Water Reuse Conference
May 21, 2014

Secure and Reliable Water is Changing Our World:

Fit-for-Purpose Reuse is a Road Forward

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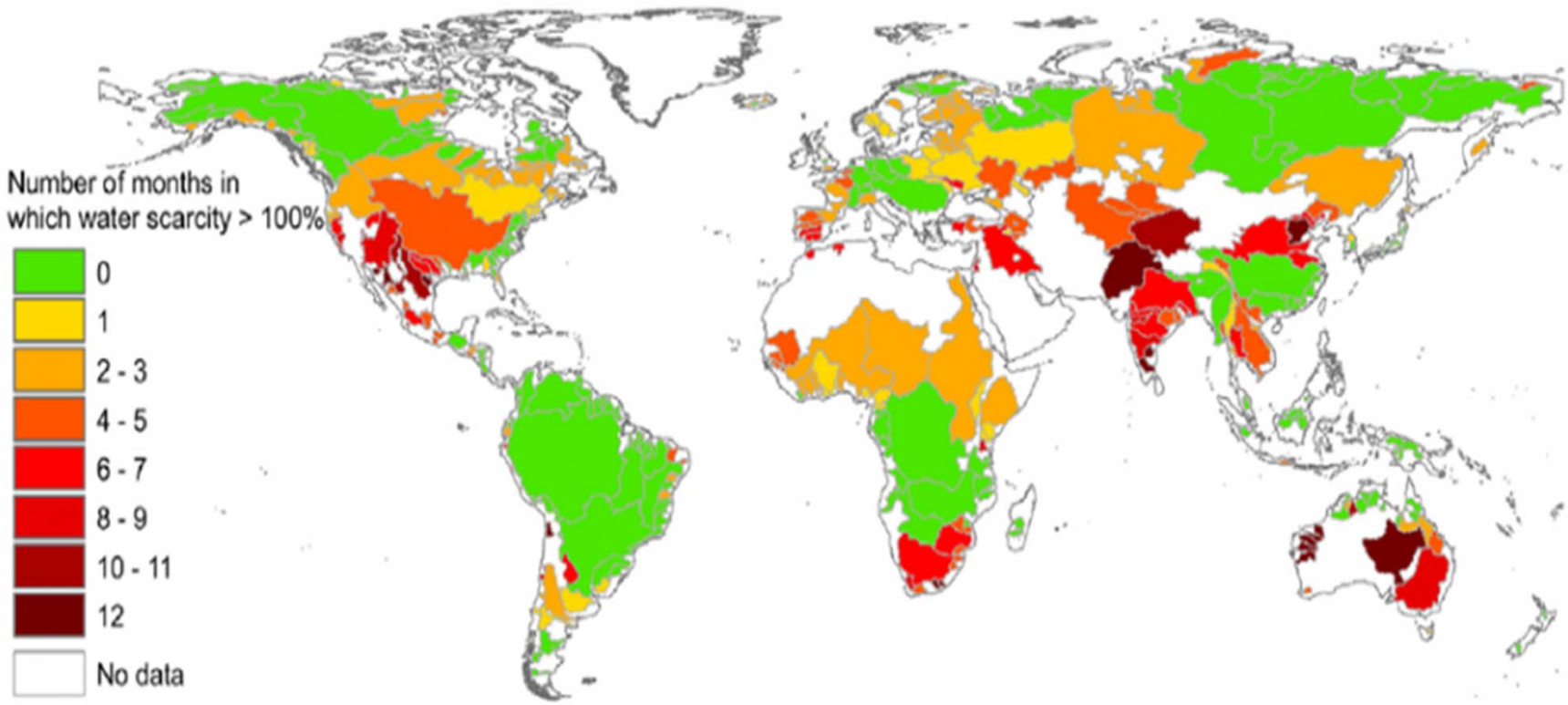
MWH®

BUILDING A BETTER WORLD

Outline

- A High Level Perspective
- The “One Water” Goal
- Fit-for-Purpose Reuse
- Technology’s Role
- Low-Hanging Fruit
- Barriers to Overcome

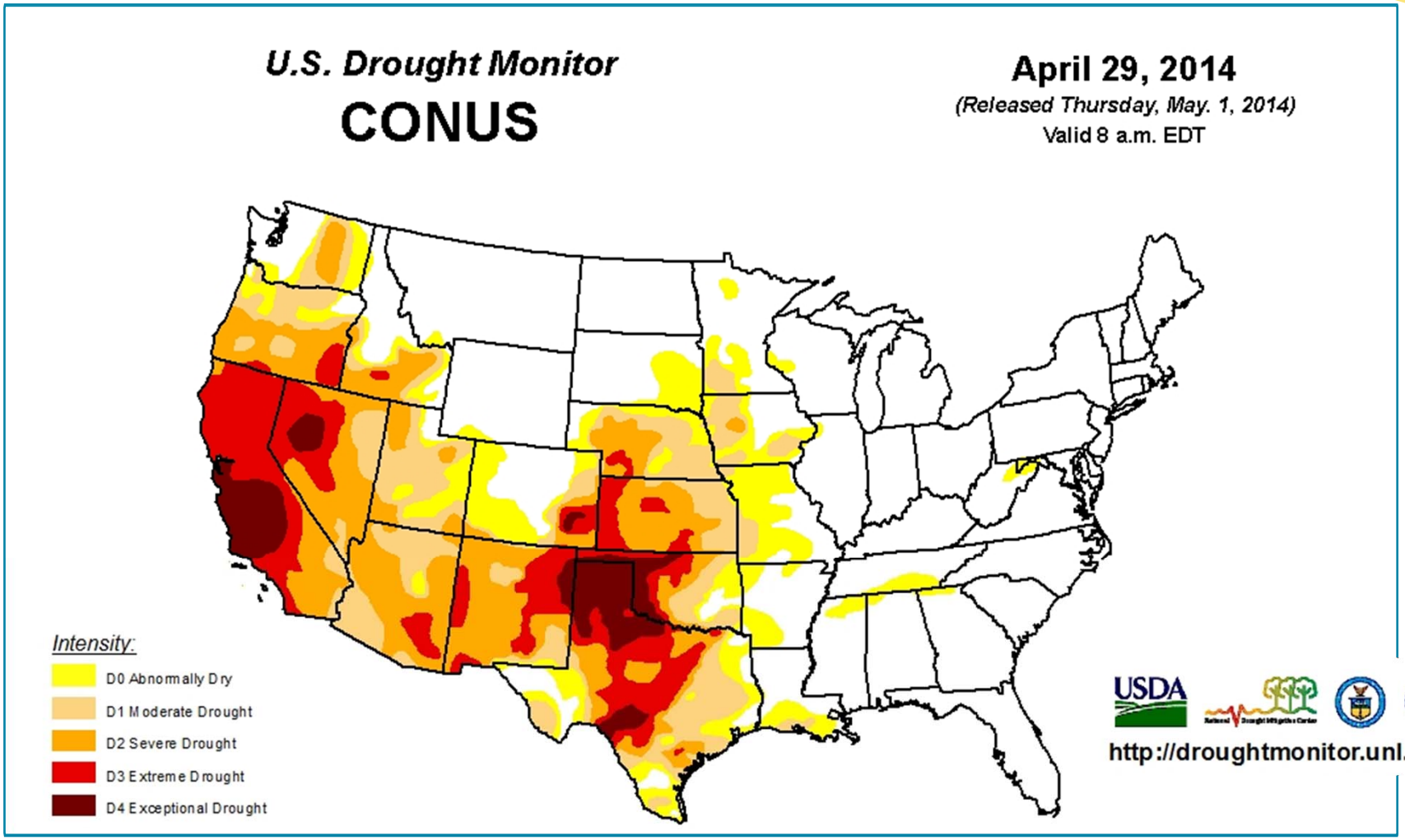
World's Current Water Scarcity Challenge



$$WSR = \frac{\text{Total Withdrawal}}{\text{Total Renewable}}$$

Source: Hoekstra (2012)

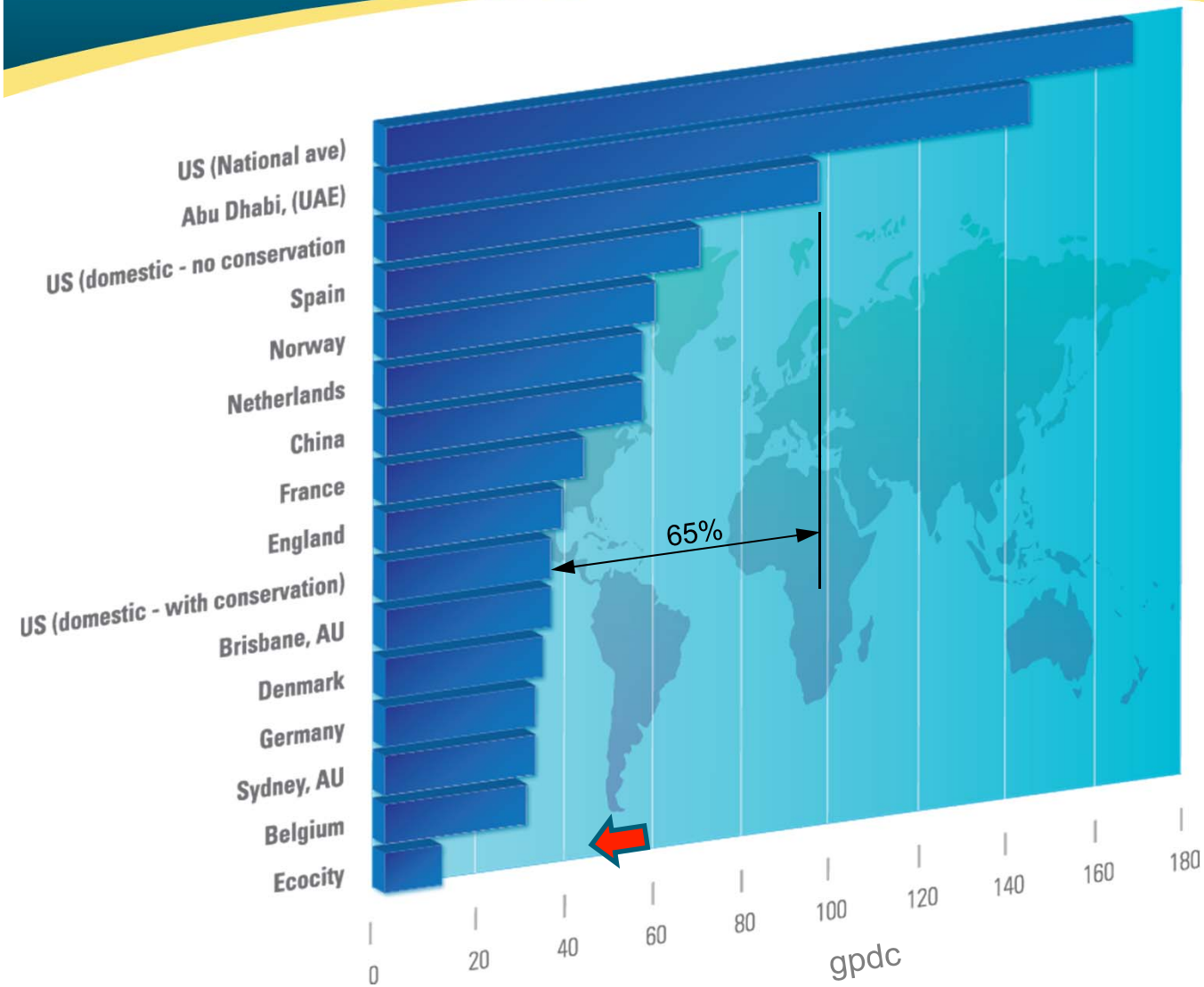
Drought Trends in the US



Why is “water scarcity” becoming of greater concern recently?

- Impacts of drought are often felt very quickly
- Can alternative reliable supplies be found in time?

