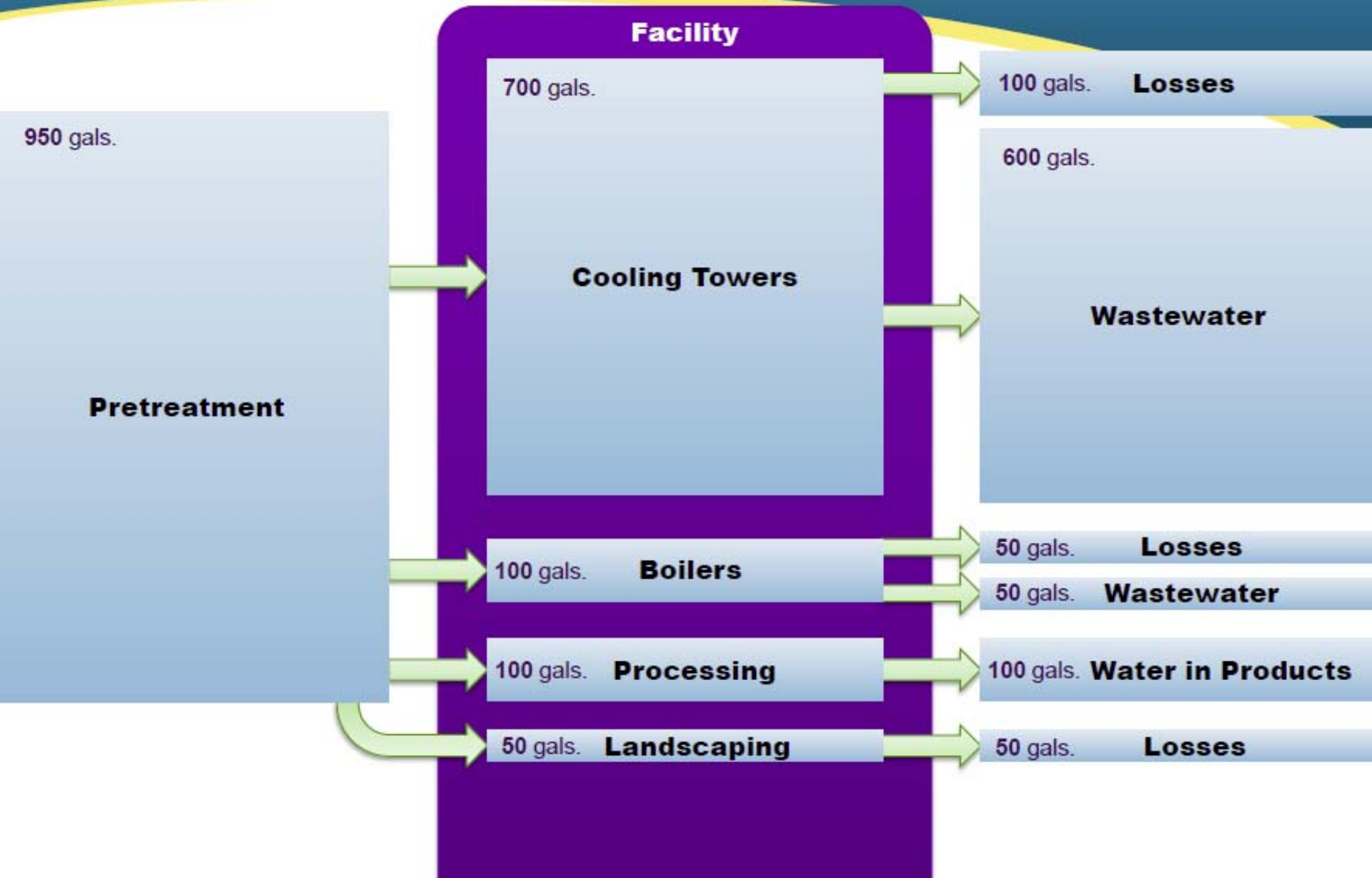
Source: www.unep.org/dewa/vitalwater/jpg/0407-runoff-scenario-EN.jpg

Steps Towards Water Reuse & Recycling



Adapted from Agana, B.A. et al. / Journal of Environmental Management 114 (2013) 446

