SKIW – Envaqua - Koelwaterdag / December 7th 2017

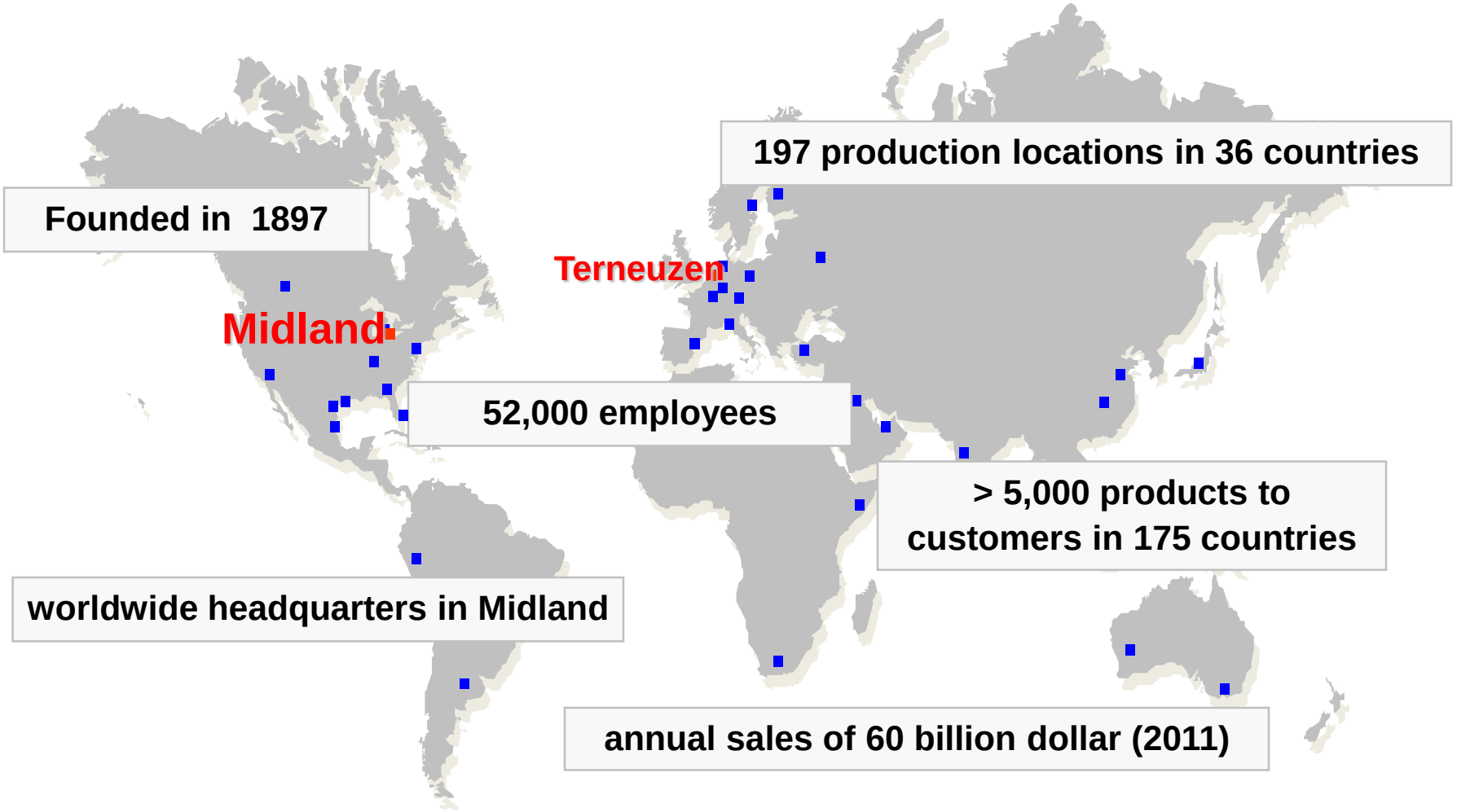
Open Circulating Cooling Towers

….reliability aspects….

Niels Groot
Environmental Technology Center

The Dow Chemical Company

- Some facts*



* Feb 2012

Our Present

Solving Challenges Through Sustainability

Many Dow Business Units are aligned to global challenges. This allows Dow's **scientists and engineers** to focus our **innovation engine** on delivering new technologies that are **good for business and good for the world**