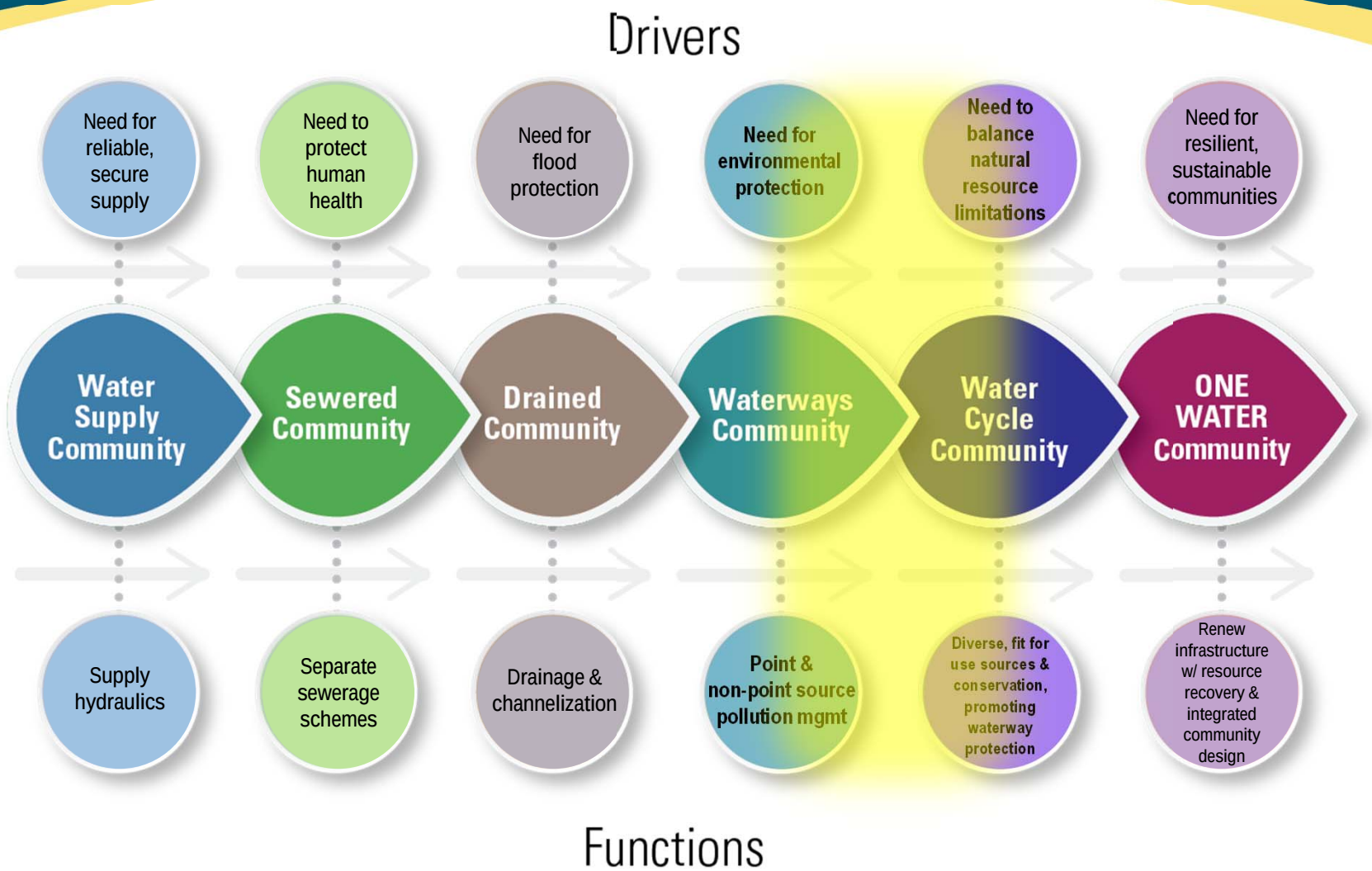
We MUST Reduce Our Demand for Water



"…sustainable cities will recognize that all water is good water, based on the concept of fit-for-purpose uses."

Adapted from: Novotny et al.

Moving towards a “One Water” Culture

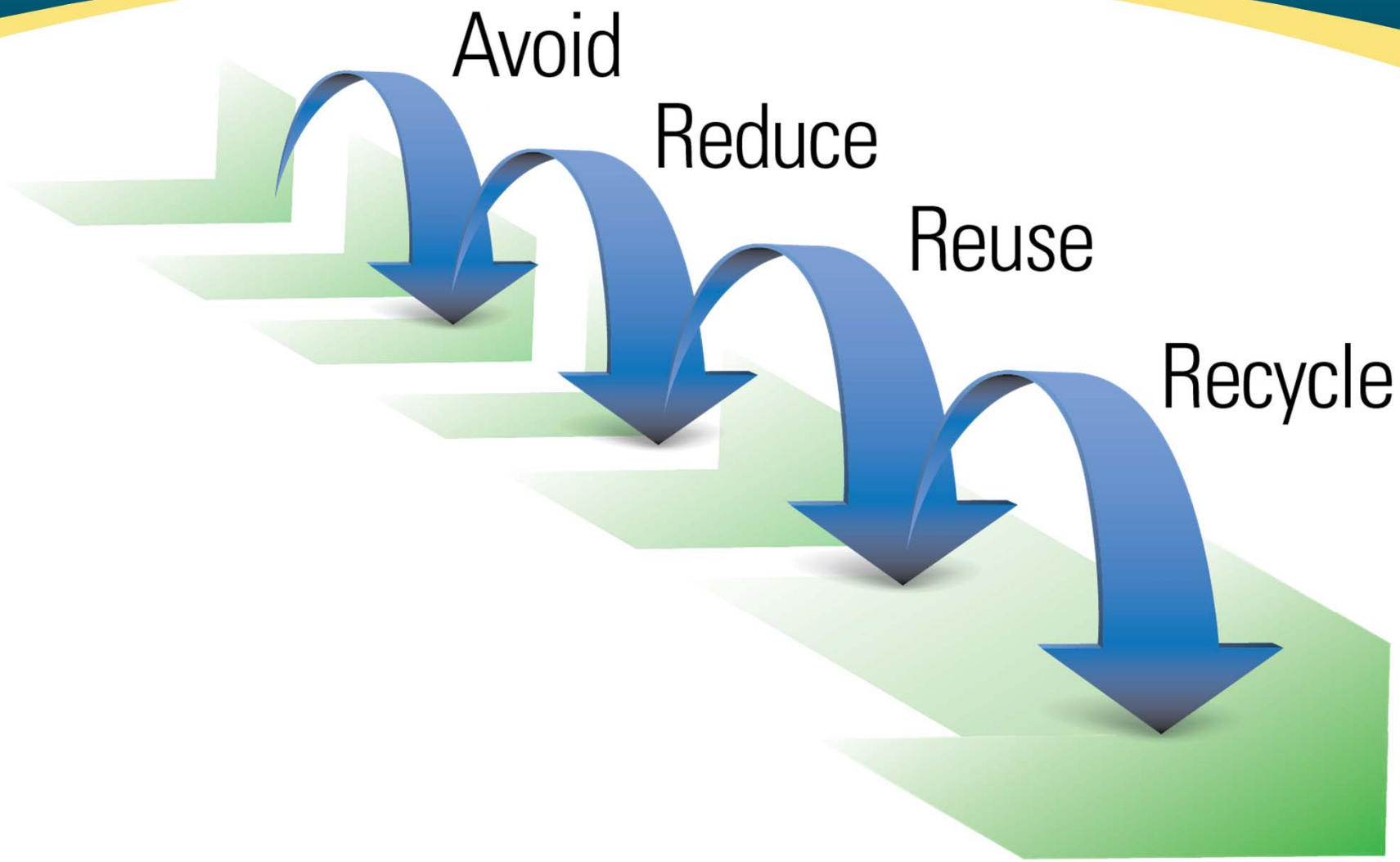


Adapted from: Howe, C., et al (2013)

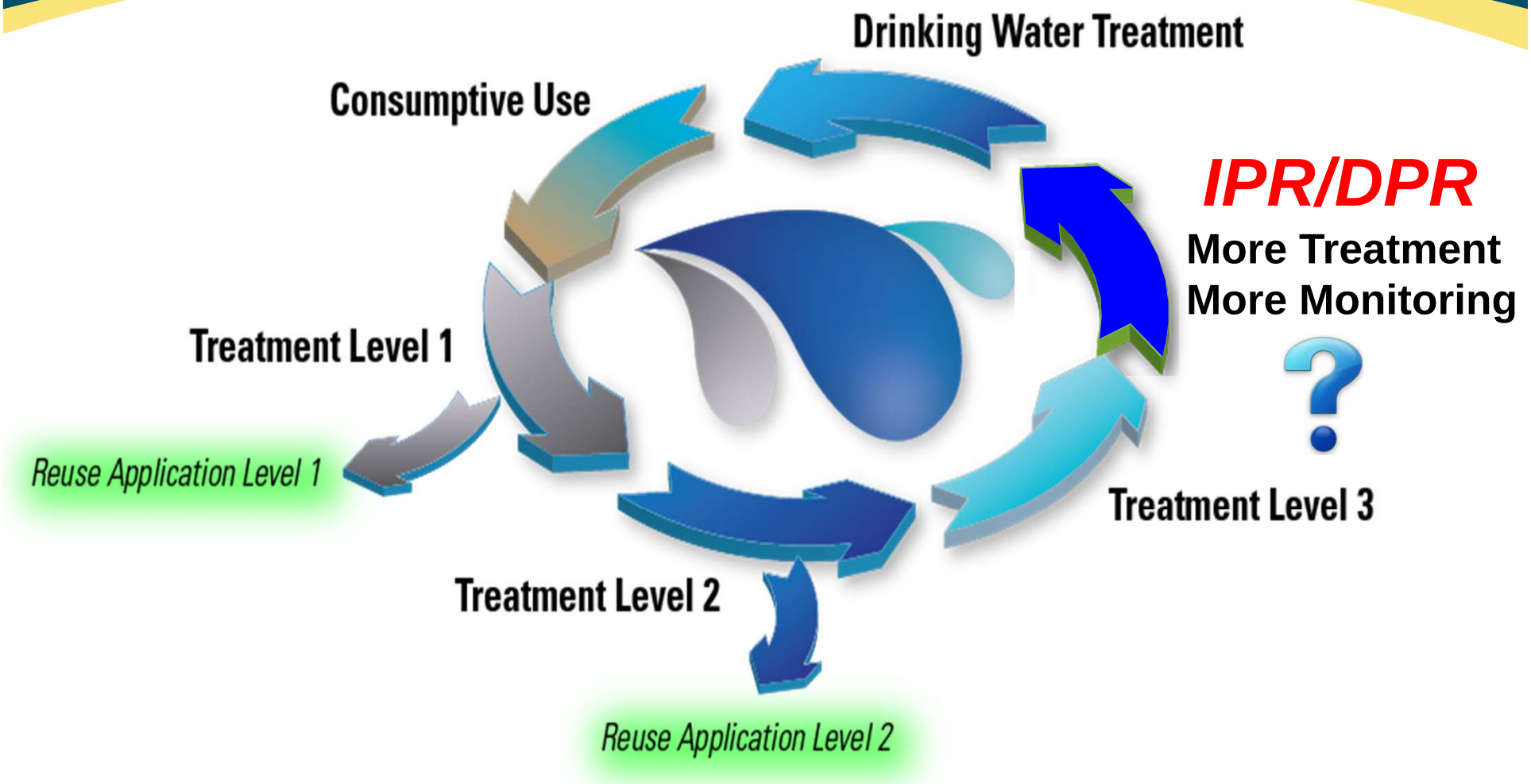
Reuse Will be Key in Tomorrow's World

Adapted from: Gatel, D., 2012

Managing Water is Not Complicated!



