MYCELX
Oil-Free Water Technology

MYCELX:
A NEW STANDARD IN WATER TREATMENT

Capability Statement for Nigeria

October 2019





5 THINGS TO KNOW ABOUT MYCELX

1	**Technology Advantage**	▪ Molecular cohesion → true oil-free ▪ >70 International Patents ▪ Active R&D creating state of the art solutions
2	**Proven track record**	▪ Installations and Projects across 15 countries across the globe ▪ Proven to meet strictest industry standards ▪ Success in all segments of O&G industry
3	**Consistently Superior Performance**	▪ Can achieve oil removal to <1 ppm ▪ Can handle droplet sizes of <1 micron ▪ Trusted as a reliable and fail safe solution
4	**Cost Advantage**	▪ Fast, efficient and operator friendly ▪ Small footprint and mobile
5	**Industry Recognition**	▪ Schlumberger's "method of choice" ▪ Recommended by SNF for Polymer Flood Water Treatment ▪ Awards for our work with SABIC

Industry Recognition

OIL & GAS AWARDS Gulf Coast

GLOBAL WATER AWARDS Recognising Excellence

PLATTS GLOBAL ENERGY AWARDS

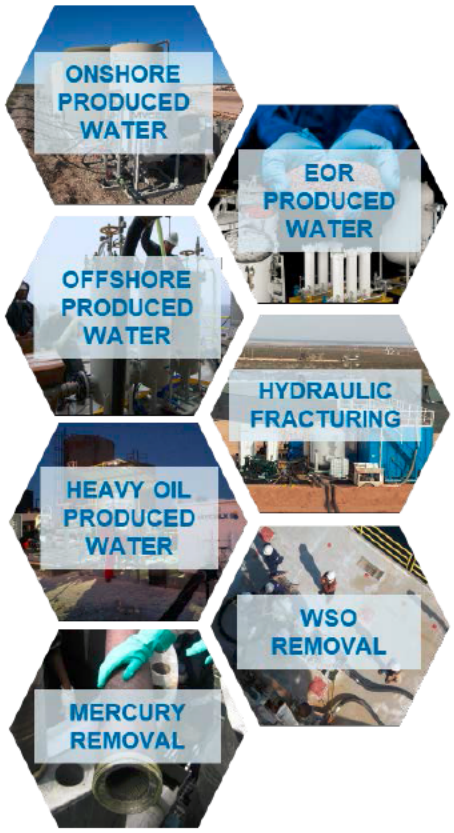
Schlumberger

SNF FLOERGER

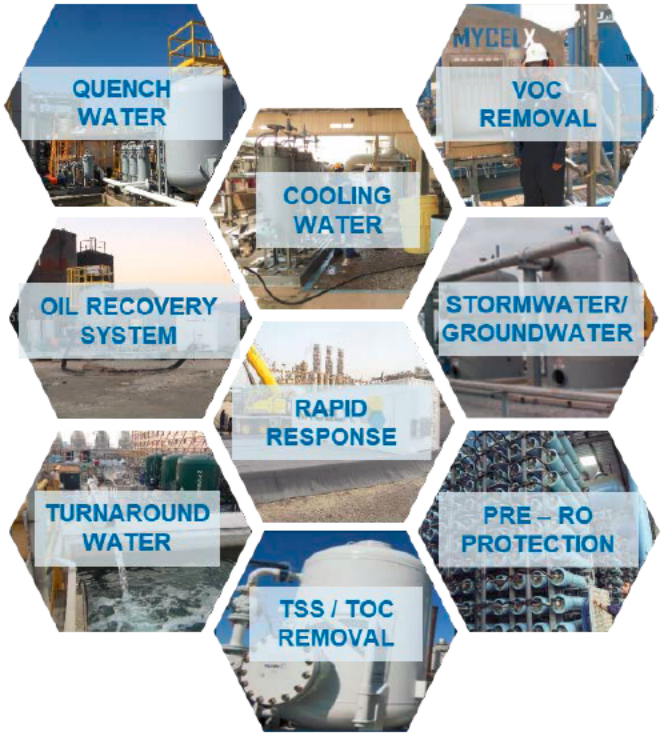
RANGE OF APPLICATIONS

- MYCELX's wide range of solutions are applicable in all segments of the Oil and Gas Industry
- We also serve the Marine, Manufacturing, Power, Healthcare and Mining industries