Energy

Climate Change

Water

Health & Nutrition

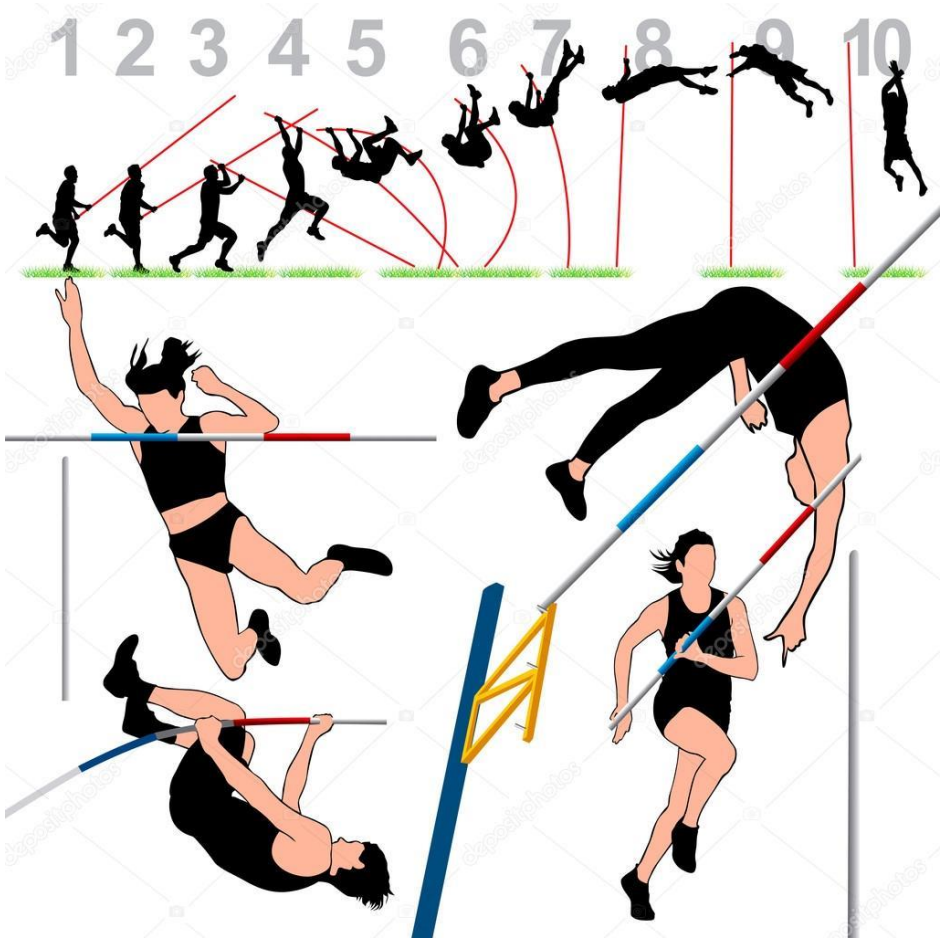
Transportation & Infrastructure

You find our chemicals everywhere

- Food
- Building Maintenance & Construction
- Transportation
- Furniture & furnishings
- Paper and Publishing
- Home Care Improvement
- Sports
- Personal and Household Care
- Health and Medicine
- Water Purification
- Electronics and Entertainment

Cooling Water Mgmt is like pole vaulting:

Everything needs to fit perfectly to prevent failures



- System design
- Feedwater quality
- Water treatment
- Regulatory
- Operations – turnarounds
- Maintenance

Cooling Water Goals

- "NEVER TAKE A FORCED OUTAGE OR LOSE PRODUCTION DUE TO WATER RELATED ISSUES"!
- Maximize production capability
- Achieve 8 Years between turnarounds on Hydrocarbon Plants
- Achieve 20-30 year exchanger life

Critical requirements for cooling towers

- Performance
  - Heat transfer (clean exchangers)
  - No regulatory issues (blow down)
  - Health & Safety (legionella)
- Reliability
  - Turnaround planning (6-8 years cycle)
    - No exchanger constraints during cycle
  - Uninterrupted supply of make-up water

→ **Resulting in maximum asset utilization, lowest energy use and costs, no EH&S issues**

Understanding potential expectation Gap

Typical Vendor Performance Monitoring Metrics

- Corrosion Rates (as measure by corrosion coupons - residuals)
  - Mild Steel < 1 mpy and < 0.5 mg/l Fe in water
  - Copper < 0.1 mpy and < 0.1 mg/L Cu in water
- Planktonic Microbiological Counts < $10^{\wedge 4}$ - $10^{\wedge 5}$
- Controlling Water within Scales Indices Constraints

Easily measurable surrogates for what is truly important

Typical Plant Performance Objectives/Desires

- Don't allow exchangers to fail prematurely (or not at all)
- Don't allow fouling that will limit heat transfer or cause lost production time due to cleaning or failure
- Control MB to prevent exchanger corrosion, tower fill fouling and other detrimental effects

The real desires and expectations

What can go wrong? A partial list…

- Multiple Sources Water
- Poor Quality /Variable Source Water
- Acid Over/ Under Feed
- Biocide Under/ Over Feed
- Deficient Blow Down Control
- Deficiently Chemical Selection
- Vendor Chemicals Control Issues
- Chemical Attack on Tower Structure
- Tower Structural Failure
- Chip Scale
- Iron Precipitation Fouling
- Excess Solids in Cycle Water
- Tower Fill Fouling
- Microbial Growth/Fouling

- Deficient System Passivation
- Exchanger Debris Fouling
- Bi-metallic Exchangers
- Low Flow Exchangers
- Throttled Exchangers
- Excess Heat Flux
- Excess Skin Temperature
- Exchanger Dry-Out Conditions
- MB Issues Due to Exchanger Leaks
- Microbial Induced Corrosion
- Copper Precipitation Induced Pitting
- Stagnant Water Event Corrosion

Cooling Water System Failures

Tower Structural Failure

Cu/CS Bi-metallic

Figure 3. Tubesheet after hydro blasting. Note severe pitting and under deposits corrosion on the tubesheet and corrosion products (greenish) inside tubes. The tubesheet corrosion may have been aggravated due to galvanic effect of tube material.

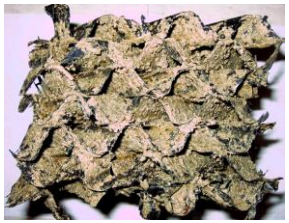
Corrosion byproducts

Tuberculation

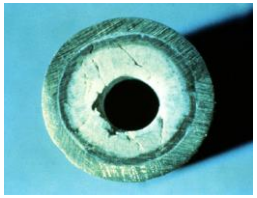
Pitting Example

Figure 3. ID - Close up of leak site.

