



Field Data from Oil in Water Polishing of Produced Water for Discharge and Reinjection

Produced Water Society Conference

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Osorb[®] Media Technology

Osorb[®] Media:

- Organically-modified silica
- Porous, Flexible Matrix
- Hydrophobic
- Adsorption & Absorption
- Regenerable & reusable

Application Methods:

- Bulk Media Vessel
- Canisters
- Injection into Flow Line

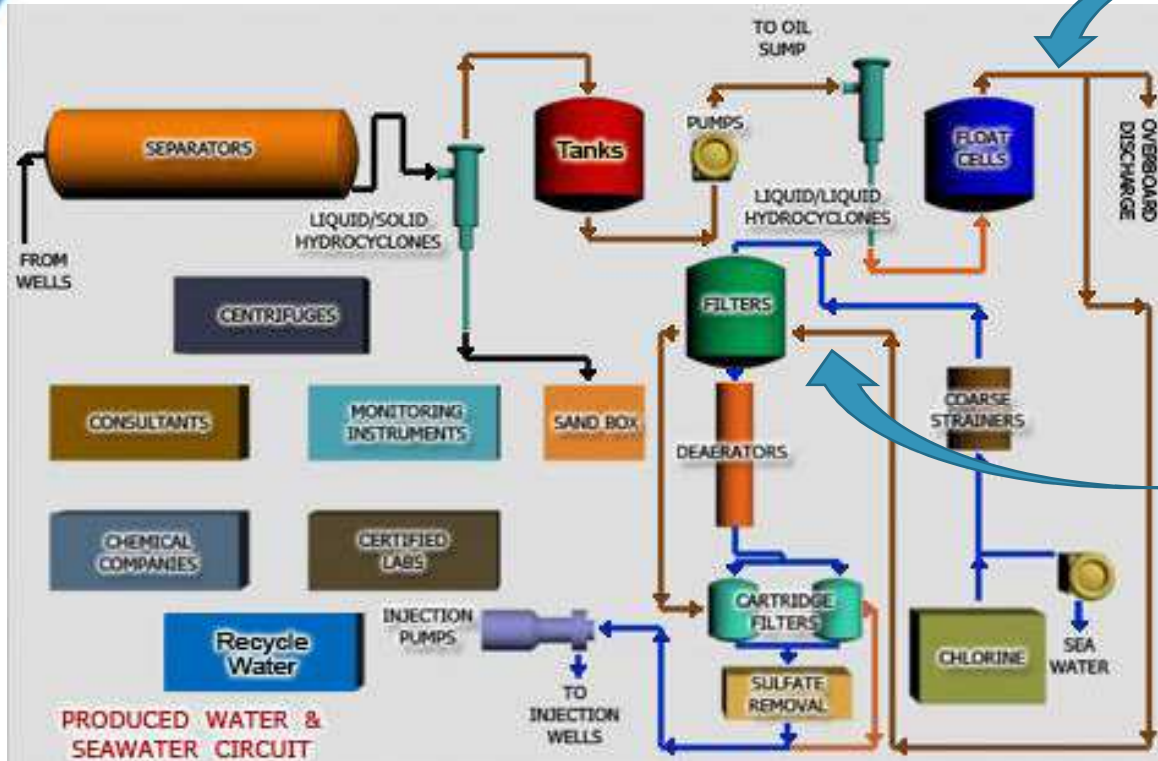
Applied to:

- **Produced Water**
- **Flowback & Completion Returns**
- **Pipeline Fluids**
- **Membrane Protection**
- **Chemical EOR**
- **Hydrocarbon Dew Point (HDP)**
- **Gas Emissions Control**

Removal of free, dispersed, emulsified, and soluble hydrocarbons and some oilfield chemicals from water.

Removal of vapor phase and micro-droplet Hydrocarbons from gas.

PW Treatment – Osorb® Media



Final Polishing for Overboard Discharge and Reinjection

The Produced Water Society – Equipment Reference Guide
www.producedwatersociety.com



Osorb[®] Media Regeneration – Basic Theory

Lower Molecular Weight Sorbates

1. Gaseous / steam purge to volatilize sorbates from Osorb

Higher Molecular Weight Sorbates

1. Displacement fluid purge to displace high molecular weight sorbates with lower molecular weight displacement fluid
2. Gaseous purge or steam purge to volatilize displacement fluid from Osorb

Other General Mechanisms of Desorption

- Thermal Swing
- Pressure Swing
- Concentration Reduction
- Chemical Changes
- Mechanical Force