UPSTREAM

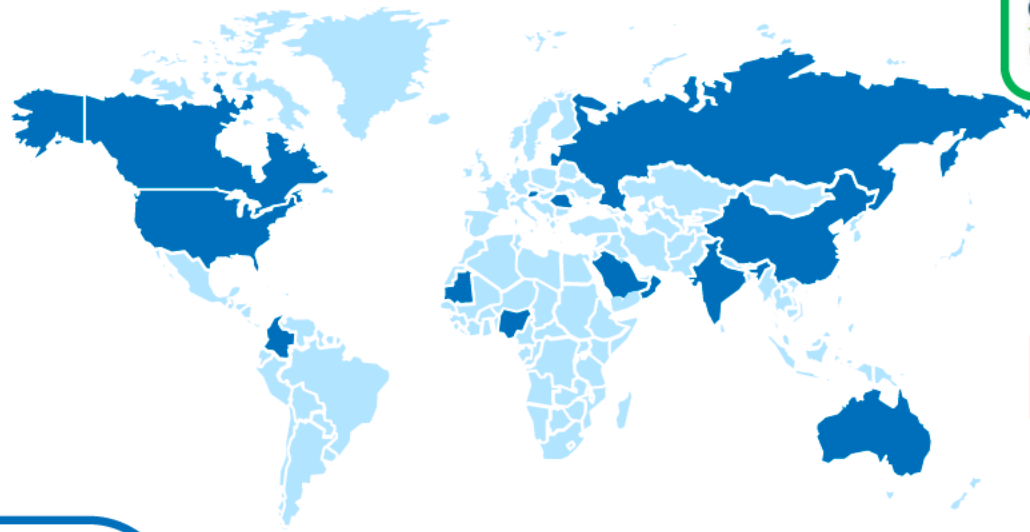


DOWNSTREAM



MIDSTREAM & OTHER

GLOBAL FOOTPRINT



Canadian Natural — EOR PRODUCED WATER
cenovus ENERGY — EOR PRODUCED WATER
enerPLUS We Add Energy — EOR PRODUCED WATER

OMV — HEAVY OIL PRODUCED WATER; EOR PRODUCED WATER

ENKA — POWER STATION WASTEWATER

bp — STORMWATER/ GROUNDWATER

Anadarko Petroleum Corporation — ONSHORE PRODUCED WATER; HYDRAULIC FRACTURING
Chevron — DEEPWATER
BOSTCO STORAGE & TERMINAL SERVICES — STORAGE & TERMINALS WASTE WATER
BILGE WATER
TOYOTA — OILY AIR FILTRATION