Reuse and the "Power of the Buffer"

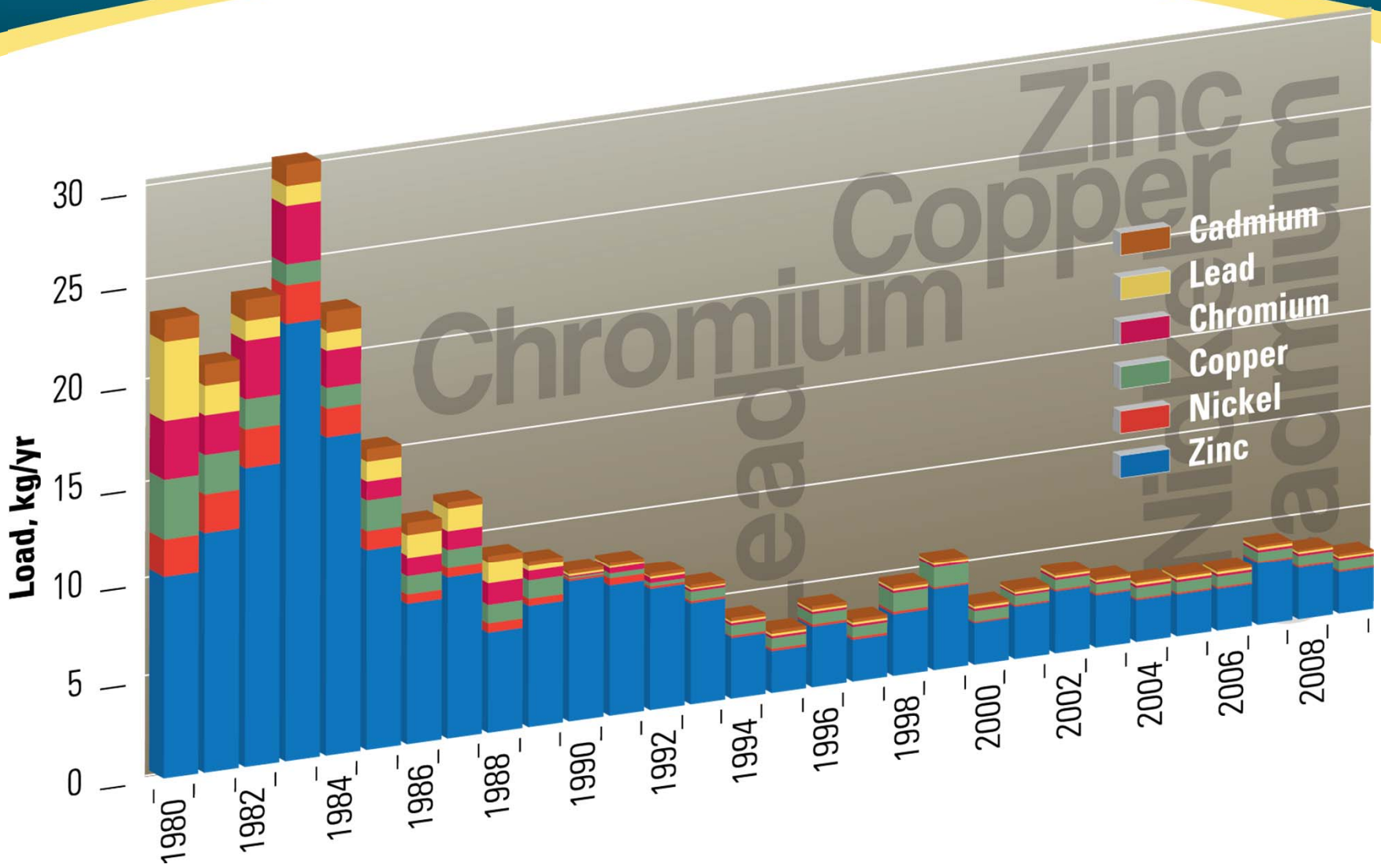


Examples Where Fit-for-Purpose is Underway

Non-Potable Reuse	Indirect Potable Reuse	Direct Potable Reuse
San Antonio, TX	Upper Occoquan, VA	Windhoek, Namibia
Clear Water, FL	Orange County, CA	Brown Wood, TX
Clark County, NV	West Basin, CA	Big Spring, TX
Queensland, Australia	Montebello Forebay, CA	Wichita Falls, TX
Colorado Springs, CO	Singapore	
	Chelmer Essex, England	
	Wulpen, Belgium	

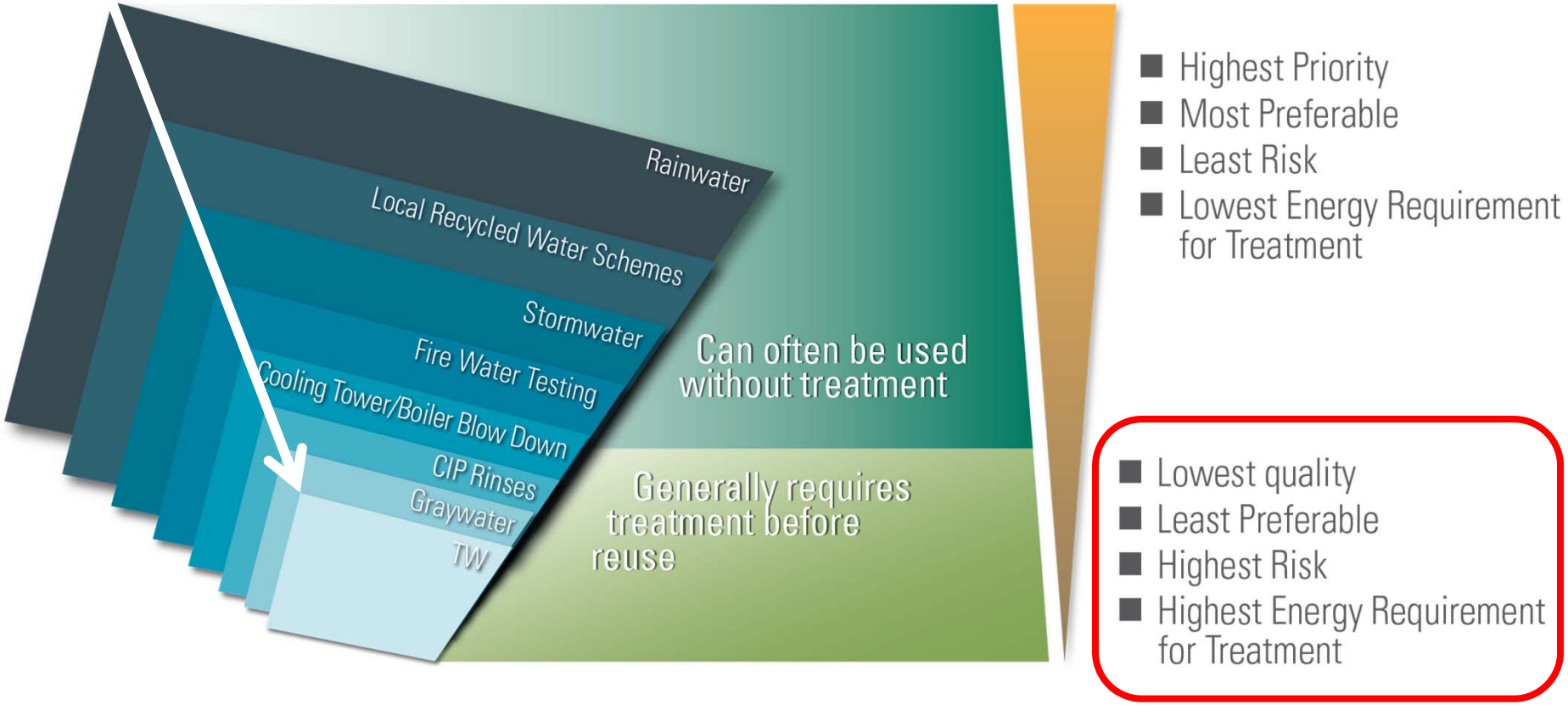
In many cities and towns, unplanned and uncontrolled reuse is already happening!

Is the Water Quality Concern About Metals?



Hierarchy of Fit-for-Purpose Water

It's ALL about human health safety



Bottom line: Does a failsafe, silver bullet solution exist for reuse?

Adapted from: O'Neill, M. and Lambert, D. (2010)

Look for Creative Fit-for-Purpose Options

Reuse Sources

- **Rainwater**
- **Stormwater**
- **Cooling Tower Blowdown**
- **Boiler Blowdown**
- **Steam Trap Condensate**
- **CIP Rinses**
- **Pump Seal Water**
- **Acoustic Water**
- **Fire Water Testing**
- **Local Recycle Schemes**
- **Local Trade Waste Schemes**
- **Product Wastewaters**

Reuse Options

- **Cooling Towers**
- **Washdowns**
- **Toilet Flushing**
- **Agricultural Irrigation**
- **Tree Farming**
- **Low-grade Product Water**
- **Fire Water Testing**
- **CIP Rinses**
- **Across Boundary Sharing**
- **Dust Suppression**
- **Cement Making**
- **Local Park & Sport Field Irrigation**

Reuse Guidelines Exist…

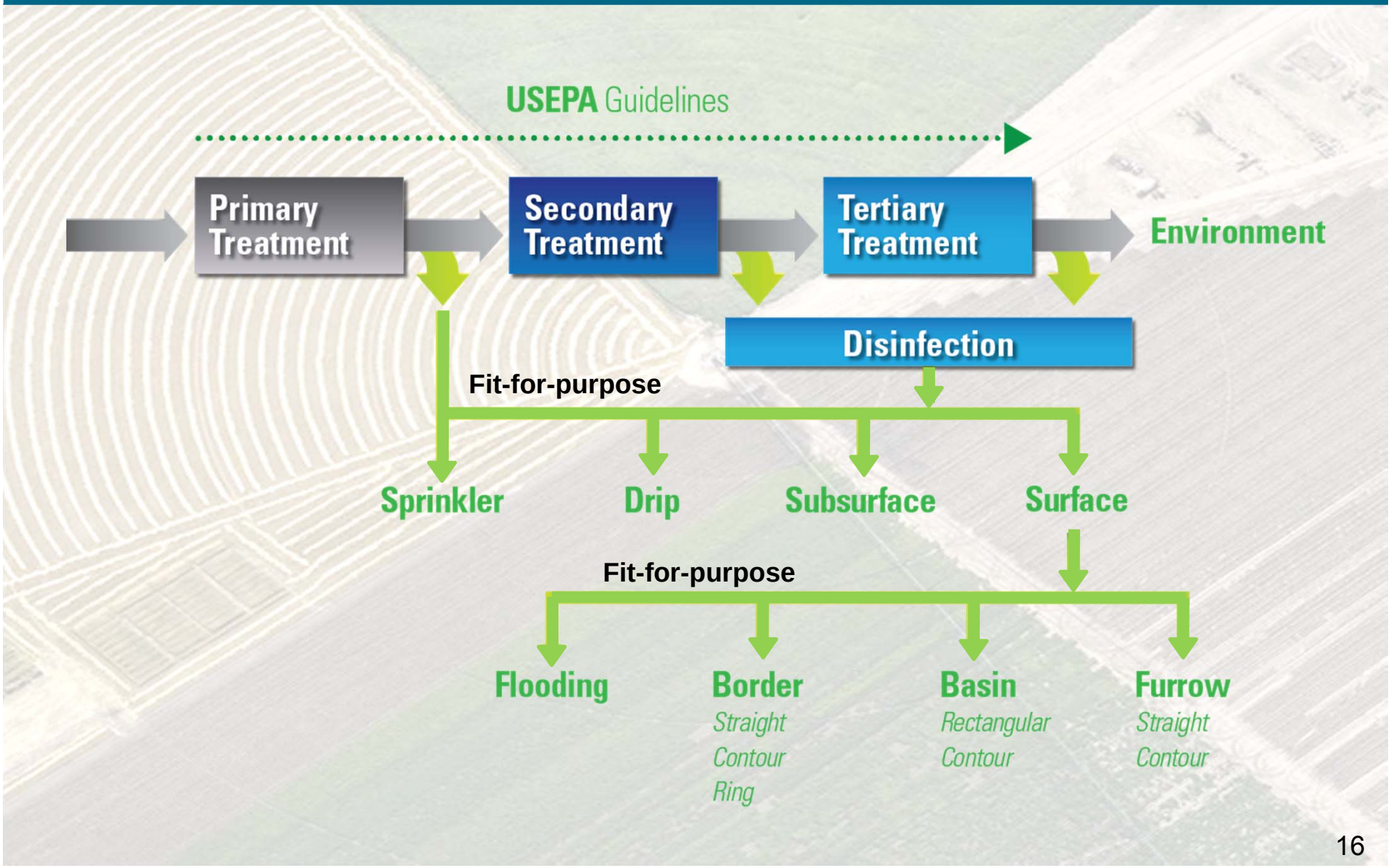
Public Health

- ***Hazards*** – toxics, pathogens, EDCs, CECs, etc.
- ***Risks*** – contamination/degradation of food quality
- ***Impacts*** – consumers/workers, neighboring populations