Osorb[®] Media Field Regeneration – Hydrocarbon Dew Point Reduction



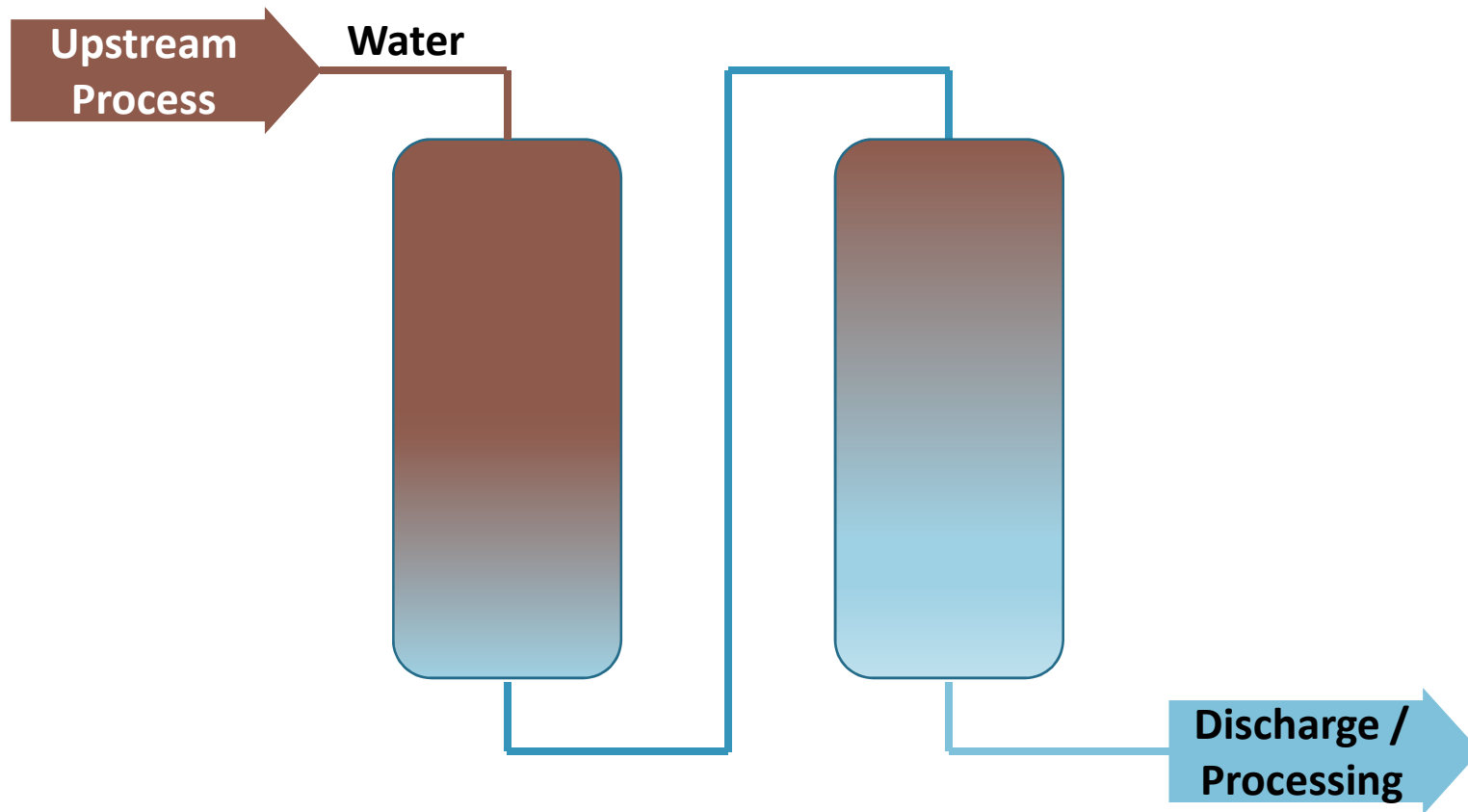
Sorbate in Osorb [®] Media	RT (min)	BP (°C)	ppm in DCM		% Regenerated
			Before Regeneration	After Regeneration	
benzene	2.63	80	26	0	100
heptane	2.98	98	429	0	100
methylcyclohexane	3.35	101	734	0	100
toluene	4.17	111	338	0	100
octane	4.96	126	730	0	100
ethylcyclohexane	5.95	131	325	0	100
p-xylene	6.92	138	510	0	100
m-xylene	7.49	139	171	0	100
nonane	7.65	151	706	0	100
propylcyclohexane	8.31	155	274	0	100