Develop a Water Flow Balance



Potential Reuse/Recycle Streams

Membrane Filtration Concentrate	➢ Water concentrated with material rejected by the membrane that is continuously (reverse osmosis) or periodically (low pressure) wasted.
Cooling Tower	➢ Cooling water used for applications
Pump Seal Water	➢ Water used to flush mechanical seals on pumps.
Continuous Monitoring Flows	➢ Sidestream flows to water quality measuring devices, including chlorine analyzers & turbidimeters.
Chemical Feed Systems	➢ Batching/dilution water used in the generation of chemical solutions.
Product Final Rinse	➢ Final rinse water used in washing of equipment
Flue Gas Scrubbing	➢ Water used in process to remove particulates from flue gas.
Miscellaneous Facility Cleaning	➢ Miscellaneous facility water from facility hose stations & for conveyor washing.
Vehicle Wash Water	➢ Water used in for cleaning vehicles.

Advanced Technologies for Reuse/Recycle

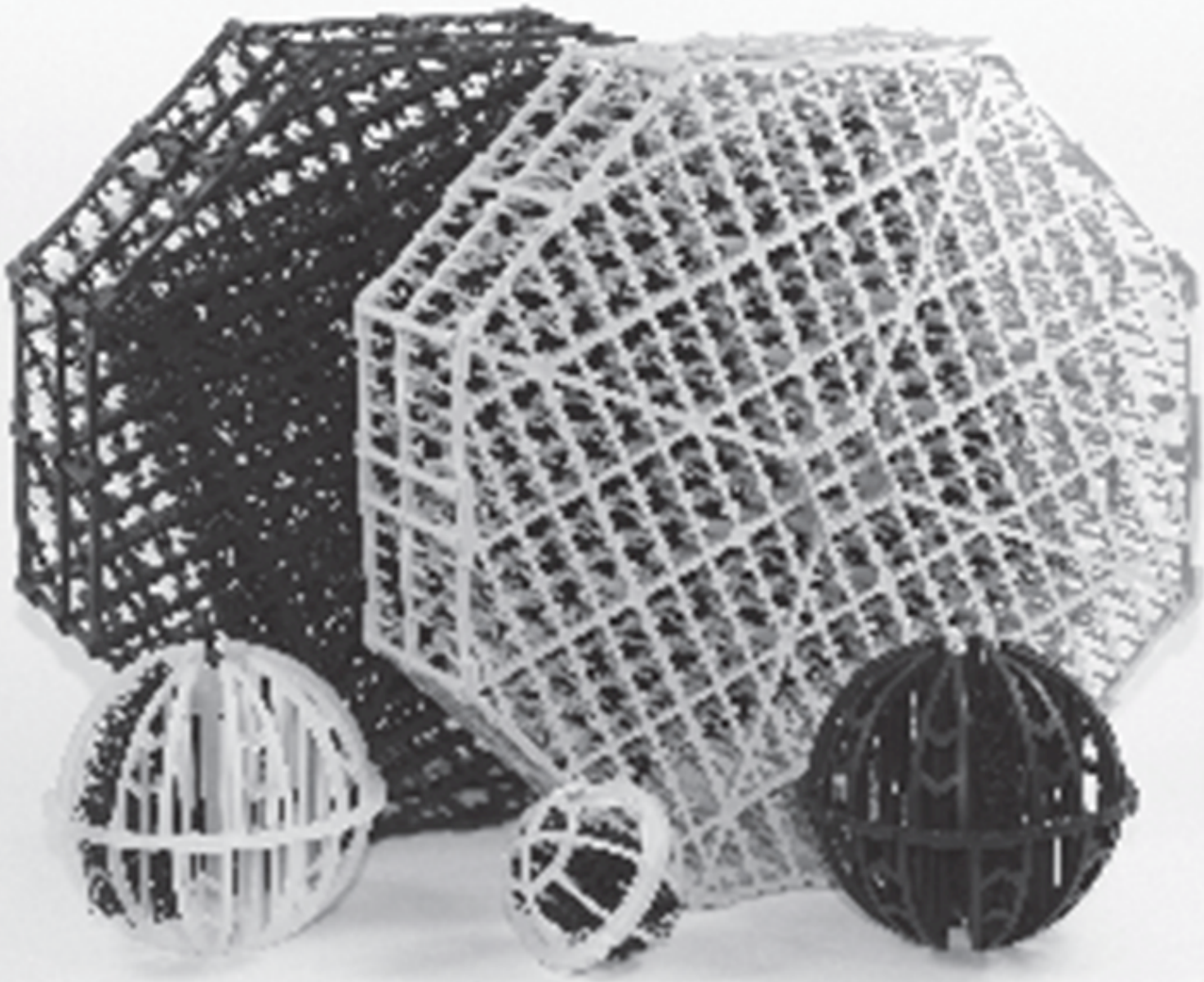
Membrane Bioreactor	Combines ultrafiltration with biological treatment in a small footprint	Excellent solids removal & low sludge production
Ultrafiltration	Uses pressure-driven barrier to remove compounds	Removes suspended solids, bacteria, other pathogens
Reverse Osmosis	Forces water through membranes under high pressure	Removes dissolved chemicals & other compounds to produce water with high purity
Ozonation	Oxidizes the water with ozone	Destroys bacteria & other microorganisms
Ultraviolet Light	Exposes water to UV light for disinfection	Inactivates any trace micro-organisms, providing 4-log reduction of microbes