Fill Fouling

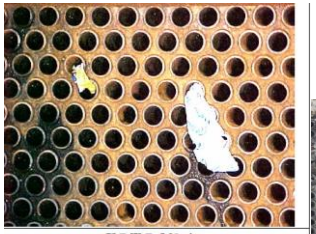


$CaCO_3$ Scale



Phosphate Scale

Debris Fouling



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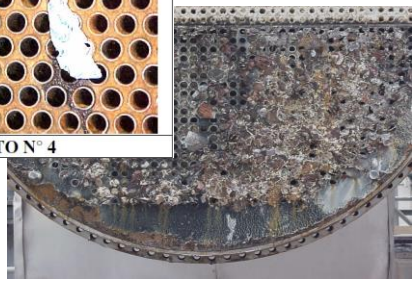
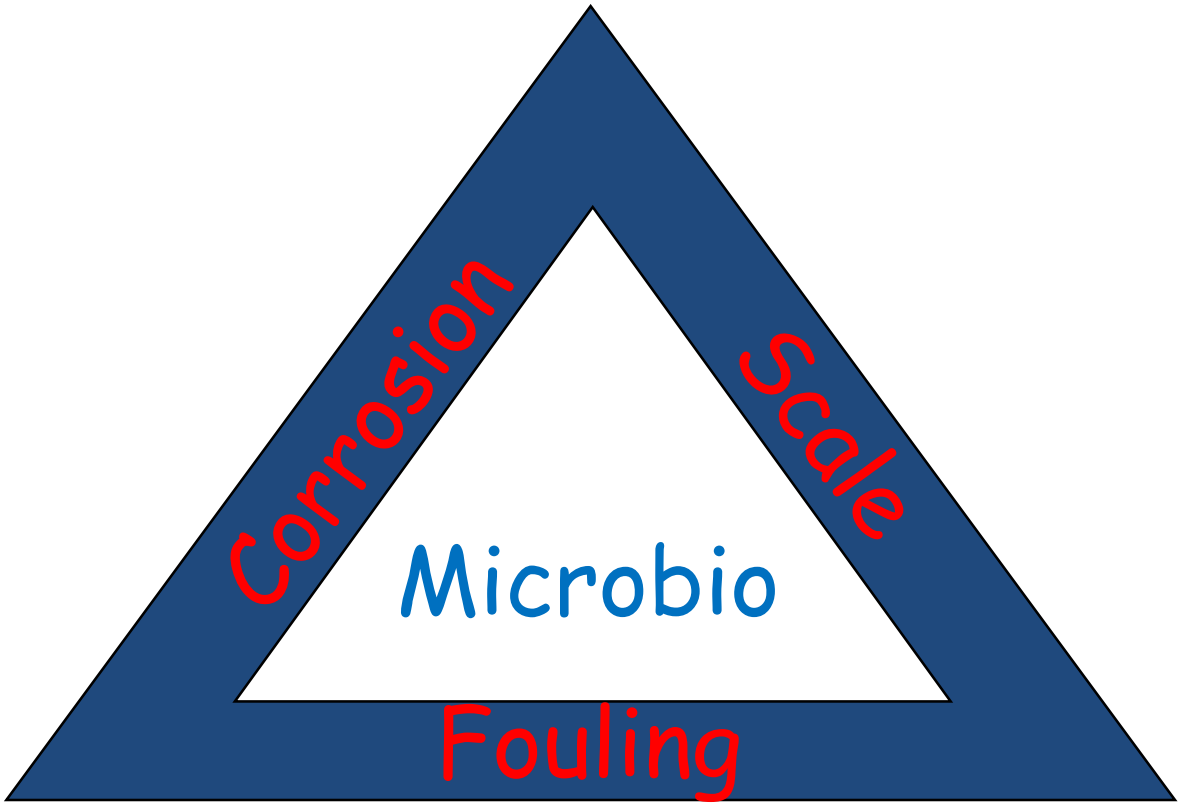


Chip Scale

Shell Side Scale/Fouling

The Cooling Water Triangle



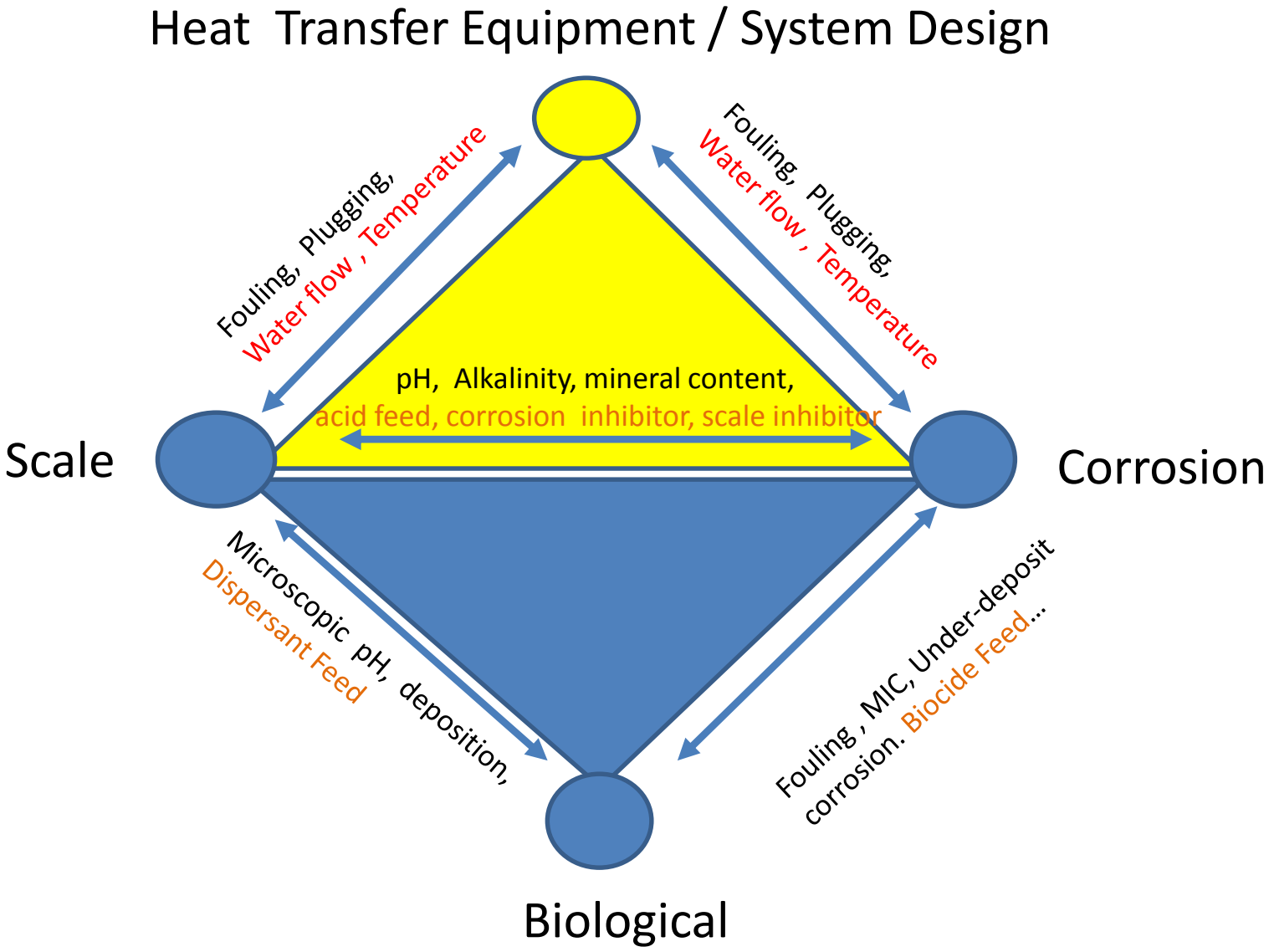
What is important? Why?