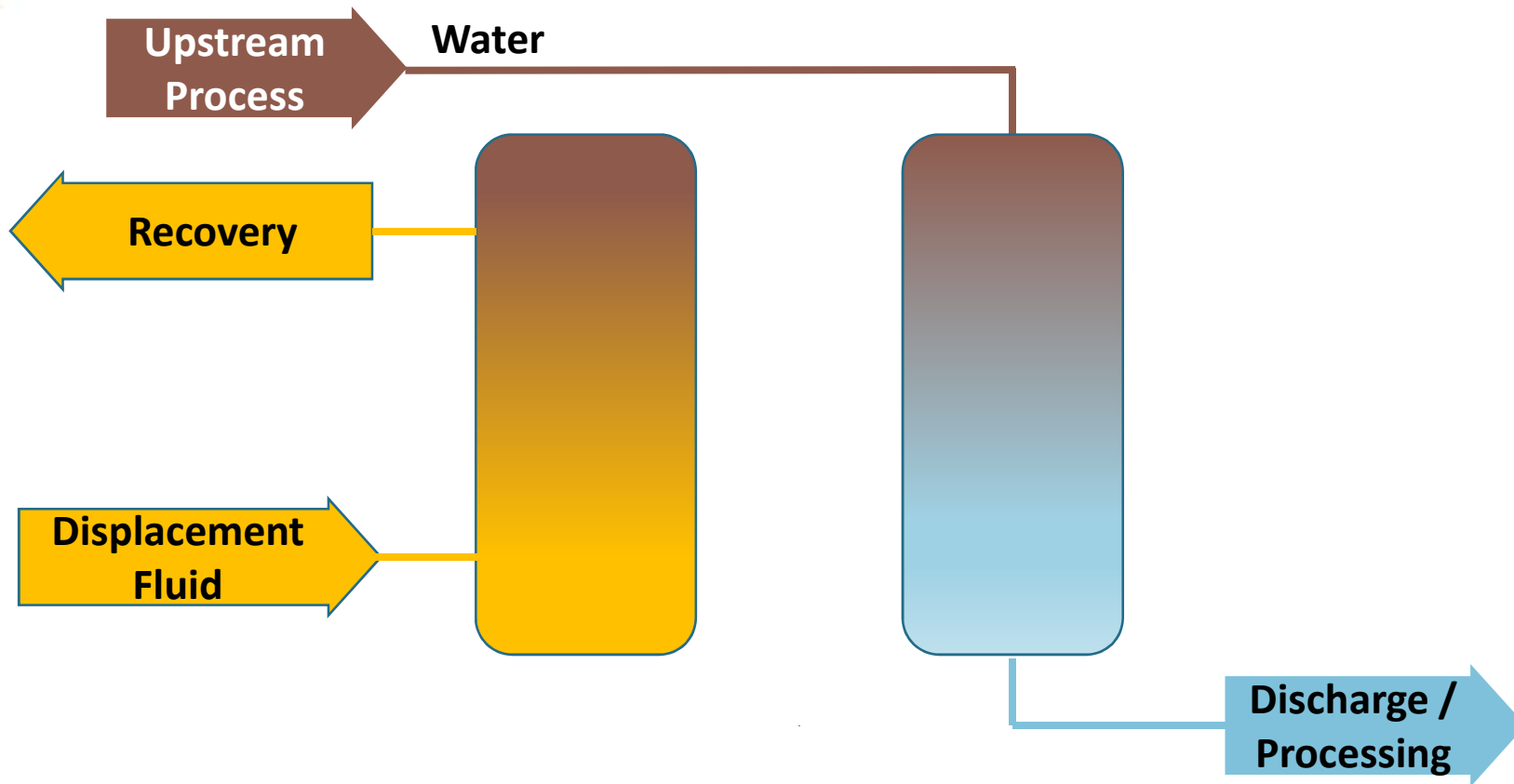
Capture of the liquid and vapor-phase heavier hydrocarbons in the gas stream

Regeneration of Osorb with heat and nitrogen purge results in **pure condensate value stream.**