WATER ENERGY NEXUS

Energy type	Total water consumed per megawatt hour (m3/MWh)	Water consumption required for U.S. daily energy production (millions of m3)[26]
Solar	0.0001	0.011
Wind	0.0001	0.011
Gas	1	11
Coal	2	22
Nuclear	2.5	27.5
Oil	4	44
Hydropower	68	748
Biofuel (1st generation)	178	1958

Source: "Linking Water, Energy & Climate Change: A proposed water and energy policy initiative for the UN Climate Change Conference, COP15, in Copenhagen 2009," DHI, Draft Concept Note, January 2008. See: http://www.semide.net/media_server/files/Y/l/water-energy-climatechange_nexus.pdf

HIGH SURFACE AREA BIOMEDIA

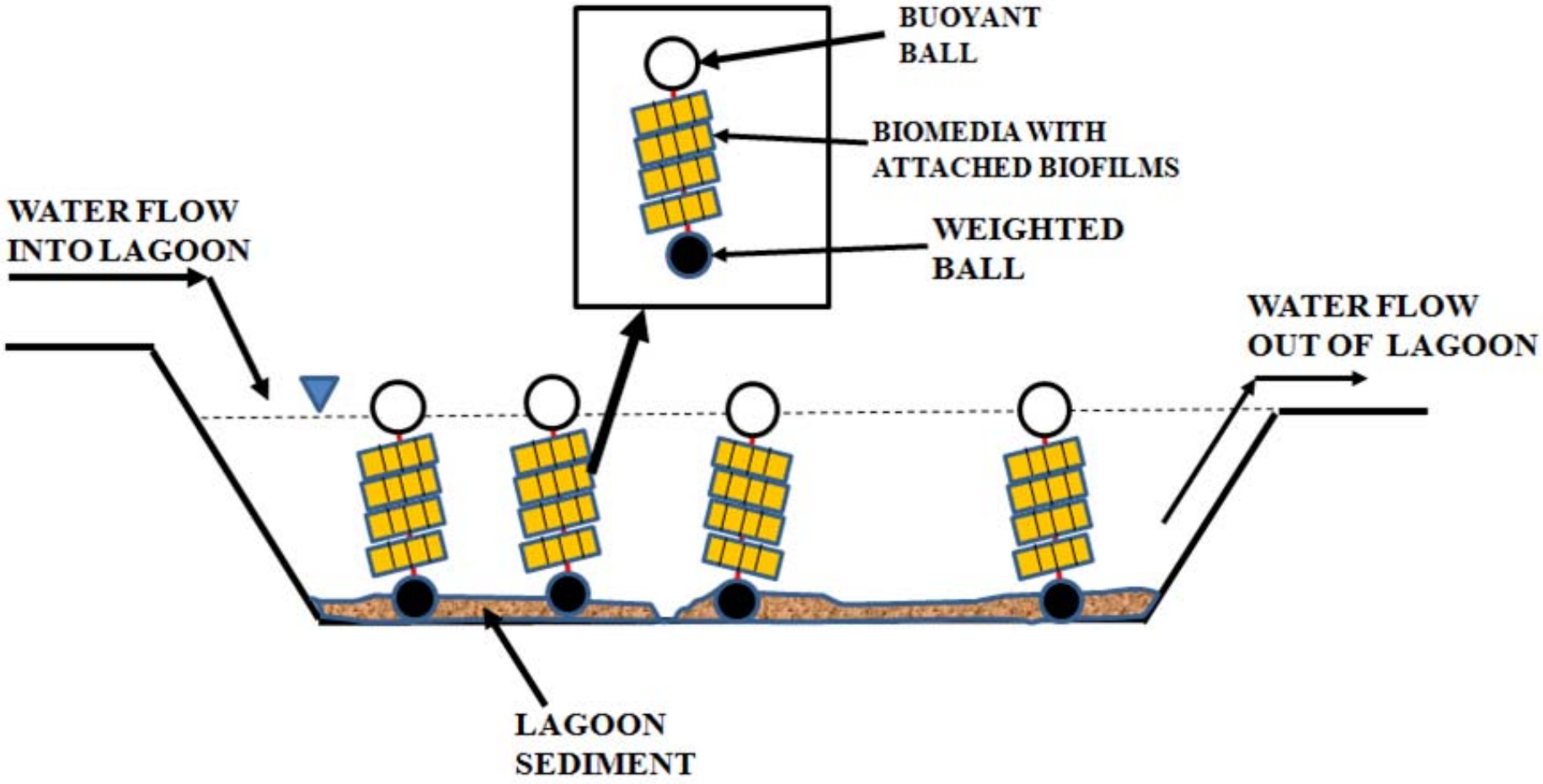


BIOMEDIA PERFORMANCE
(Activated Sludge Plant)

Water Parameter	Influent	Effluent with no Biomedia	Effluent with B^3 Biomedia
Plant Loading	0.96 kg BOD/m3.day		Media Volume = 20% of bioreactor
BOD5	200 mg/L	15 mg/L	2 mg/L
COD	320 mg/L	34 mg/L	18 mg/L
TKN	37 mg/L	15 mg/L	3 mg/L
Total P	8 mg/L	4 mg/L	< 1 mg/L
Ammonia Removal			0.92 kg NH_3-N/1000 m^3.day