Environment

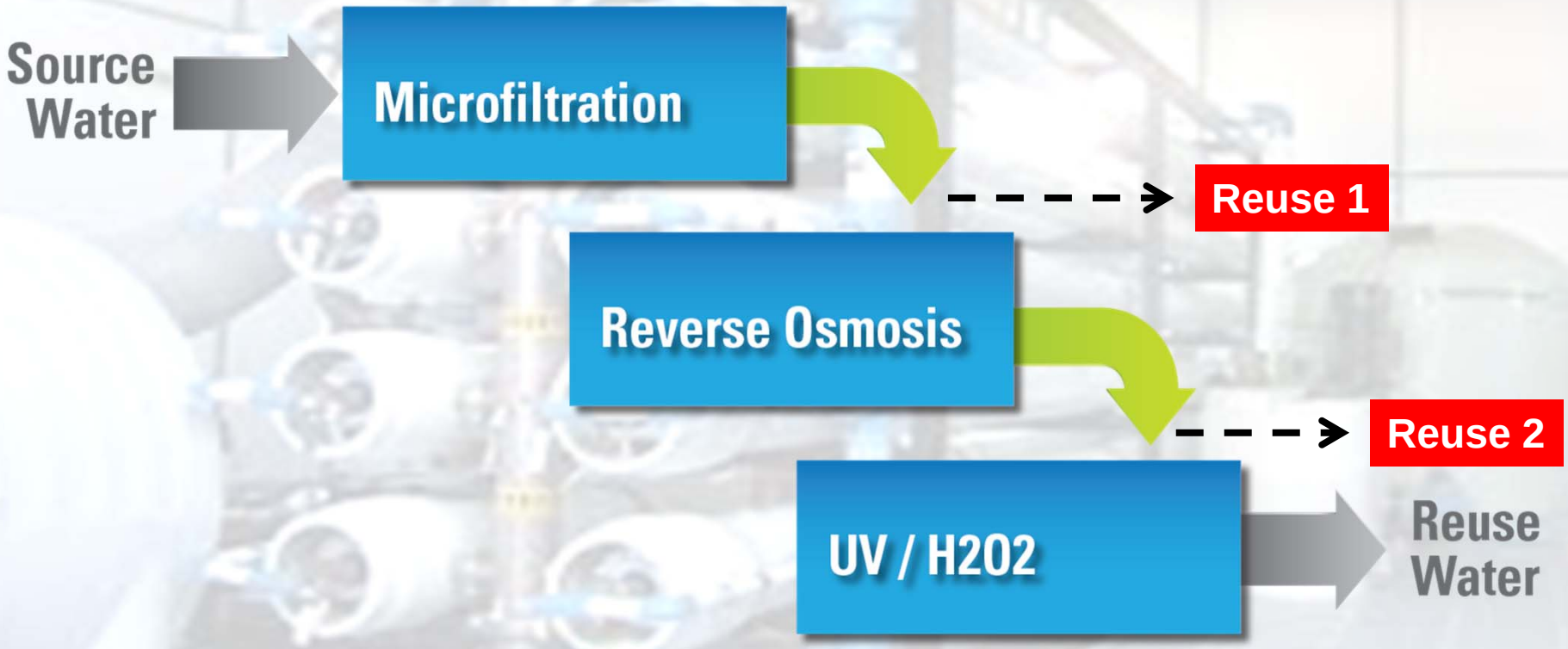
- ***Hazards*** – N, P, toxics, heavy metals, TDS
- ***Risks*** – eutrophication, groundwater pollution, soil salinity, plant toxicity, pollutants in soils

For Reclaimed Wastewaters…

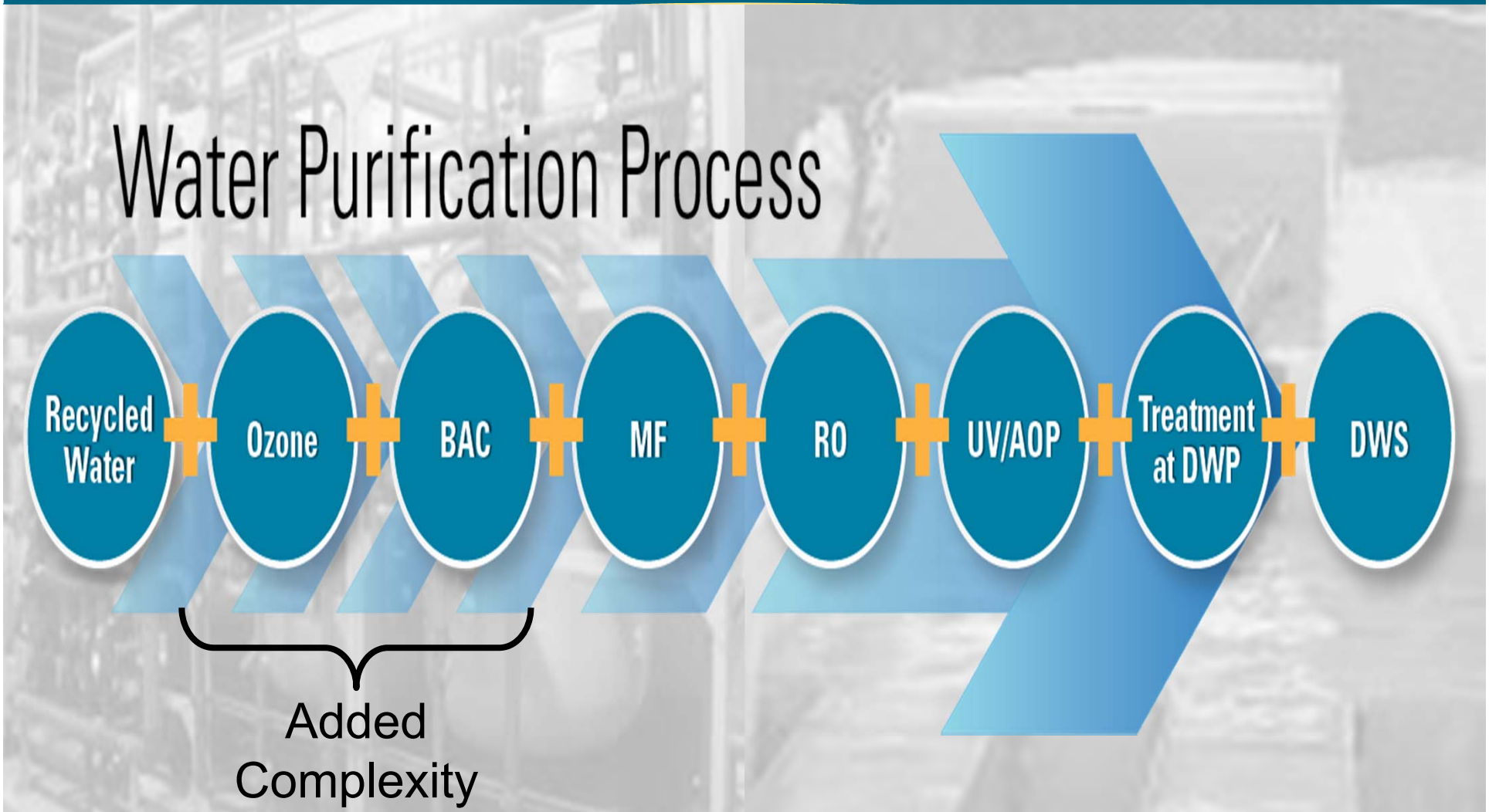


Key to Failsafe System: Reliable Technology

- 3 Basic Technological Steps



Expanding the Technology Baseline

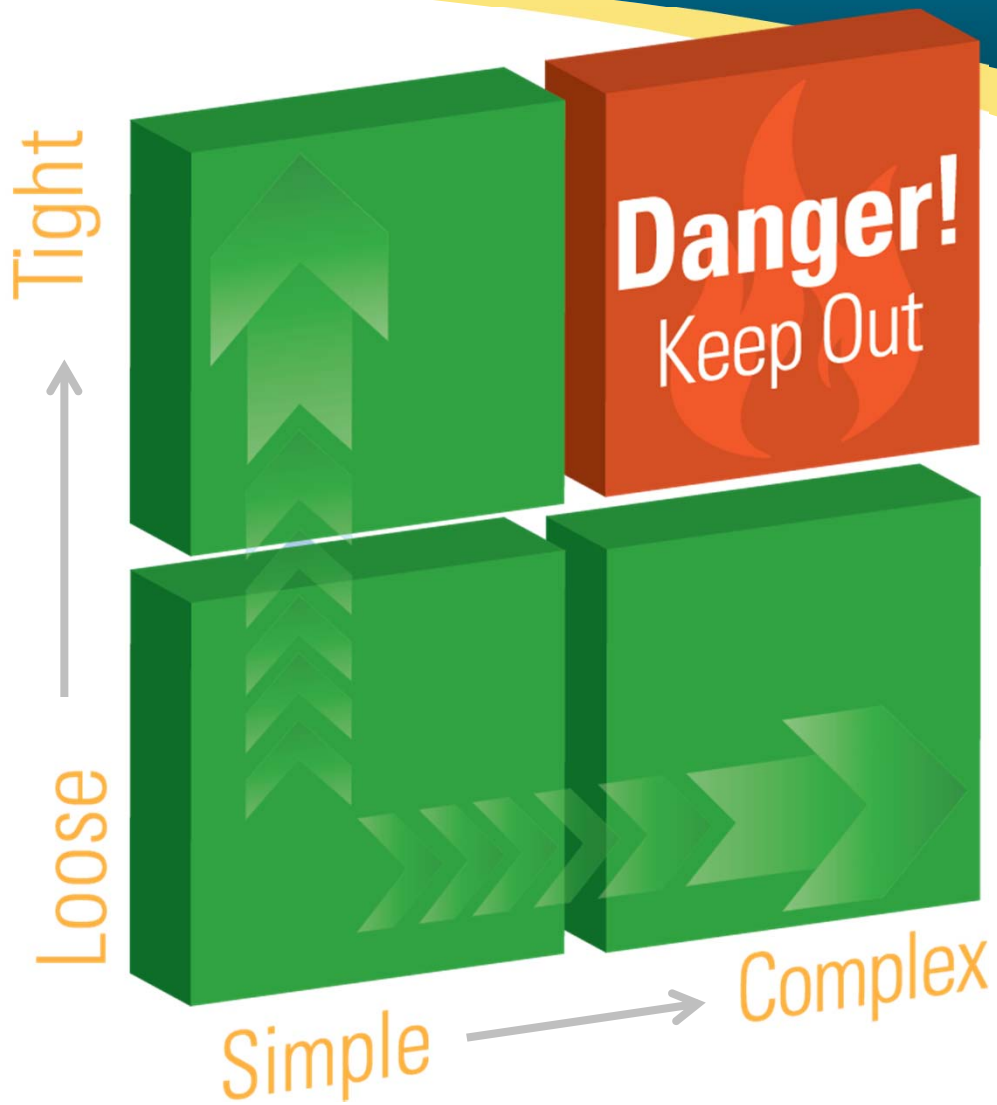


Adapted from: Pearce, W. (2013)

MUST keep things simple and uncoupled

- Decouple issues
- Minimize issue dependencies
- Simplify process descriptions
- Minimize processes
- Decouple processes