- Cooling water is a utility that should never limit production

What is needed prevent production losses		Why?
Consistently cool water relative to wet bulb(Tower)		Protect production capacity
Consistently distribute water (Pumps, pipes, valves …)		Prevents exchanger fouling & failure
Prevent debris and sediment fouling (Screens & Filters)		Assure treatment at surfaces
Control corrosion	Typical Vendor focus, But not entirely	Prevents exchanger fouling & failure
Prevent scale		Prevents exchanger fouling & failure
Control microbiological growth		Prevent Numerous Failure Issues
Proper design and start up (Screens & Filters)		Prevents certain failure
Maintenance and operation consistently with design		Assures 24/7 consistency

In summary, it should protect equipment life and production capability

It is a Cooling Water Square



Managing Integration

- Maintain **Knowledgeable Staff** and Support Resources
- Establish Clear Design Expectations …**Design it right !!!**
- Start-up, Commissioning & Passivation …Treat it right from the start
- Treatment Vendor Selection/Management …Use Reputable/Experienced Vendor
- Chemical Program Selection/Review **Establish Clear Performance Expectations**
- **Chemistry Monitoring and Control ... 24/7 monitoring by plant/Vendor**
- Chemistry Monitoring/Feed Equipment Maintenance …Maint. Accountability
- Conduct Reviews/Audits ...2nd Level Performance Checks
- Flow Distribution Monitoring and Maintenance …Avoid Low Flows
- Cooling Tower Maintenance …**Understand Inspections**
- **Exchanger Monitoring and Maintenance** …Minimize/Awareness of Defects
- Failure Event Reporting
- Training
- Change Management

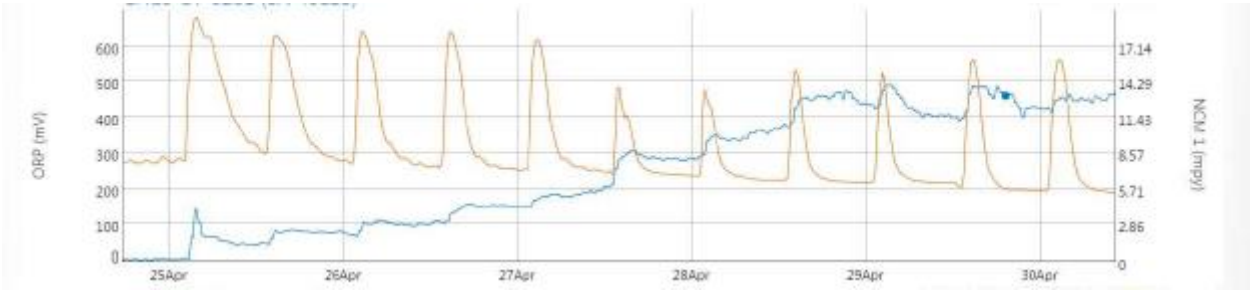
Corrosion

Turnaround management

Poor lay-up practices during turnarounds (open to air, inadequate draining, flushing with wet air) cause irreversible corrosion in distribution piping → chip scale → fouling and plugging → heat exchangers failures

Impact of poor passivation

Increased CS corrosion rate after start-up



Enhanced CS corrosion due to shock chlorination

Regulatory trends and impact

- Low/no P programs, low/no Zn programs → tighter operating windows requiring more consistent feed water quality
- Use of biocides
  - discontinuous → spiking corrosion
  - continuous → more effective provided decent make-up water quality is available
- Reduce fresh water intake → water reuse, higher cycles, less chemicals, less energy