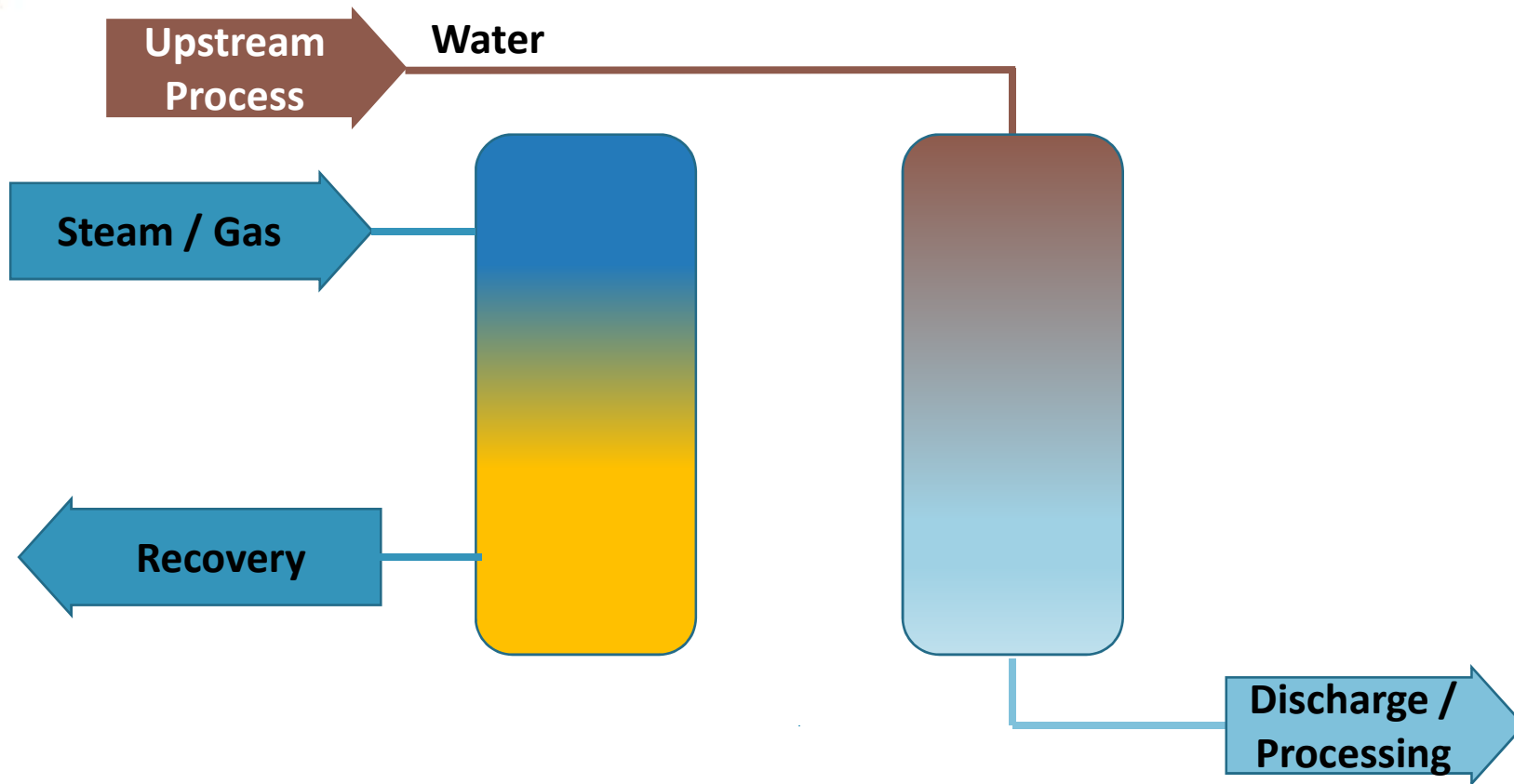
Lead-Lag Treatment & Regeneration



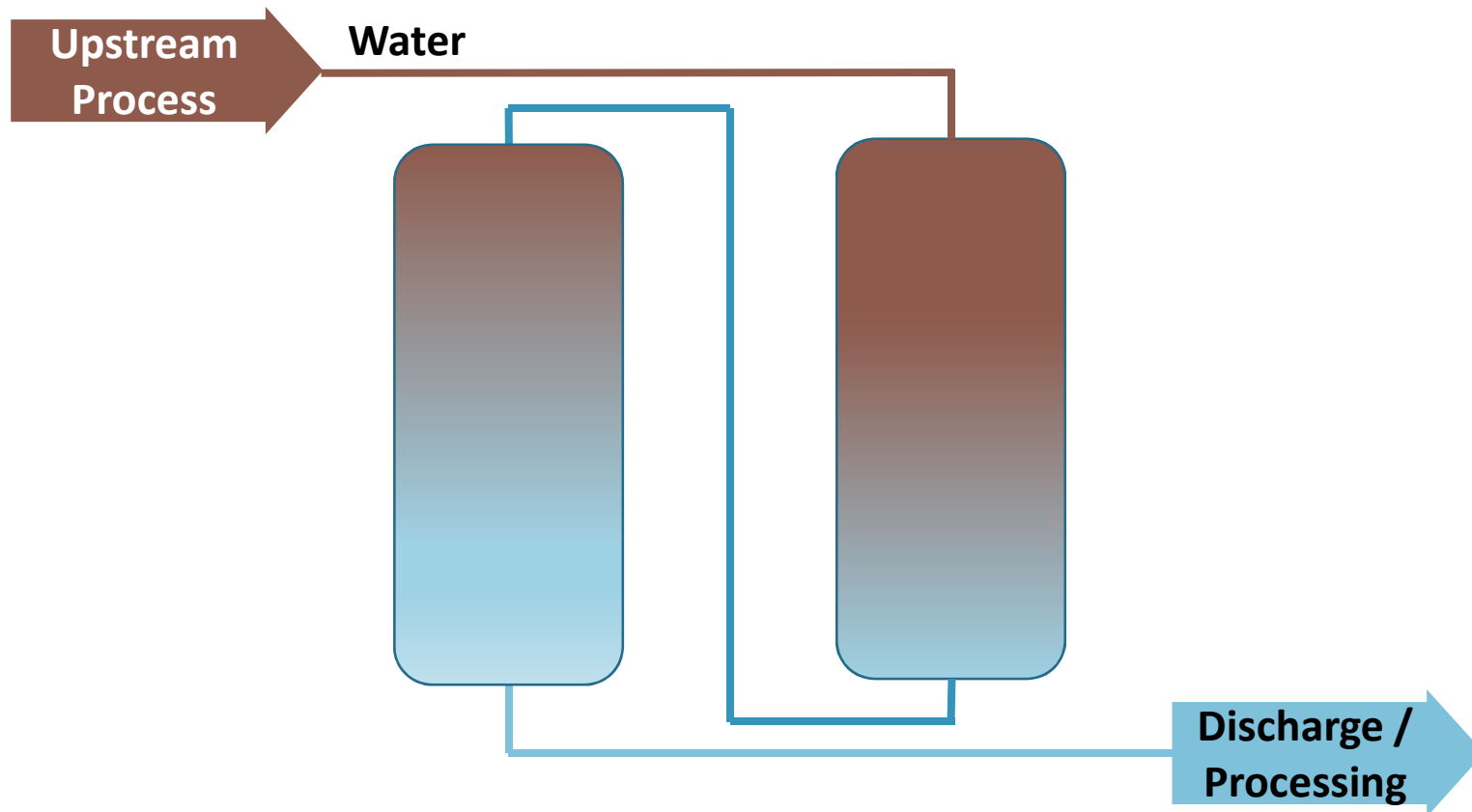
Lead-Lag Treatment & Regeneration



Lead-Lag Treatment & Regeneration



Lead-Lag Treatment & Regeneration



Offshore Bulk Media & Filter Skids

Designed to: DNV 2.7-1, ASME Section VIII Div. 1 / PD 5500, CE Mark

OBV036 - 36" Bulk Media Skid



1.9 m x 1.6 m x 2.8 m

DSF018 – Dual 18" Filter Skid



2.0 m x 1.4 m x 2.2 m

Offshore Axial Flow Test Columns

- Low flow feasibility testing & performance evaluations
- In situ regeneration evaluations
- Far East, Middle East, Europe, North America

3" Diameter Column



6" Diameter Column



6" Acrylic Column



Produced Water for Oil Recovery and Steam Generation

Middle East 6" Test Column

- Onshore treatment for reinjection
- 18-20 API Oil
- 43-52°C
- > 120% w/w oil Osorb® Loading



Sample Time	Total Treatment Time	Inlet Oil & Grease (mg/L)	Outlet Oil & Grease (mg/L)	Flow Rate (GPM)	Inlet Pressure (PSI)	Outlet Pressure (PSI)
10-Oct						
8:05	0	--	--	0.5	128	127
8:25	20	63,020	--	0.5	129	128
8:55	50	927	<1	0.5	129	128
9:25	80	1,855	--	0.5	129	128
9:55	110	1,565	31	0.6	129	128
10:25	140	5,927	13	0.5	129	127
10:55	170	1,740	--	0.5	129	127
10:55	170	94	--	0.65	129	127
11:25	200	533	--	0.5	128	126
11:55	230	32,746	11	0.5	129	126
24-Oct						
8:15	230	--	--	0.5	129	128
8:45	260	72	3	0.5	128.5	127
9:45	320	110	<1	0.7	133	131
10:45	380	127	<1	0.7	132	130
10:46	381	--	--	1.5	130	127.5
11:45	440	78	2	1.4	131	129
12:45	500	69	<1	1.4	131	128
13:45	560	72	<1	1.4	129	124
14:15	590	--	--	1.6	132	128