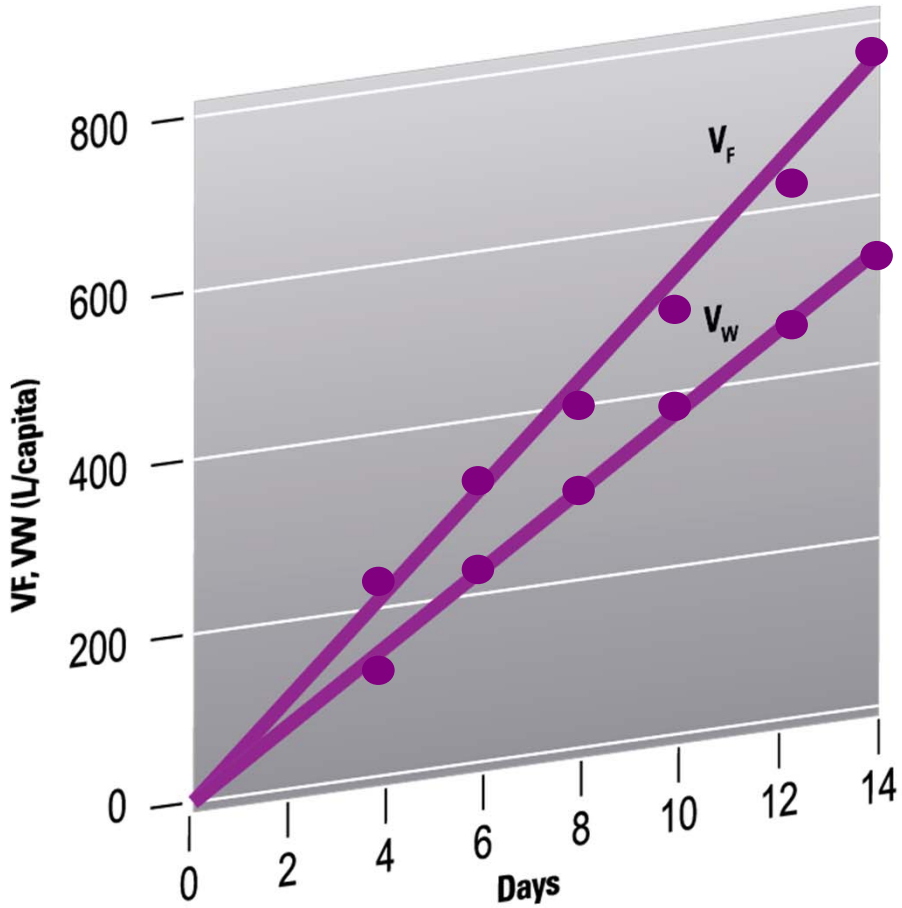
Danger zone = Failure

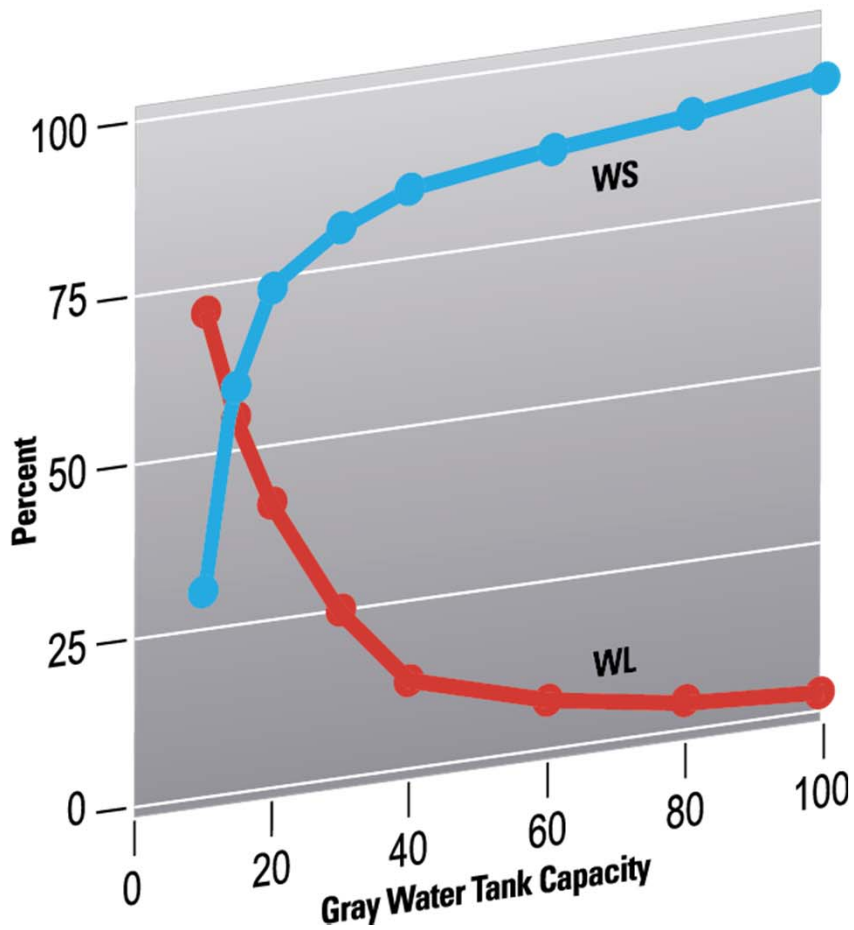


Adapted from: Perrow, C.

Practical First Step: Grey Water Reuse

Domestic Grey Water ⟶ Toilet Flushing

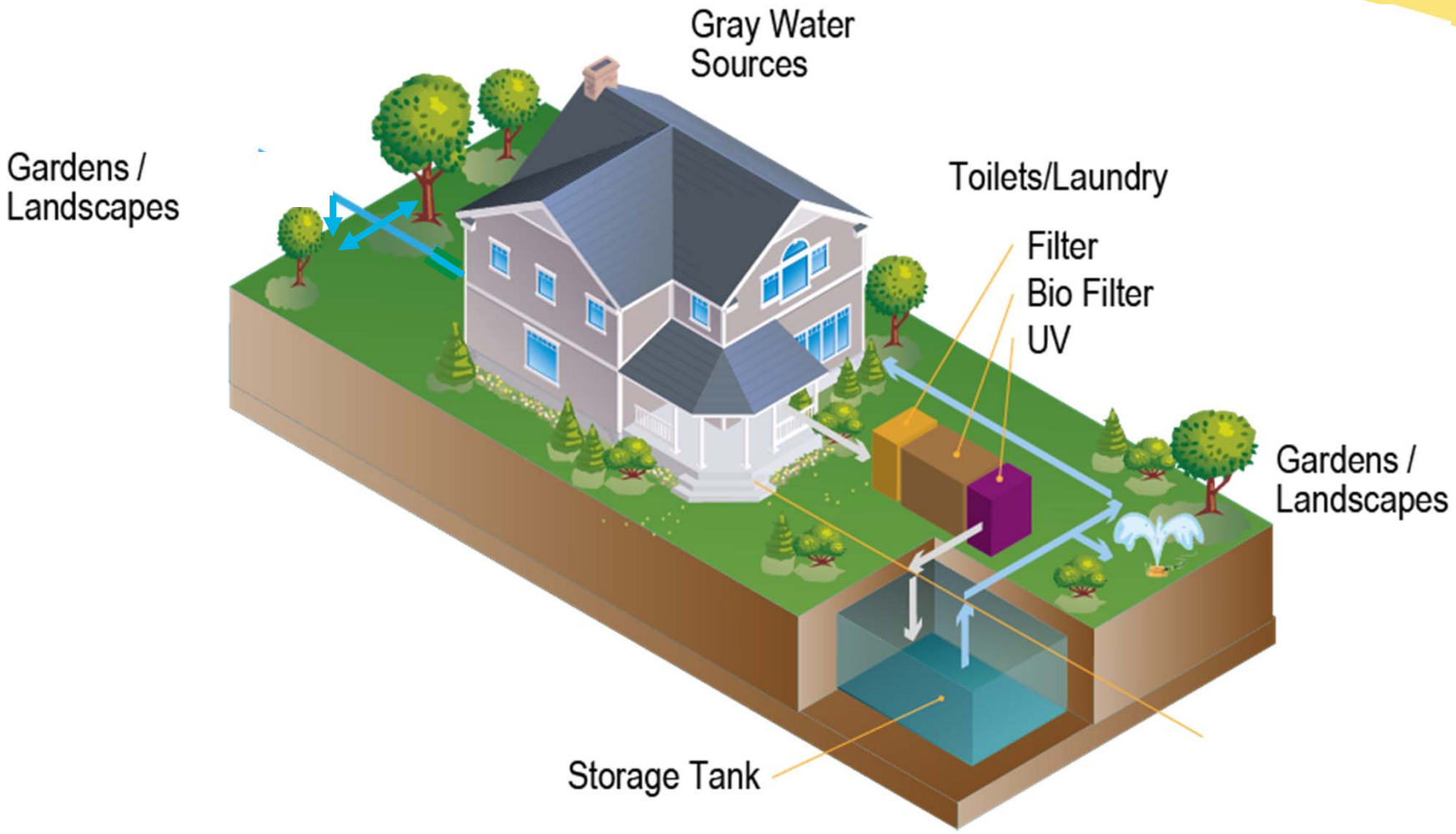




Adapted from: Campisano et al. (2008)

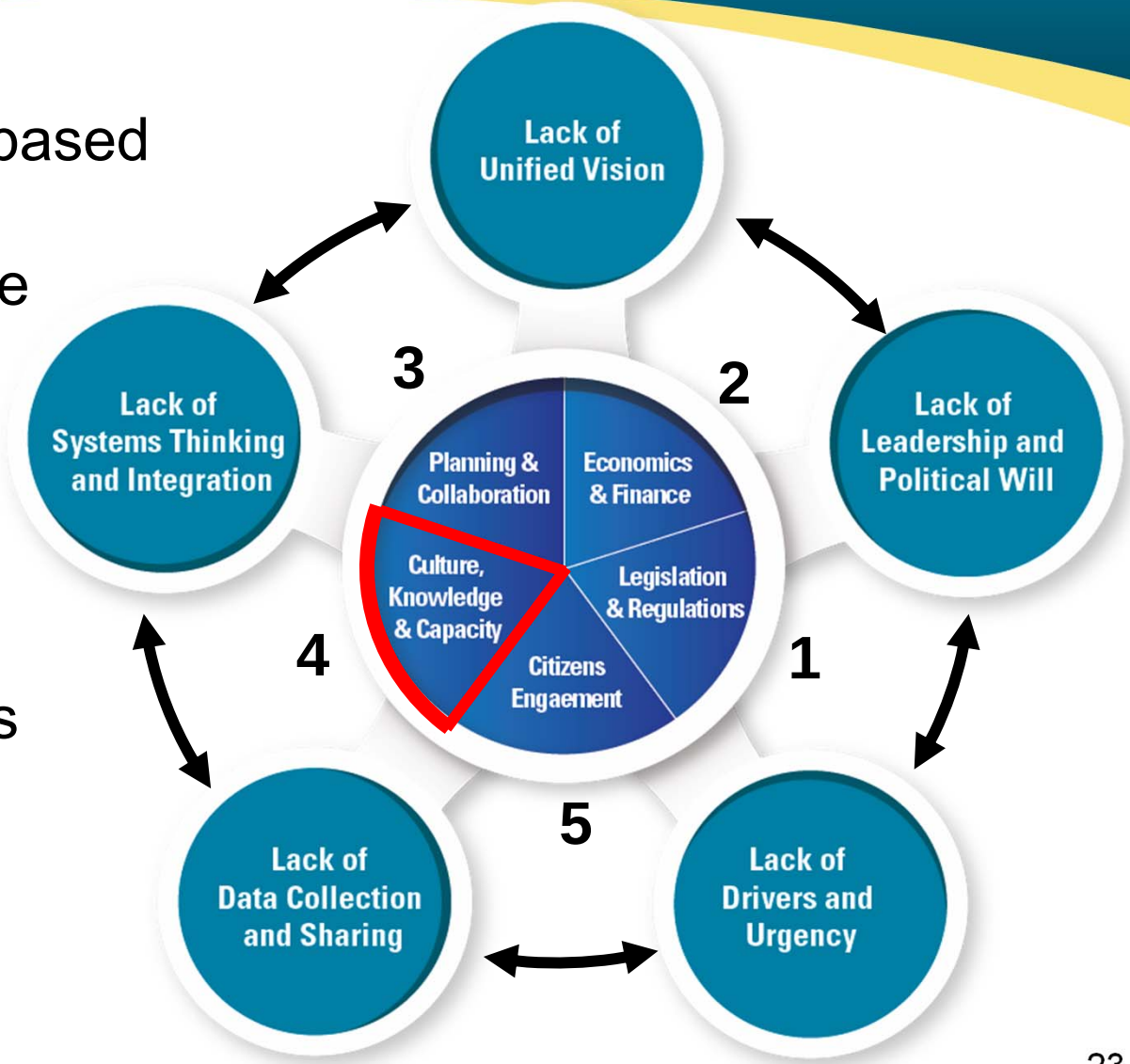
Washbasin-to-Toilet

Grey Water Reuse Must be Integrated into New Development



…but institutional challenges exist

- Need performance-based regulations
- Tools to calculate the true valve of water
- Holistic planning tools
- "Right-scaled" communications
- System of incentives and rewards



Adapted from: Howe, C., et al (2013)

Surprise!! There are legal hurdles!

- We must re-structure water's legal landscape
  - Current framework is based on "preservation"
  - Conflict between public welfare and private property rights
  - Threat of litigation hinders innovation
  - A "one chance" culture fosters litigation
  - Climate change is THE game-changer

Water law is entering totally new territory.

Summary

- The global solution for water involves
  - Avoid, Reduce, Reuse, Recycle
- Fit-for-Purpose reuse requires hierarchy of risk
- Guidelines are needed now
- Technology is simplest part of solution
  - Decouple interdependencies
  - Simplify technological processes
- Grey Water reuse is the logical first step
- Inertia is our biggest obstacle

Thank you!!