Fresh water demand

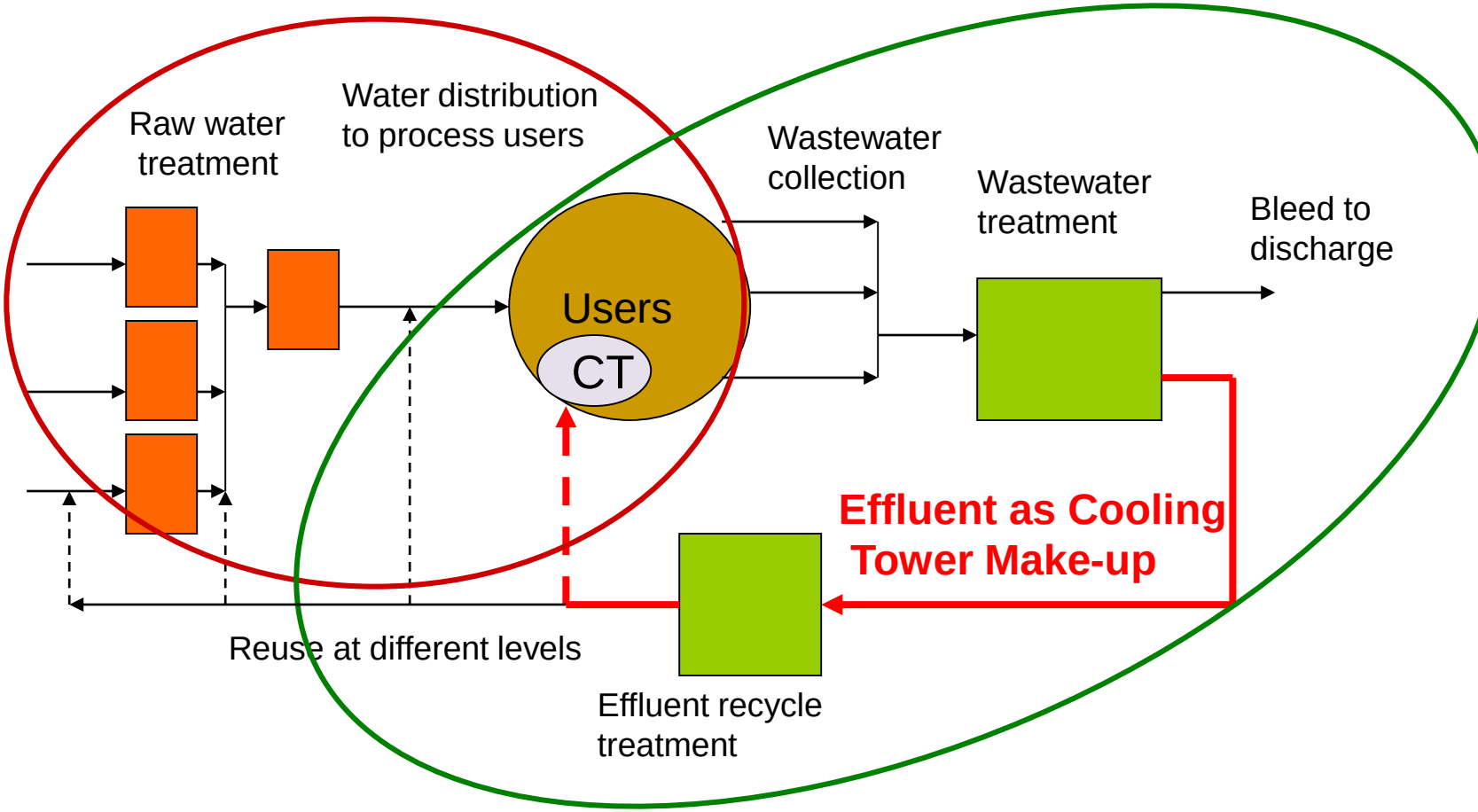
- Supply of raw water
- Reuse water

Requirements

- Consistent water quality
- Availability

Impact

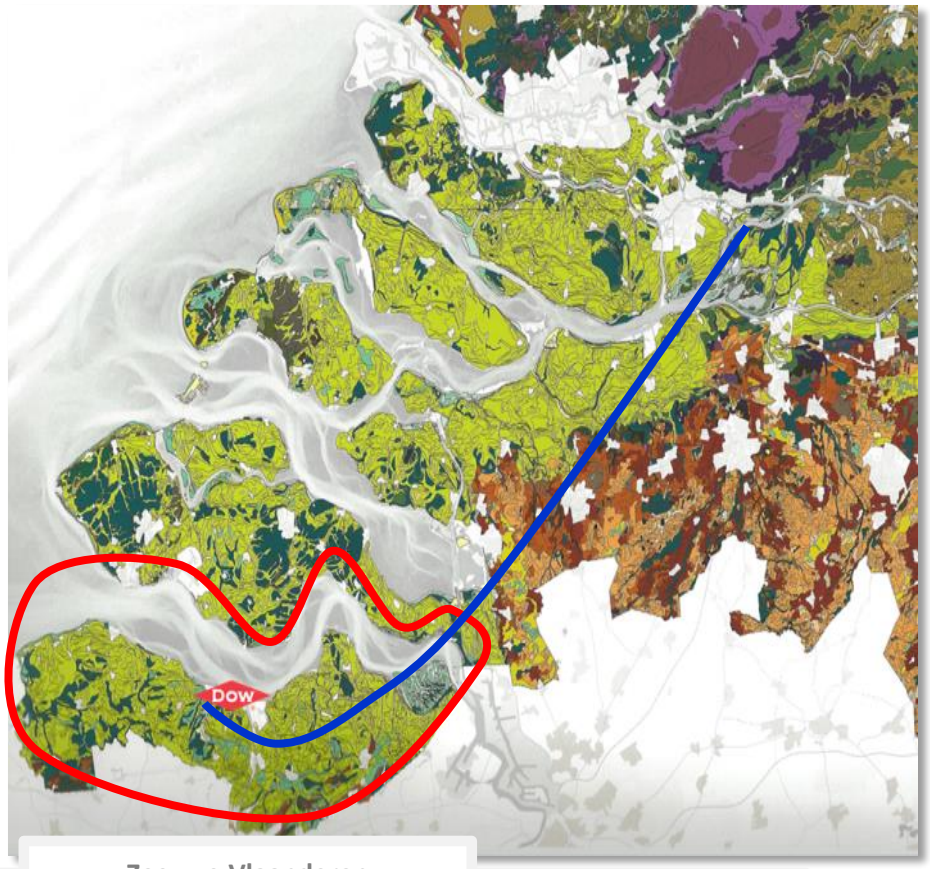
- Corrosion, scaling tendency
- Microbiology (biofilm, legionella)
- Water treatment effectiveness
- Heat exchanger performance and longevity
- Water and Energy use



Dow Terneuzen

Feiten

- Second biggest Dow site globally
- 440 hectares
- 1,700 employees + 600 contractors
- 17 Plants incl. 3 Ethylene crackers
- 800+ different chemicals and plastics
- 85% of products exported
- Located in a Water Stressed Delta
- Zoetwater verbruik is jaarlijks 22 Miljoen m³