Produced Water for Reinjection – Osorb Regeneration

Middle East Osorb Regeneration

1. Hydrocarbon Displacement fluid
2. Nitrogen Purge
 - Thermal Input



Sample Time	Total Treatment Time	Inlet Oil & Grease (mg/L)	Outlet Oil & Grease (mg/L)	Flow Rate (GPM)	Inlet Pressure (PSI)	Outlet Pressure (PSI)
29-Oct						
09:00	0			0.5	129.5	128.5
09:15	15	--	--	0.5	128.5	128.5
09:30	30	7	<1	0.5	126.5	125.5
09:45	45	10	--	0.5	129	127.5
10:00	60	4	<1	0.5	129	127.7

**Post
Regeneration
Treatment
Performance**

18-20 API oil

Gas Deliquification Produced Water

Jar Testing

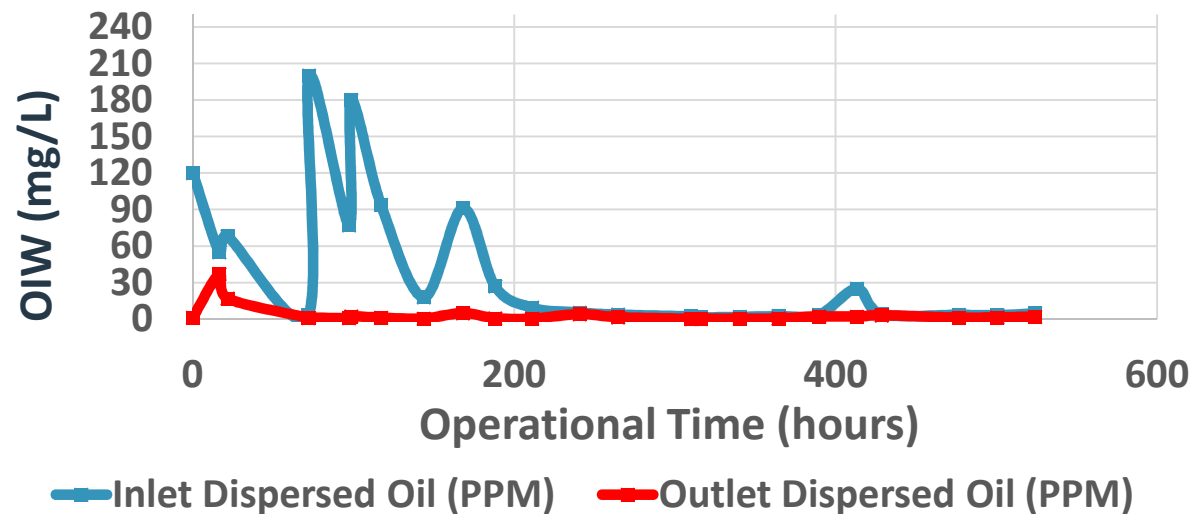
- Q3 2013

Company	Platform #	Untreated (OIW ppm)	Treated (OIW ppm)	Foamer Added – Treated (OIW ppm)
Operator 1	1	210	5.1	-
	2	14000	1	21
Operator 2	4	2000	17	-
	5	42	0.34	3.6
Operator 3	6	1900	1.3	-