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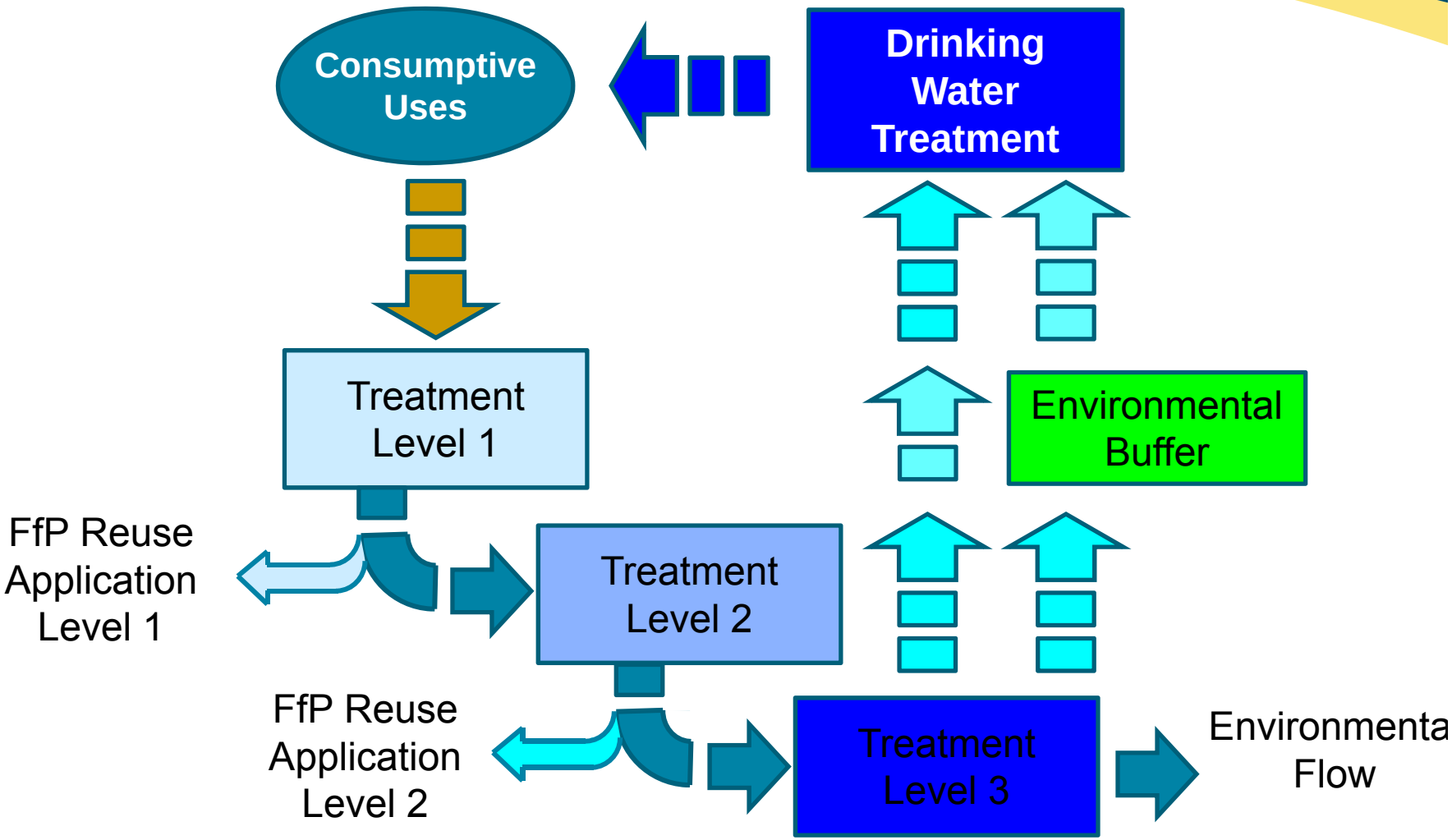
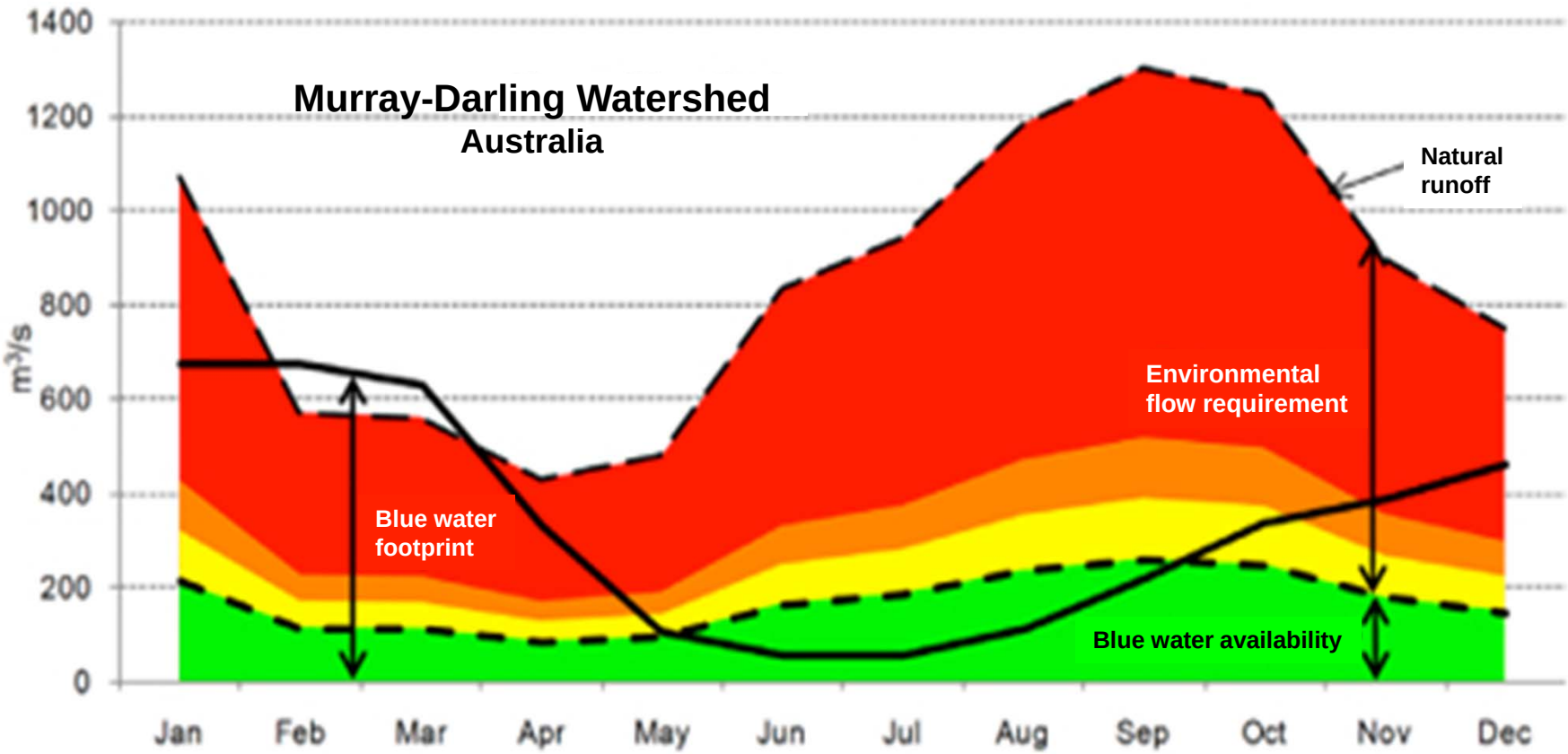
When Will We be Ready?