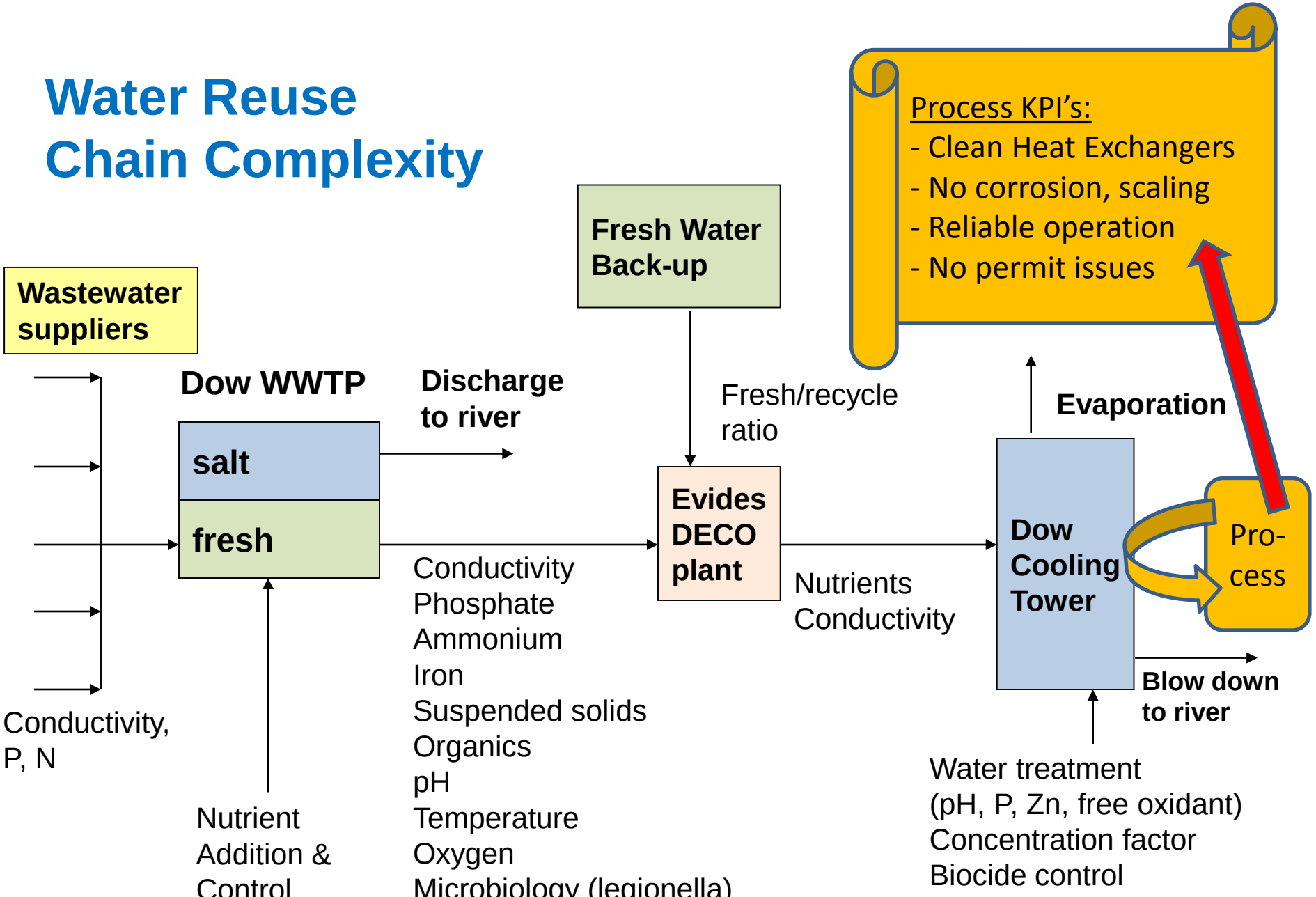


Zeeuws-Vlaanderen

- 1-2 Miljoen m³ water local beschikbaar
- Aanvoer over grote afstand: pijpleiding ~120km
- Grond- en oppervlaktewater zijn mild brak

Terneuzen / Naphtha Cracker-3 Cooling Tower
fed with > 50% WWTP effluent recycle
2-3 million m³/year

Water Reuse Chain Complexity



Process stability requires advanced chain control

“Sustain the gain” - operational challenges

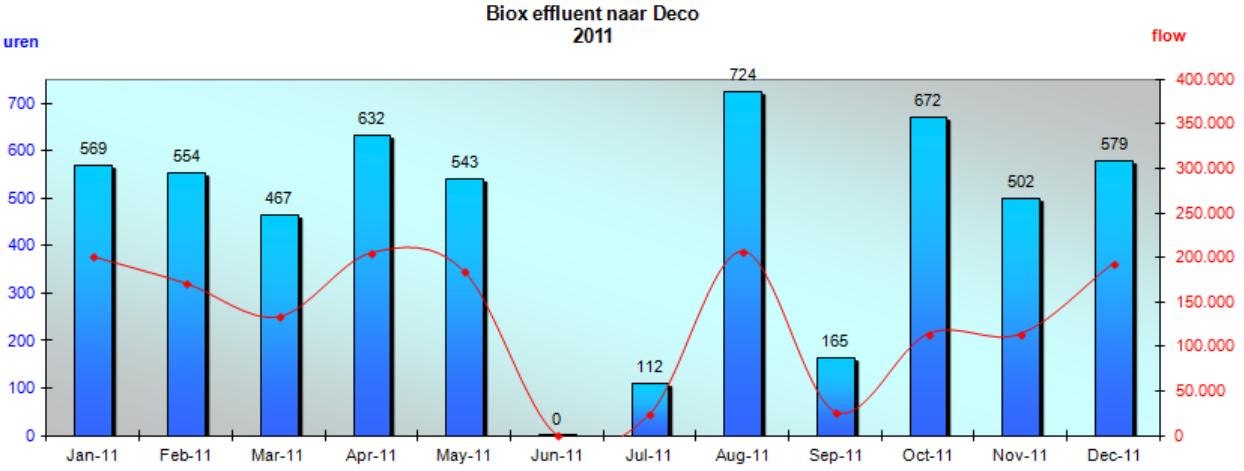
BIOX ZOET VERPOMPING NAAR DECO

2011

	% doel	deze maand	totaal
Aantal uren verpompt		579	5519
Aantal m3 verpompt	84,11%	193.120	1.567.780
		deze maand	totaal
Bijdrage Biox in CTS water	%	61,40	39,88
Aandeel van zoete influent	%	40,13	36,74

Oorzaak (in uren):	deze maand	totaal
PO4	0	532
NH3	15	176
uS	17	1461
pH	0	0
TOC	11	20
Troebelheid	8	232

deze maand	totaal



Optimization opportunities via recycling of valuable constituents for water treatment (phosphate, zinc)