Offshore North Sea 6" Test Column

- Q4 2013
- Offshore treatment for discharge.
- Bulk Media Q1 2014

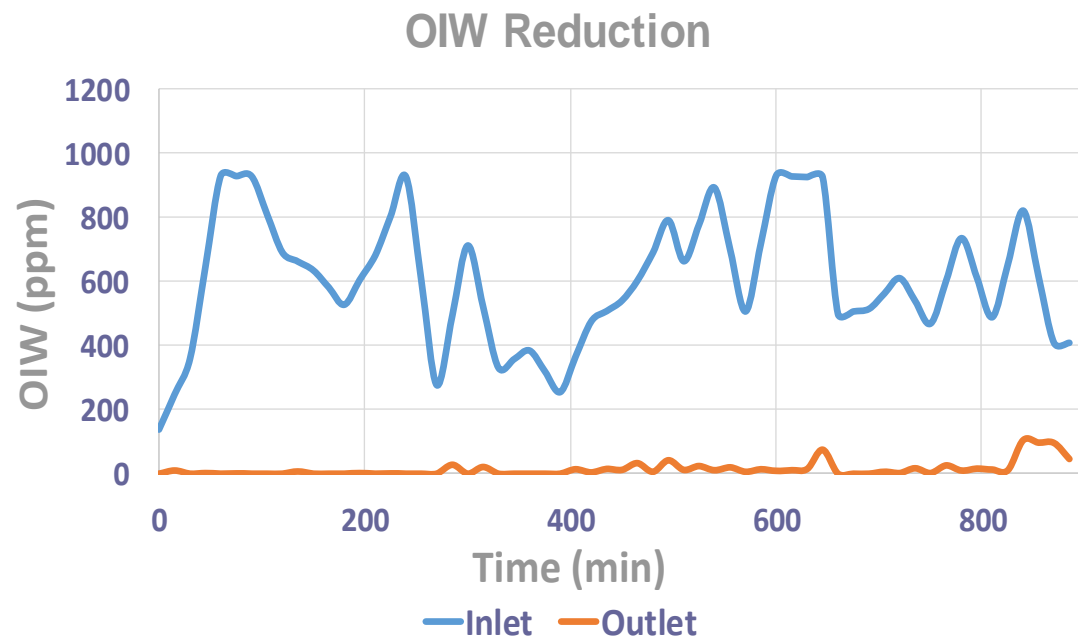
OIW Removal



Offshore Produced Water Discharge

Far East 6" Test Column

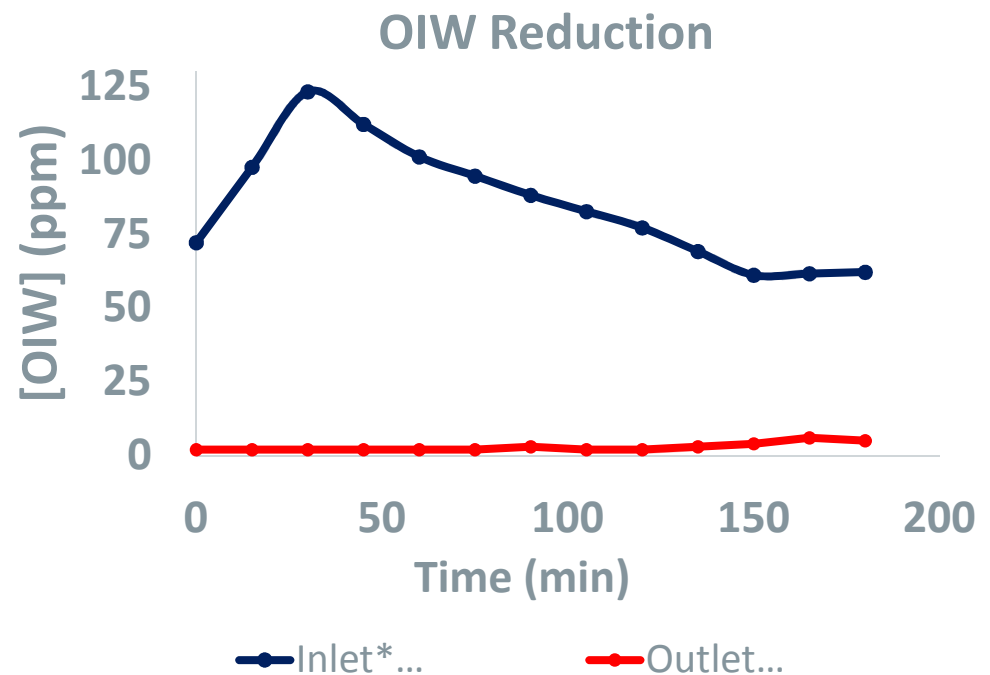
- Q2 2013
- Offshore treatment for discharge
- Avg. **98.7% OIW** Removal
 - Avg. Influent = **604 ppm**
 - Avg. Effluent = **7.4 ppm**
- API 44 Oil