Scarcity Defined by “Net Available” Water



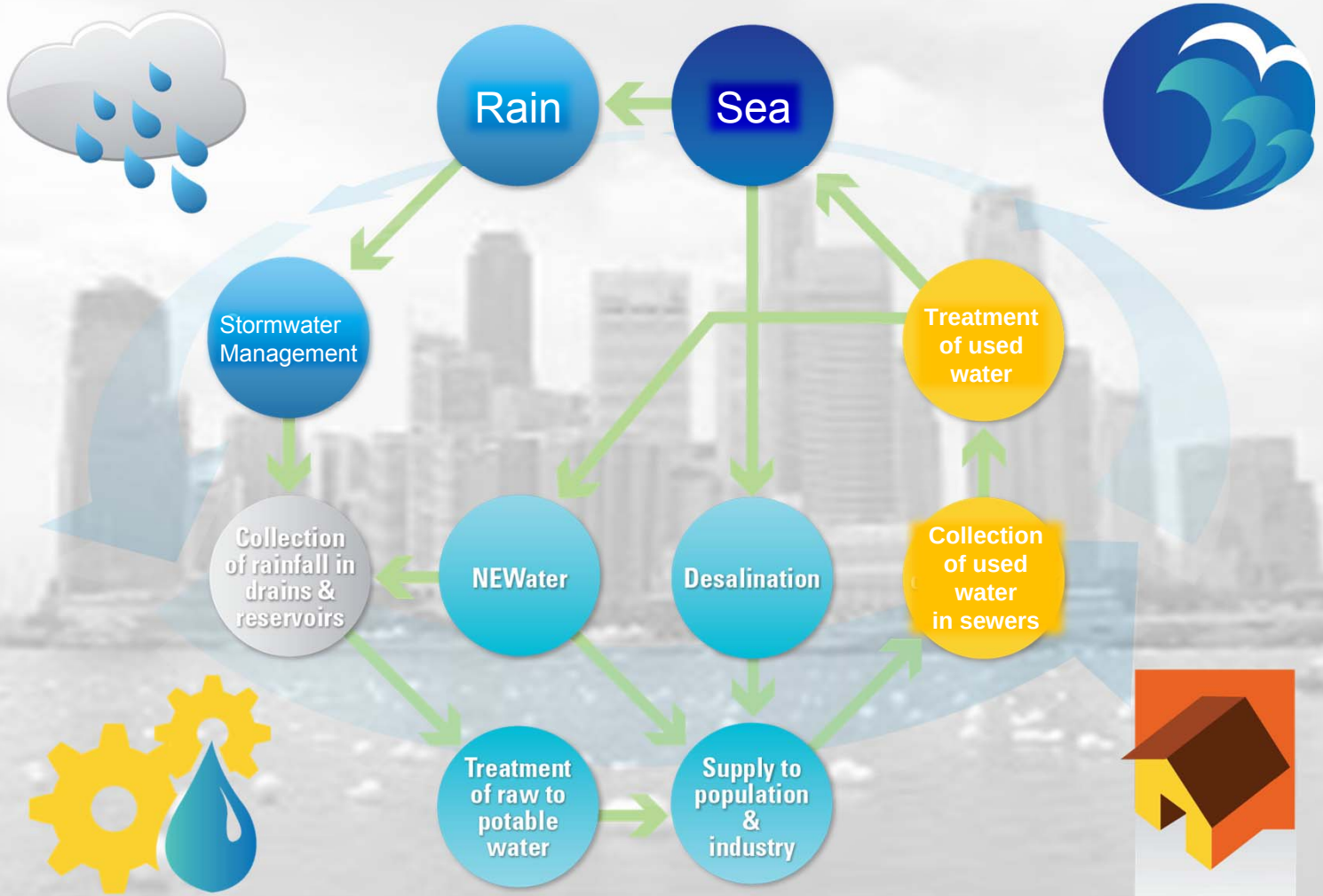
Example of Reuse

1. Collecting every drop

2. Collecting every used drop

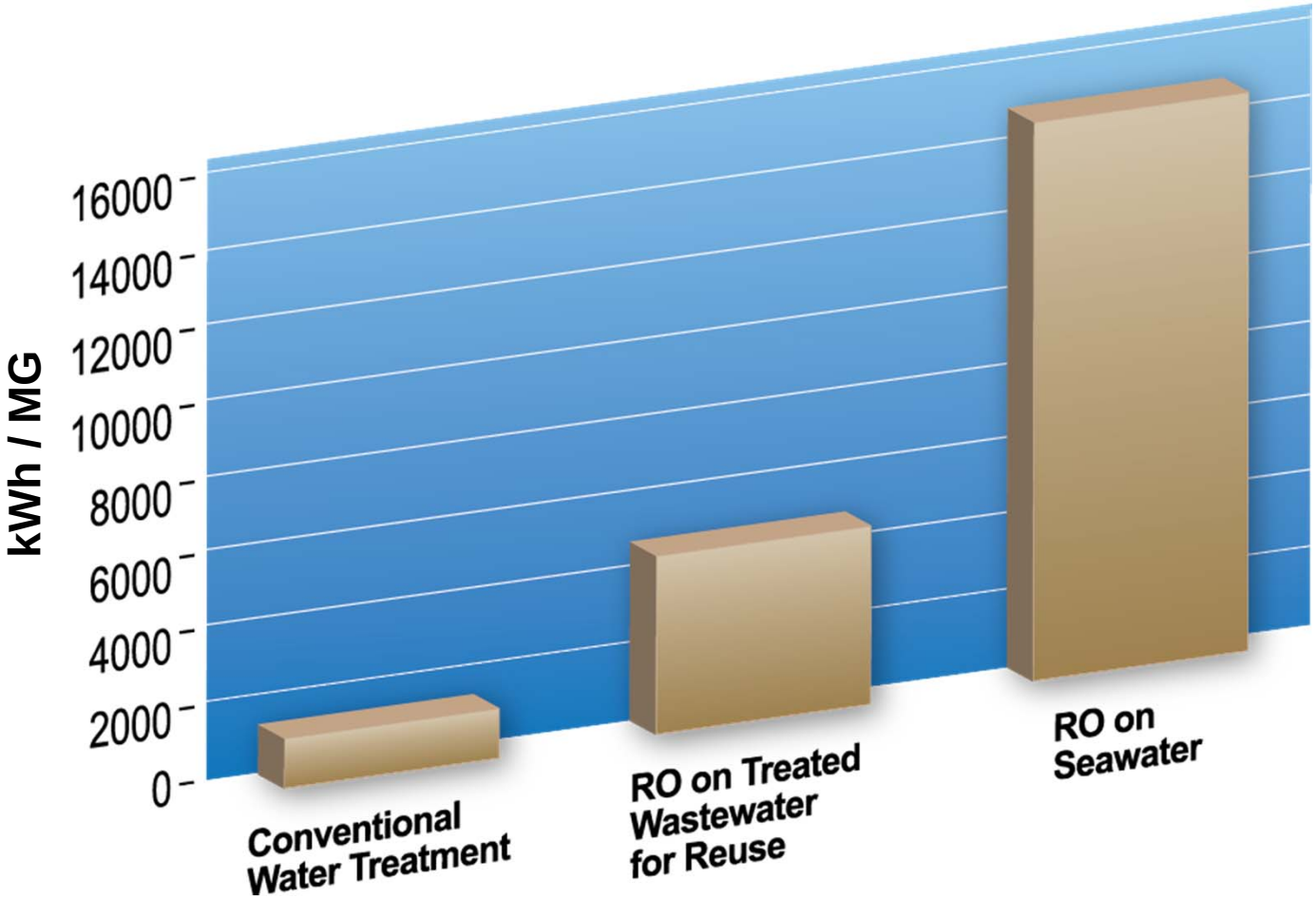
3. Using every drop more than once

4. Creating new drops

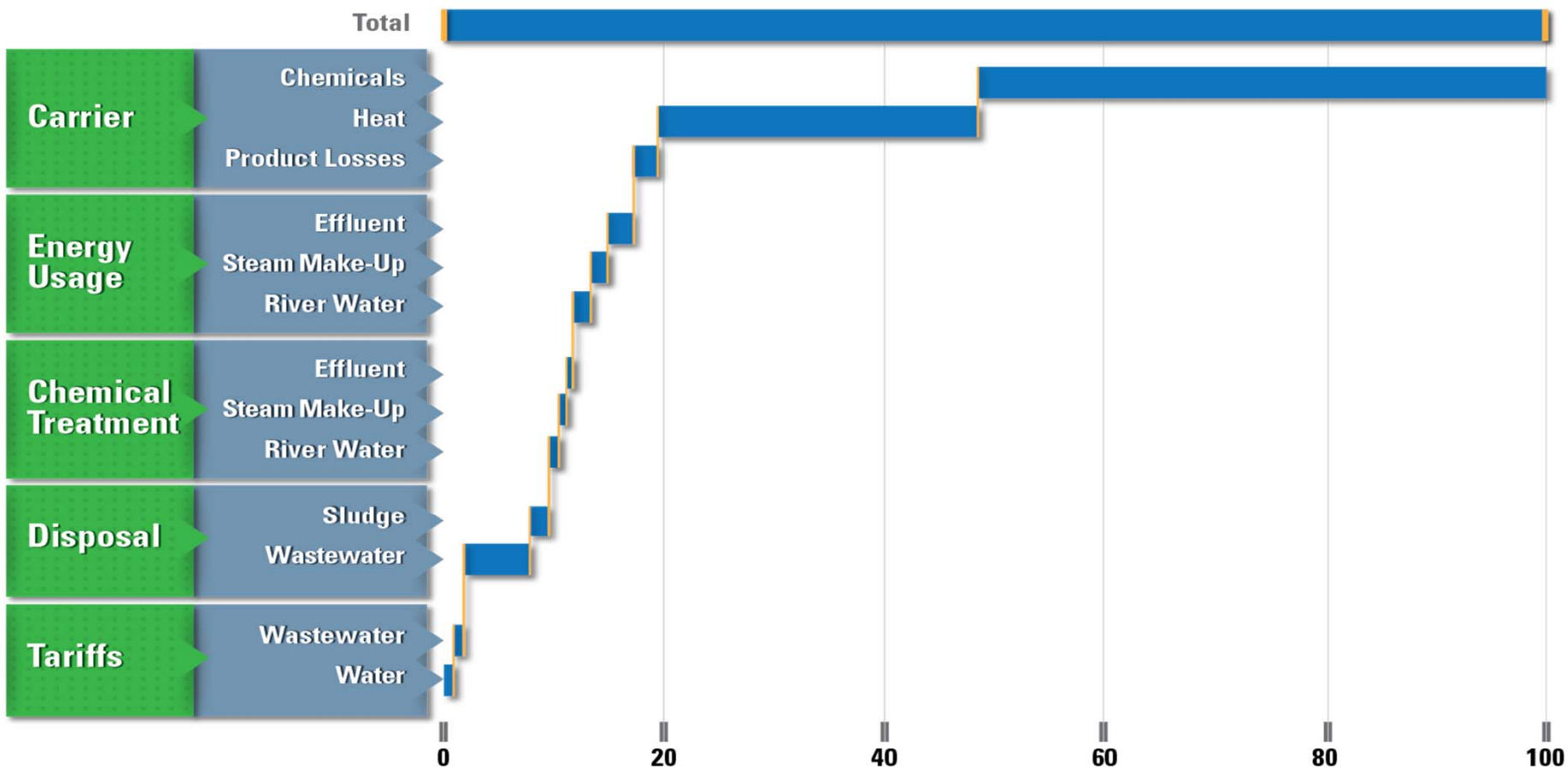


- US water reuse revenues: $1.32 Billion
- AAGR = 8.8% in 2011
- Highest growth occurring with high-volume users
- Landscaping & agricultural irrigation growth: 11%/yr

- The BIG choice:
  - Do we replace our aging infrastructure, or…
  - Do we consider other options?
  - Is desalination the answer?

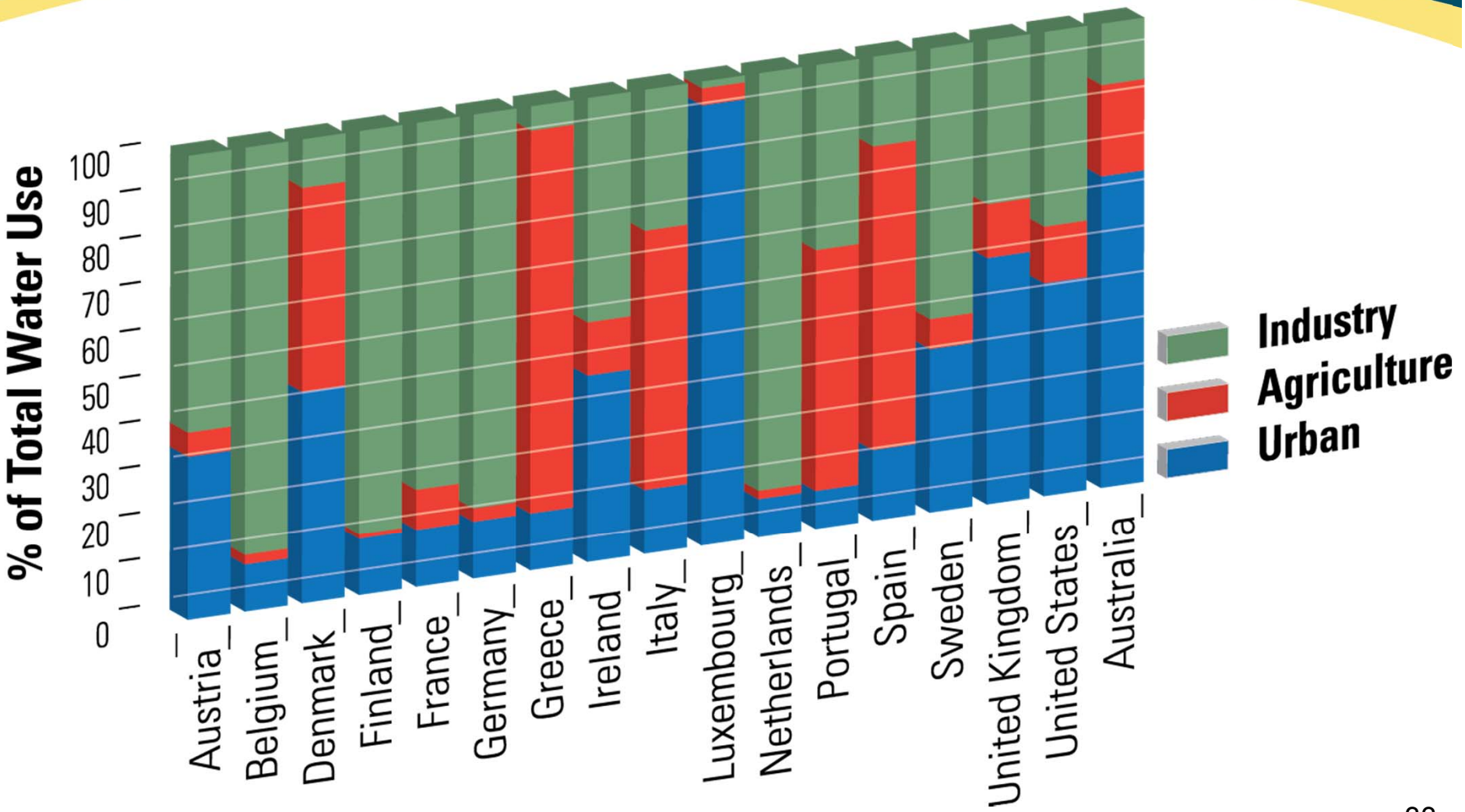


Adapted from: CISRO (2008)



Adapted from: McKinsey Co. (2013)

Water Use by Sector



Adapted from: Bixio, D., et al (2006)

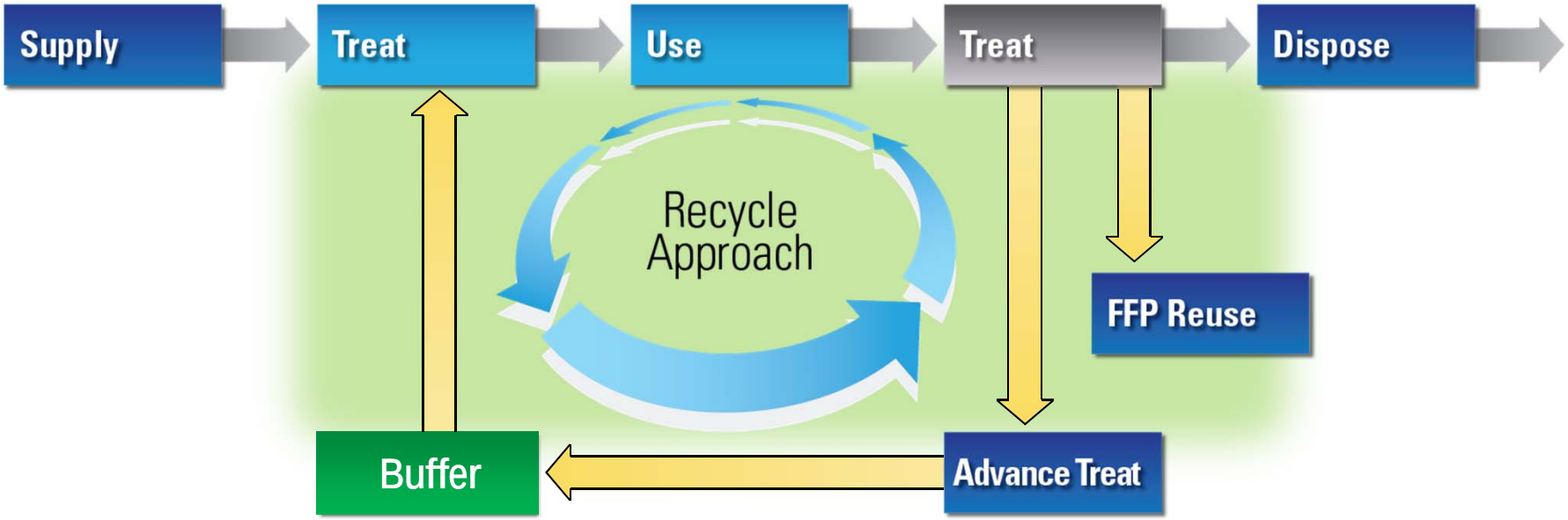
Public Health & Safety is No. 1

- To date, NO reliable epidemiological evidence of disease from recycled water
- Success is from the combination of appropriate treatment and best practices in application
- Source control is often overlooked

Keys to Reuse Success

- Quality is THE most important technical issue
- Technology is the least important issue
- Stakeholder involvement is THE crucial factor
- Reuse still “suffers” from the under-evaluation of water as a resource

The New Approach to Managing Water



"The 'abuse' of water use for diluting human waste for transport is unsustainable."