Manage Make-up Quality Variability

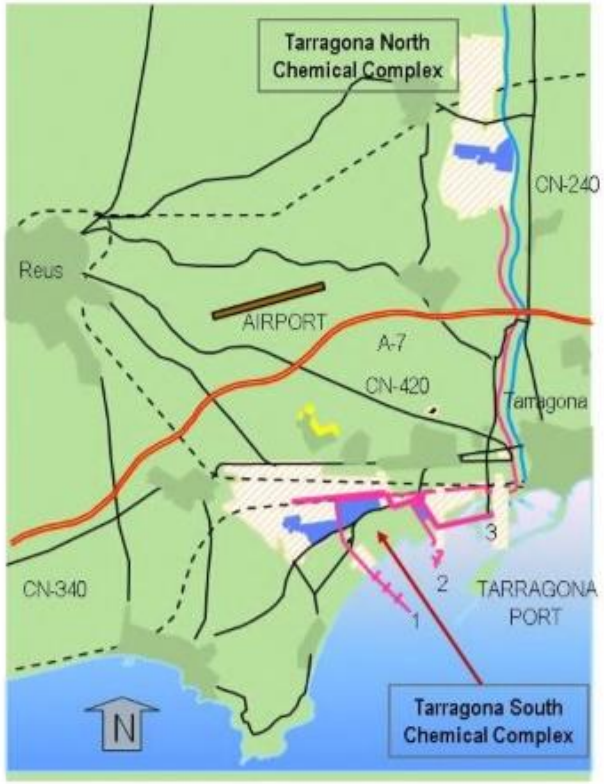
Short term fixes

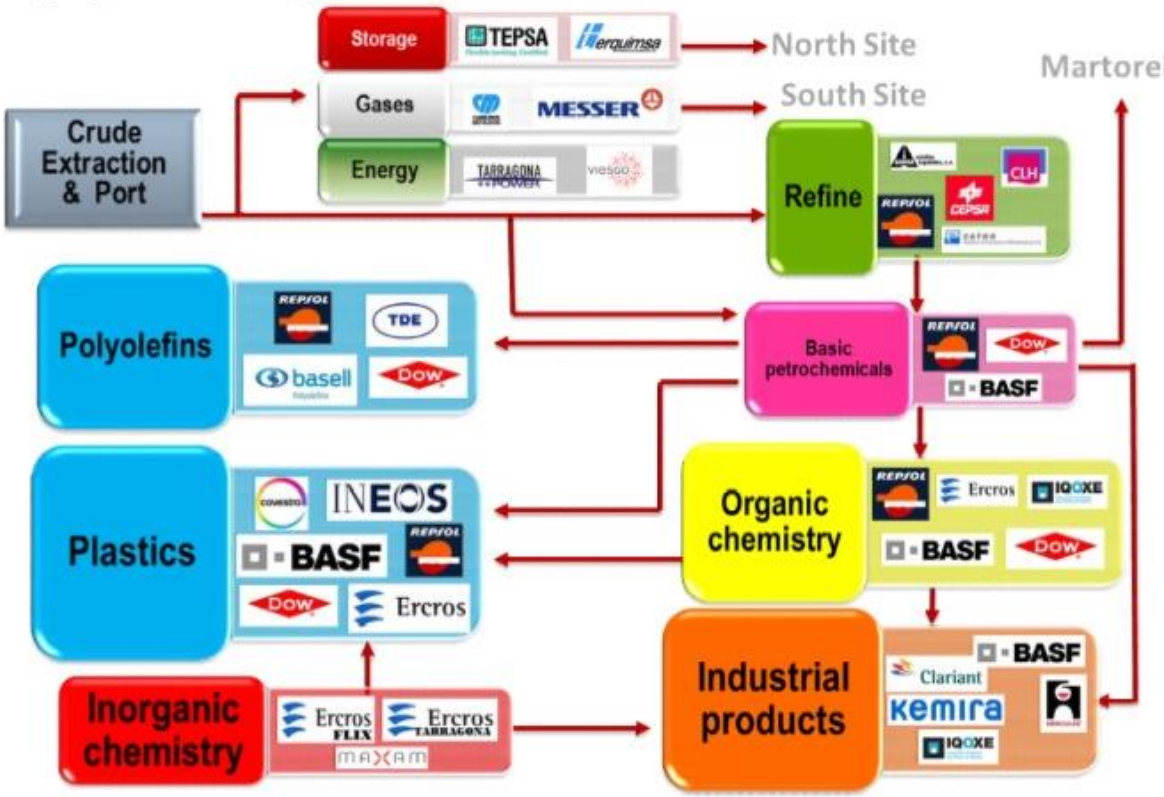
- Enhanced chemical & biocide control
- Split chemical dosing (multiple drums)
- Side stream treatment
- Automation

Long term or new systems

- Robust pretreatment comprising
  - biological stabilization
  - removal of solids, iron, etc
  - (mild) desalination (di- and monovalent ions)

ChemMed. Strongly Integrated Chemical Cluster



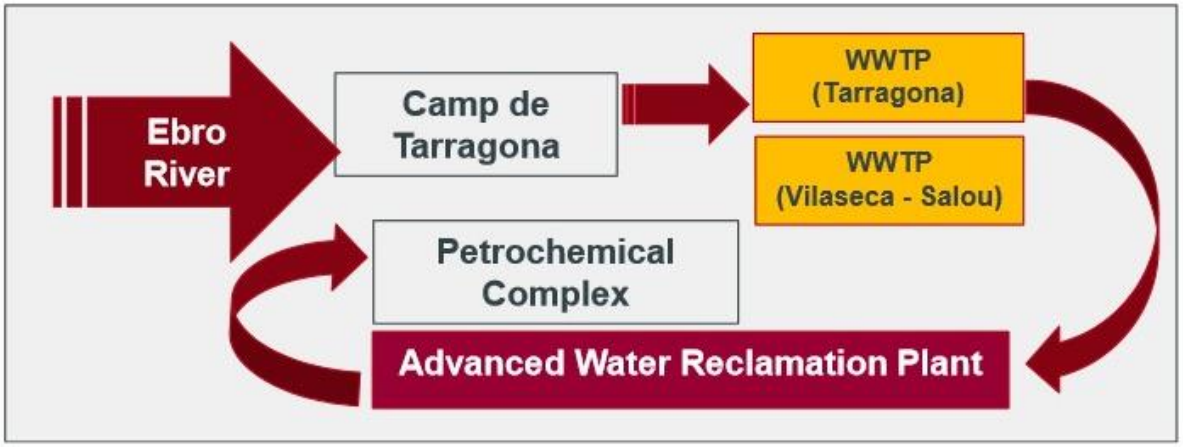


Logistics Operators: SM · CHEMIPRATS, S.L. · Sidmar · Vopak Terquímsa · TEPSA · DP WORLD · BERTSCHI

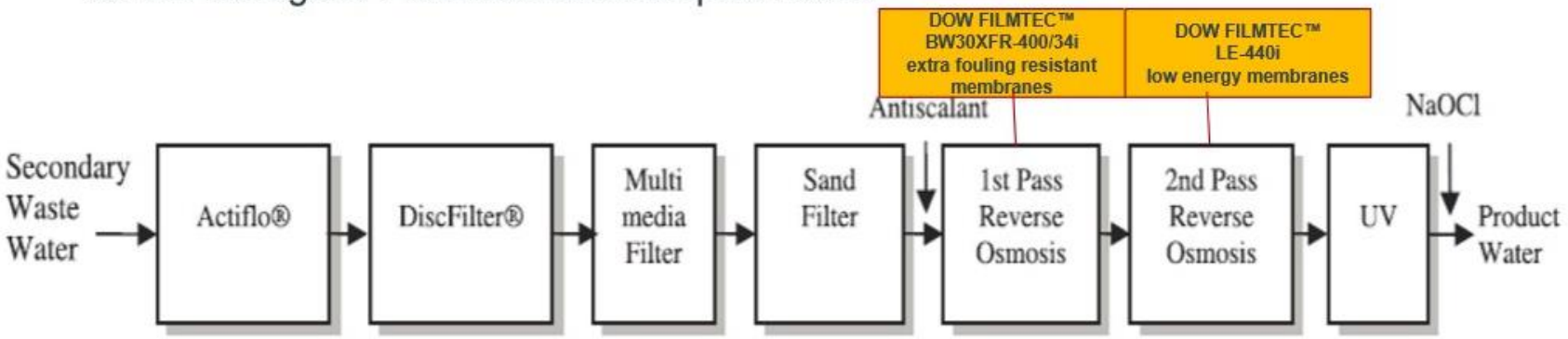
Tarragona Chemical Cluster (ChemMed)