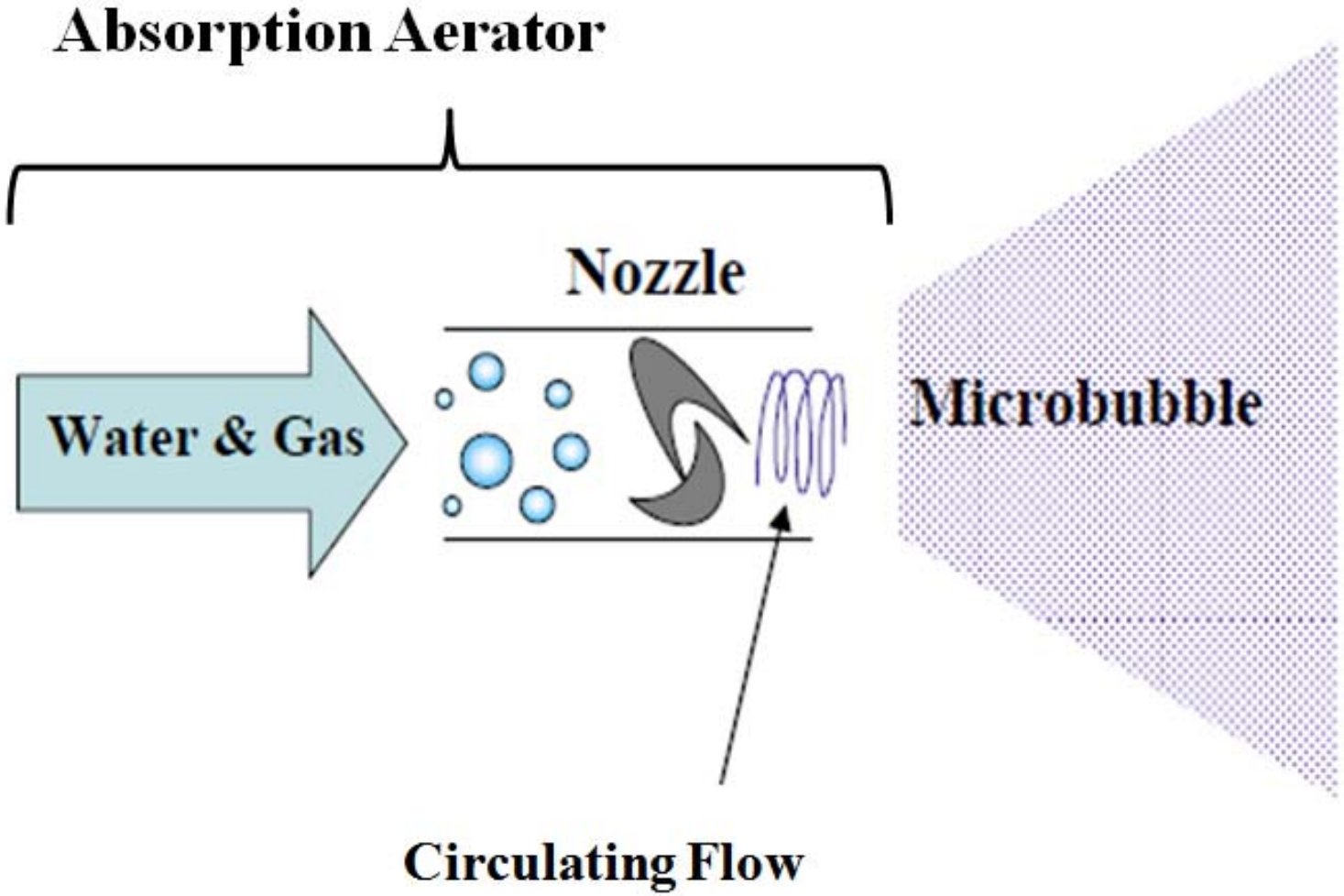
BOD: Biological Oxygen Demand
COD: Chemical Oxygen Demand
TKN: Total Kjeldahl Nitrogen
Total P: Total Phosphorus

USE OF BIOMEDIA IN LAGOON



Even in lagoons with no water flow in and out of the Lagoon, this type of treatment can treat the water in-place (*in-situ)* with no water being pumped in and out of the lagoon.