Offshore Produced Water Discharge

Far East 6" Test Column

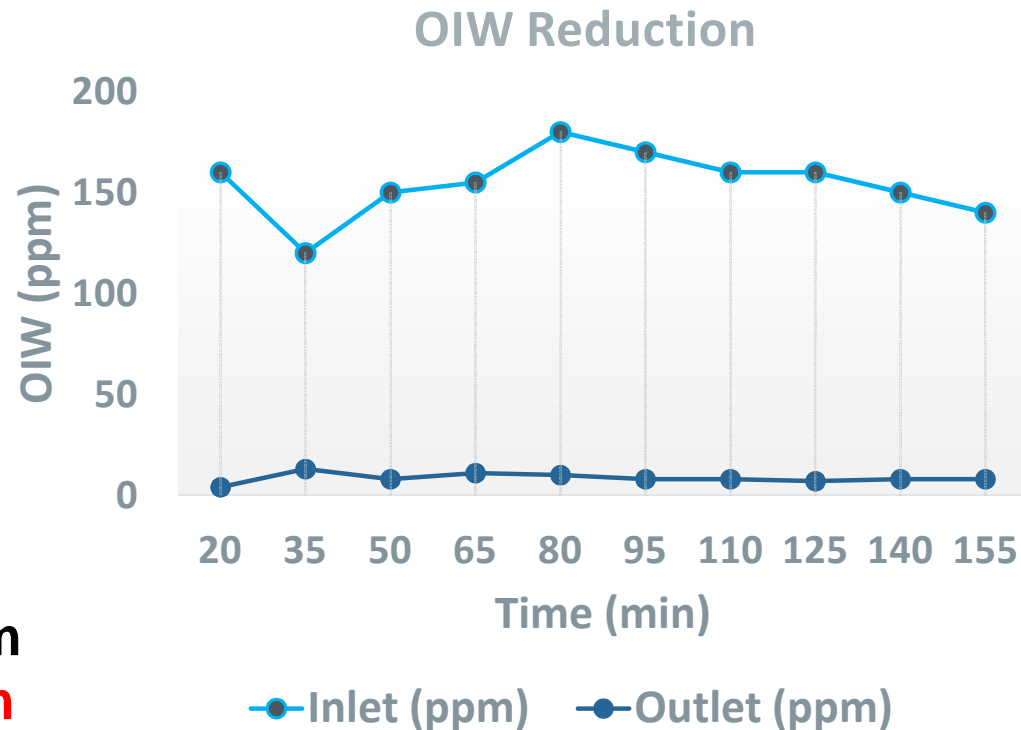
- Q1 2013
- Onshore treatment for discharge of offshore produced water
- Avg. **96.6% OIW** Removal
 - Avg. Influent = **85 ppm**
 - Avg. Effluent = **2.9 ppm**
- API 39.4 Oil, 1% TDS, pH 7



Onshore Produced Water Reinjection

Far East 3" Test Column

- Q2 2013
- Onshore treatment for reinjection
- Avg. **94.3%% OIW** Removal
 - Avg. Influent = **155 ppm**
 - Avg. Effluent = **8.2 ppm**



Downstream Process Water – Case 1

Middle East 6" Test Column

- Removal of BTEX from downstream process water
- Steam Regeneration of Osorb[®] media

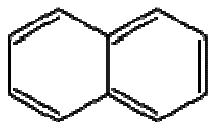
Time (hr)	Total BTEX (ppb)	
	Inlet	Outlet
0	241	<1
2	1104	71
5	1121	7
9	1626	94
21	(visual free oil)	6
Post Regeneration	(visual free oil)	13

Parameter (ppb)	Treatment Duration (hours)									
	0		2		5		9		21	
	In	Out	In	Out	In	Out	In	Out	In	Out
Benzene	120	<1	873	47	773	<1	1,316	78	<1	<1
Toluene	7	<1	89	11	267	7	154	14	12	6
Ethyl-Benzene	56	<1	74	3	26	<1	66	<1	<1	<1
Xylene	58	<1	68	10	55	<1	90	2	1	<1

Downstream Process Water – Case 2

Middle East 6" Test Column

- Polyaromatic Hydrocarbons (PAH)
- 97°C
- Steam Regeneration
- **4681.3 ppb to 275.3 ppb Total PAH**



Naphthalene

Constituent	Inlet (ppb)	Outlet (ppb)
Acenaphthene	42.7	< 1.0
Acenaphthylene	725	5.3
Anthracene	19.5	< 1.0
Benzo(a)anthracene	3.1	< 1.0
Benzo(a)pyrene	0.9	< 1.0
Benzo(b)fluoranthene	< 1.0	< 1.0
Benzo(b)perylene	< 1.0	< 1.0
Benzo(k)fluoranthene	< 1.0	< 1.0
Chrysene	1.8	< 1.0
Dibenzo(a,h)anthracene	< 1.0	< 1.0
Fluoranthene	7.1	< 1.0
Fluorene	133	< 1.0
Indeno(1,2,3-dc)pyrene	<1.0	< 1.0
Naphthalene	3630	270.0
Phenanthrene	106	< 1.0
Pyrene	12.2	< 1.0

Current Technical Path Forward - 2014

- Bulk Media – Offshore North Sea
- Closed Loop Bulk Media / Regeneration – Onshore Middle East
- Bulk Media – Offshore Far East
- Osorb Regeneration
 - Mass Balances & Efficiency Curves
 - Resource Evaluations
- Complimentary ProSep Technology Integration
 - TORR Coalescing Media
 - C-Tour Process

PWA-ProSep

Thank you!