- *Largest Petrochemical complex in the Mediterranean*
- *Total Production 21 MM Tones (Chem. 60% / Ref. 40%)*
- *Employment: 6,000 Direct / 4.000 Indirect / 35.000 Induced*
- *Water consumption DOW Tarragona: 6 - 7 MM m^3/y*

Camp de Tarragona Advanced Water Reclamation Plant

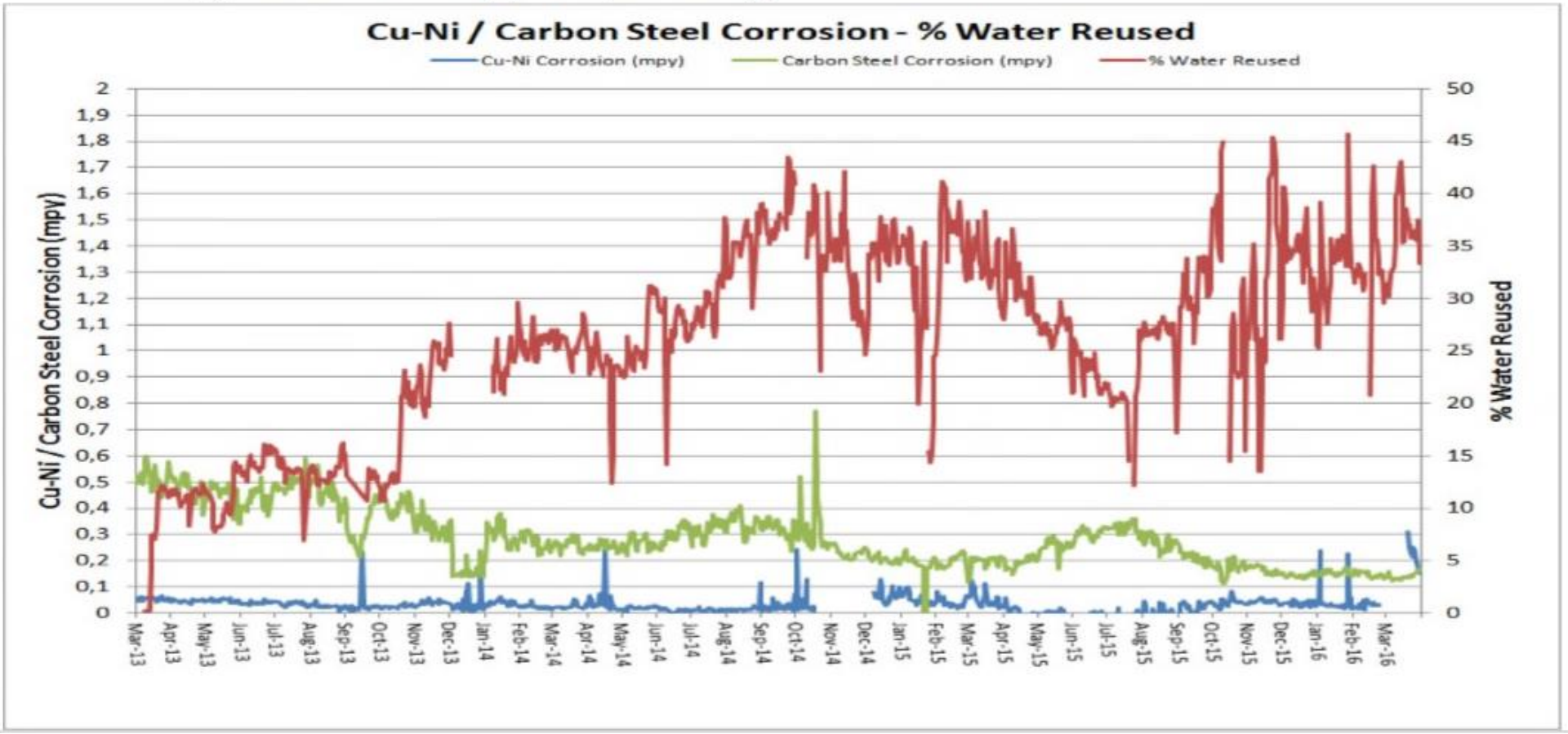


- Reclamation Plant designed for 19,000 m^3/d of permeate water from Tarragona and Vila-seca Wastewater Treatment Plant.
- Owned by ACA (Water Catalan Agency) and operated by Veolia and AITASA
- Reused water is blended with Ebro River water in order to provide make-up cooling water for the Tarragona Petrochemical Complex Plants



Performance at 40% recycle

- Carbon Steel and Copper-Nickel corrosion is not affected by using Reverse Osmosis permeate water as both are kept negligible (<1 mpy and < 0.1 mpy respectively)



Microbiological Analysis

- Ammonia is just found in traces levels
- Total Organic Carbon (TOC) is below recommended limit of 50 ppm
- Aerobic Bacteria are below recommended range of < 10,000 UFC/mL
- Legionella concentration is below minimum range of 40 UFC/ml
- We can conclude RO Permeate is a “safe” water

	River Water (100%)	River Water (60%) + Reclaimed Water (40%)
Cooling Water NH3 (mg/L)	0.05	0.03
Cooling Water TOC (mg/L)	19.3	21.0

Enhanced system automation

Freeport plant saves > 4 million m^3/yr

Description

The water conservation and cost-saving of Nalco's 3D TRASAR Cooling Water Technology at Dow's Freeport plant enables saving more than 4 million m^3 of fresh water for process cooling

Sustainability Profile

- Dow's Freeport site – Dow's largest production facility – saves enough water to supply 40,000 people with water for one year
- Water savings amounts to $4 million dollars in cost savings
- Dow provides basic building blocks for chemistry in the 3D TRASAR system
- Nalco's Cooling Water Technology received 2010 U.S. Presidential Green Chemistry Challenge Award

Take aways ....

Continuously raising the bar ..... requires

- Assure proper system design (water velocity, distribution, heat flux, limit skin temperature)
- Manage incoming water within strict boundaries (both quality and quantity)
- Best in class water treatment for corrosion inhibition (steel, yellow metal), scale inhibition, minimizing microbiology
  - compatible chemicals (azole, biocide, a.o.)
  - not limited by EH&S constraints
- Adequate maintenance and turnaround management


Dow Benelux BV
Connects
Chemistry & Water
with passion!
Water
Each drop counts!