- S. Volkman, Michigan Tech University (2003)

…so, what are the obstacles?

- Water governance needs restructuring
  - Must reorient to fully integrated water management
- Cooperation among stakeholders
  - Must agree on responsibilities and liabilities
- Lack of consistent criteria on reuse quality
  - Results in conservative assumptions which lead to misunderstandings
- Economic instruments are weak
  - Must have cost/benefit methodologies that reflect true costs
- Lack of trust, credibility and confidence from public
  - You never get a second chance with single failure event

Don’t be mislead…reuse is not cheap!

- Statistically, 5 homes produce enough reuse water for irrigating 1 lawn
- Annually amortized Capital = \$0.45 / m^3
- In CA, \$4 million required for each 1 million m^3/yr of reuse made available
- Cost of high-end grey water reuse ~ \$5,000/house
- For treatment:
  - UASB + Stabilization Pond = \$4/capita
  - Activated Sludge = \$8/capita
  - Soil Aquifer Treatment = \$20 - \$50/capita

Is Reuse Economical?

- Advantages
  - Capital costs are low-to-medium and recoverable in short time
  - O&M costs are relatively simple
  - Quality of the reuse is often superior to that of well water
- Disadvantages
  - If large scale, utilities may experience revenues shortfalls as demand for potable for non-potable uses is reduced
  - May require additional distribution systems
  - Reuse demand may only be seasonal

Environmental Barriers are Beneficial

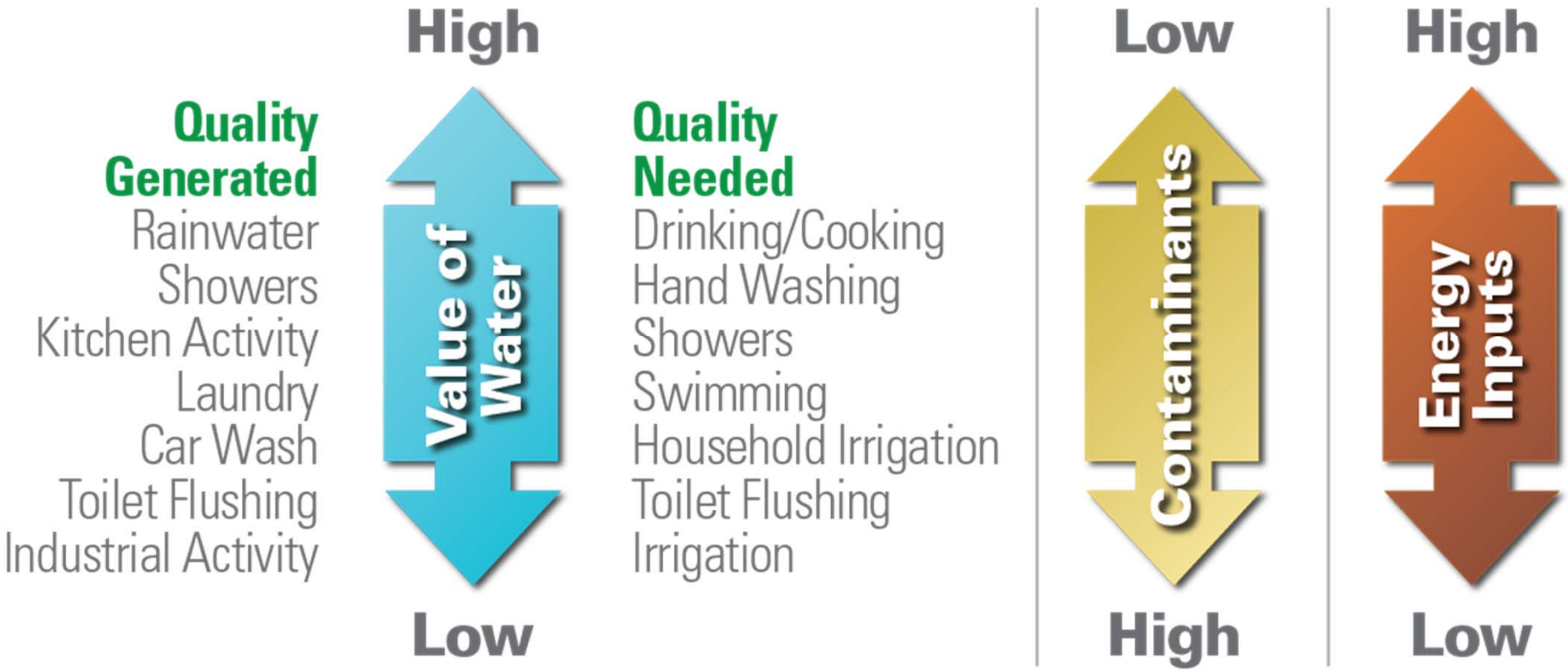
Organism	Log Reduction req'd	Log Reduction achieved	Biological & Tertiary	MF	RO	UV/AOP	AOP	Aquifer Retention (6 months)	
Crypto	10	16	No Credit Given	4	-	6	-	6	
Giardia	10	14		2	-	6	-	6	
Viruses	12	12		2	-	4	-	6	
							Post Treatment Cl2	Res Storage	Water Treatment
Crypt	10	15	2	4	1	6	-	-	2
Giardia	10	14	2	2	1	6	-	-	3
Viruses	12	14	1	2	1	4	2	-	4

…is the buffer essential to meeting the risk goals?

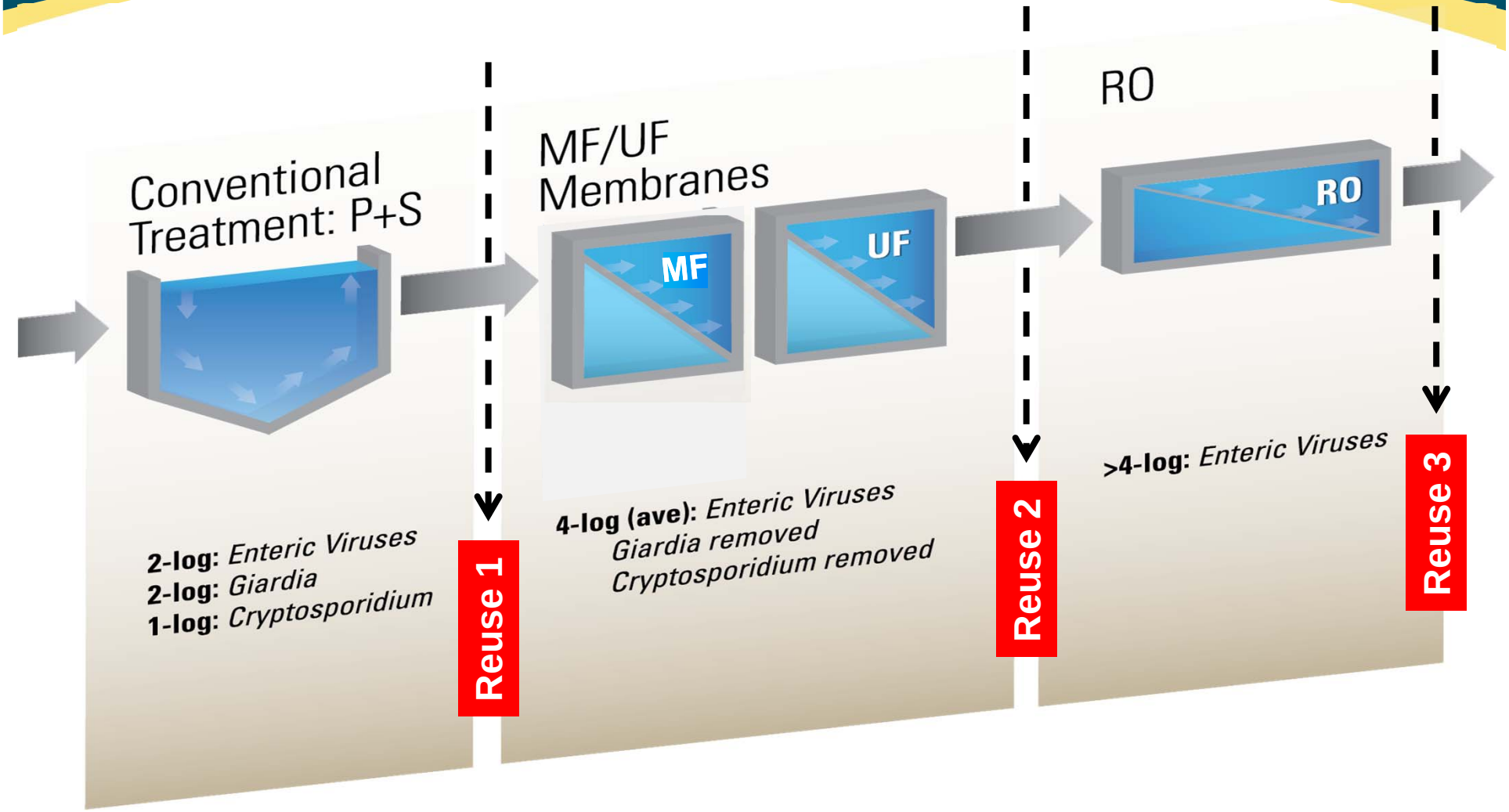
…No, but… engineered buffers will failure!

Adapted from: Trussell, R. (2013)

General Framework for Fit-for-Purpose



Don’t Forget About CAS…It Counts!!



Key to a Failsafe System: High Level Monitoring

Critical Control Point	Frequency	Critical Limit	Monitoring Parameter
MF / UF	1/day	0.4 psi / 5 min based on 4-log Crypto removal	Pressure decay
RO	Continuous	On-line permeate conductivity of 150 µs/cm; on-line permeate TOC = 100 ppb	Conductivity, TOC
UV / AOP	Continuous	0% (8 or more lamp failures or 4 ballast failures)	Reactor power level
	1/day	0 ml/min (indicating pump failure or loss of flow confirmation)	H2O2 dose

Source: Pearce, B. (2013)

Treatment Technology: Pulling it all Together for Reuse

Process	Colloidal Solids	Dissolved Org. Matter	Nitrogen / Phosphorus	Trace Organics	TDS	Bacteria & Protozoa	Viruses
Microfiltration	X					X	
Ultrafiltration	X					X	X
Nanofiltration		X		X	X	X	X
RO		X			X	X	X
Electrodialysis	X				X		
GAC		X		X			
Ion Exchange					X		
AOP		X		X		X	X
UV Disinfection						X	X (poor)

Reuse Option 1

Reuse Option 2

Reuse Option 3

Fit-for-purpose reuse pulls effluent from any or all of these treatment steps, depending on the quality required by the reuse.