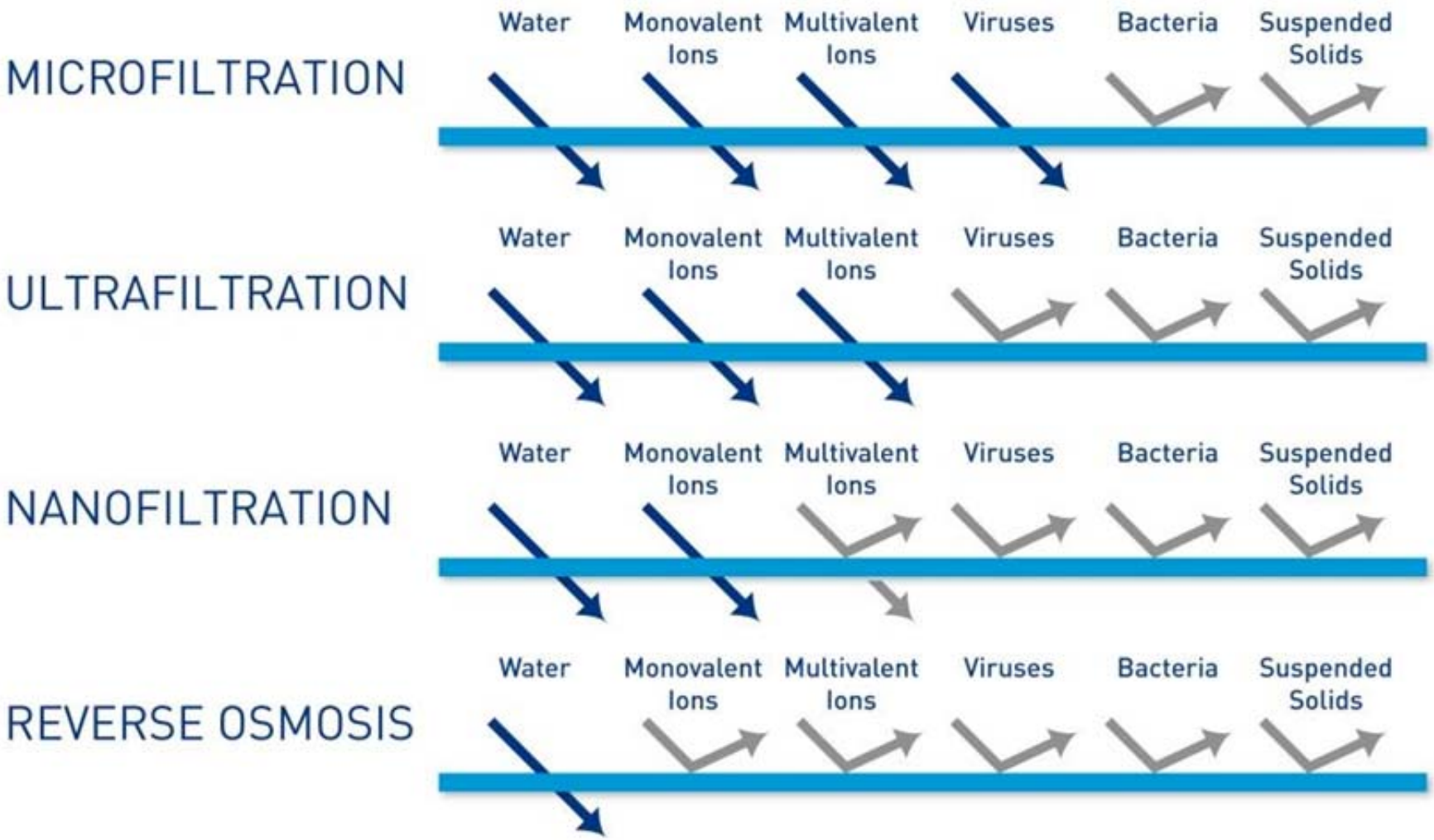
ABSORPTION AERATOR MECHANISM



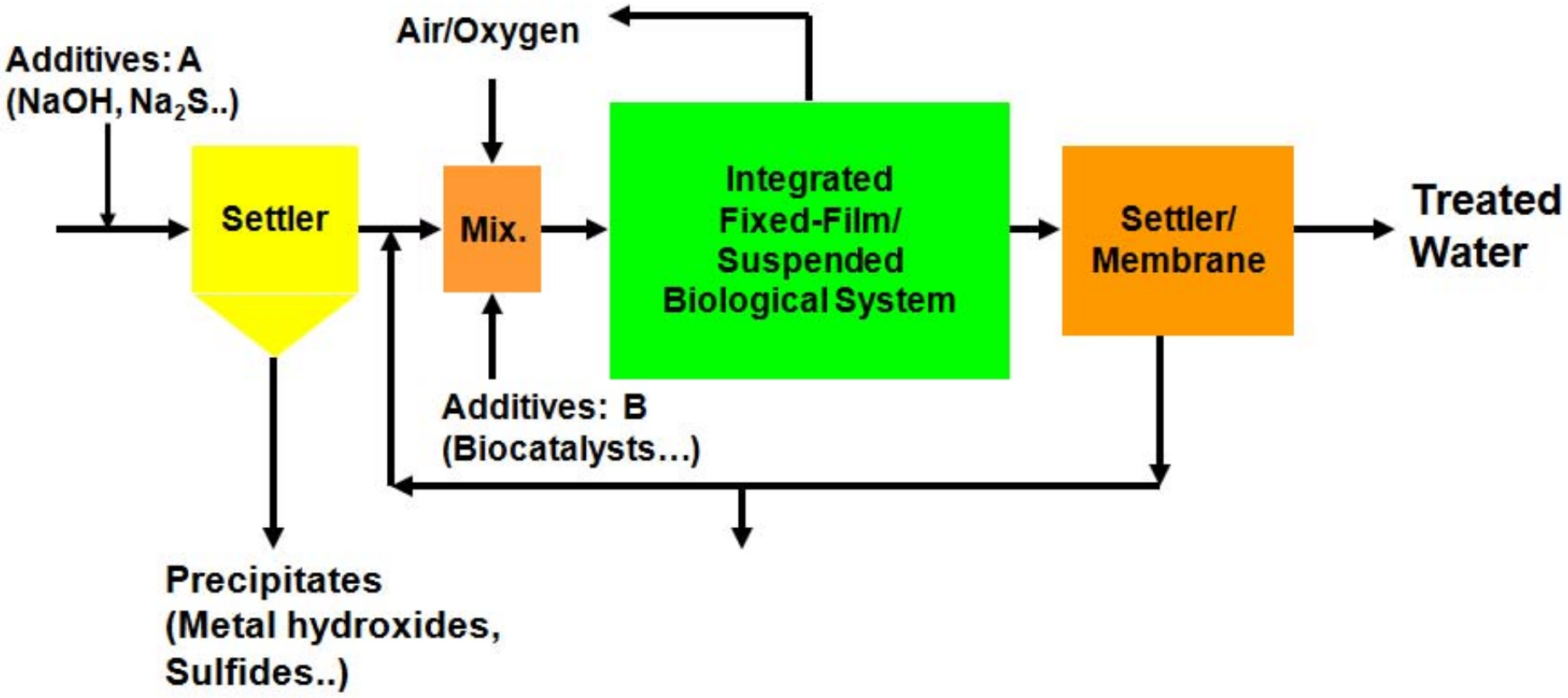
VARIOUS KINETIC TRANSFER MODEL MECHANICAL AERATION DEVICES' SOTE

• Following are various AOTR's for mechanical aeration devices:	lbs. O_2/hp/hr
• **Absorption Aerator**	**2.73 -3.06**
• Surface aerator w/draft tube	1.2 - 2.1
• Surface high speed	1.2 - 2.0
• Submerged turbine	1.0 - 2.0
• Submerged turbine/sparger	1.2 - 1.8
• Surface brush and blade	0.8 - 1.8
• Fine Bubble Diffusers	0.5 - 1.5

TYPE OF MEMBRANES AND CHARACTERISTICS



COMPACT PROCESS



KEY ISSUES

- Reduction in net consumption of water and power
- Use of biological treatment rather than chemical
- Small footprint
- Flexibility to handle wastewater from various sources

NEXTGEN TECHNOLOGY

continued

Characteristics of Influent Wastewater for Testing the NewGen Septic System.

Parameter	Units	No. of Analyses	Median	Minimum	Maximum
Ammonia-N	mg/L-N	37	29.5	21.1	39.7
TOC	mg/L	33	52	37	122
Total Suspended Solids	mg/L	38	46	29	118
Volatile Suspended Solids	mg/L	33	42	27	103
Turbidity	NTU	21	56	35	78

Performance of the NewGen Septic system.

Parameter	Units	Influent	Effluent
Ammonia-N	mg/L-N	29.5	<0.1
TOC	mg/L	52	3.7
Total Suspended Solids	mg/L	46	Below Detection Limit
Volatile Suspended Solids	mg/L	42	2.7
Turbidity	NTU	56	0.02
cBOD5	mg/L	47	2.8
Nitrate – N	mg/L	98.3	8.7
Fecal coliform	CFU/100 ml	6.2×10^6	3.0

CONCLUSIONS

- The world is running out of fresh water, and wood product and bioenergy industries cannot function without water;
- On-site water treatment, recycle and reuse is becoming a necessity, with rising water costs and diminishing groundwater levels;
- Biological treatment is one of the most common and cost-effective treatment processes that can handle a wide variety of contaminants, and use of biomedia can enhance treatment capability and capacity; and
- Synergistic combination of advanced biological treatment with membranes provides a very efficient process that can enable water recycle/reuse.