NECONDE ENERGY LIMITED — SHALLOW WATER

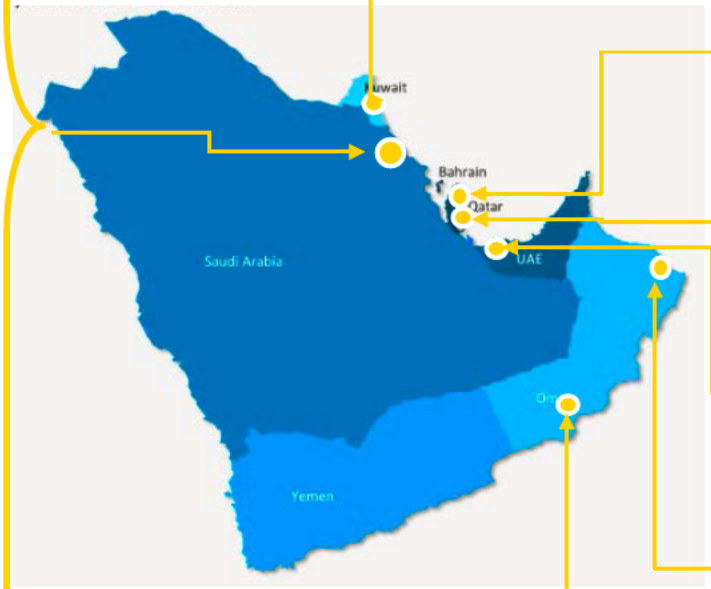
ओएनजीसी ONGC — PRE – RO PROTECTION; OIL RECOVERY SYSTEM

RioTinto — WASH WATER
Woodside — MERCURY REMOVAL
Chevron — OIL RECOVERY SYSTEM

Key: Equipment Sale | Project/Lease

GCC EXPERIENCE

Client	Application	Since
ابن سينا ibn sina	BTEX REMOVAL	2008
كيان السعودية saudi kayan	QUENCH WATER, BTEX REMOVAL, TURNAROUND WATER	2011
بتروكيميا petrokemya	QUENCH WATER, BTEX REMOVAL, TURNAROUND WATER	2012
شرق sharq	QUENCH WATER, BTEX REMOVAL, TURNAROUND WATER	2016
صدف sadaf	BTEX REMOVAL, TURNAROUND WATER	2018
FARABI PETROCHEMICALS	BTEX REMOVAL	2013



Client	Application	Since
EQUATE	TURNAROUND WATER	2015
Chevron	TURNAROUND WATER	2014
قطرغاز QATARGAS	COOLING WATER	2014
أدنوك ADNOC	OIL RECOVERY SYSTEM	2013
Oman LNG L.L.C.	COOLING WATER	2015
شركة تنمية نفط عمان Petroleum Development Oman	EOR PRODUCED WATER	2012

Key: Equipment Sale | Project/Lease

TECHNOLOGY OVERVIEW

A New Standard – Beyond Ordinary Filtration

MYCELX

THE MYCELX EFFECT: BEYOND ORDINARY FILTRATION

- At the heart of our systems is the patented polymer called MYCELX® (CAS#'s: 173967-80-1, 173967-81-2)

MYCELX polymer can:

- **Instantly and permanently remove oil and hydrocarbons from water** to previously unattainable levels, under a wider range of conditions and flow rates than ever before, regardless of loading and droplet size.
- Has a very high affinity for oil and repels water.
- MYCELX polymer does not simply filter or hold oil as other approaches do; it instantly bonds with and permanently removes oil and contaminants upon contact through **molecular cohesion**
- Once oil comes in contact with MYCELX, it will never reenter the water stream
- MYCELX solutions deliver **true oil-free water**.

TECHNOLOGY OVERVIEW

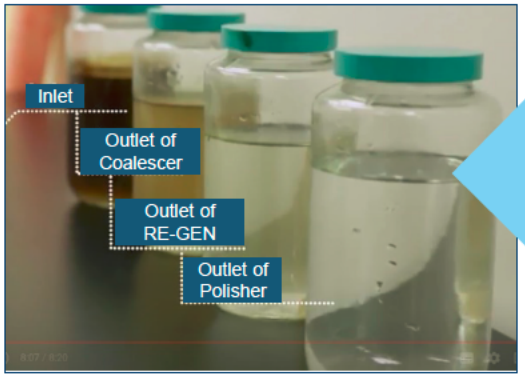
Technology – MYCELX's patented polymer

MYCELX's treatment media (polymer) is infused into purpose built back-washable media or standard filters

MYCELX's treatment media is housed inside specially modified standard vessels

Filter replacement can be carried out by MYCELX or by the client operators

- 99.9% oil removal
- No water retention

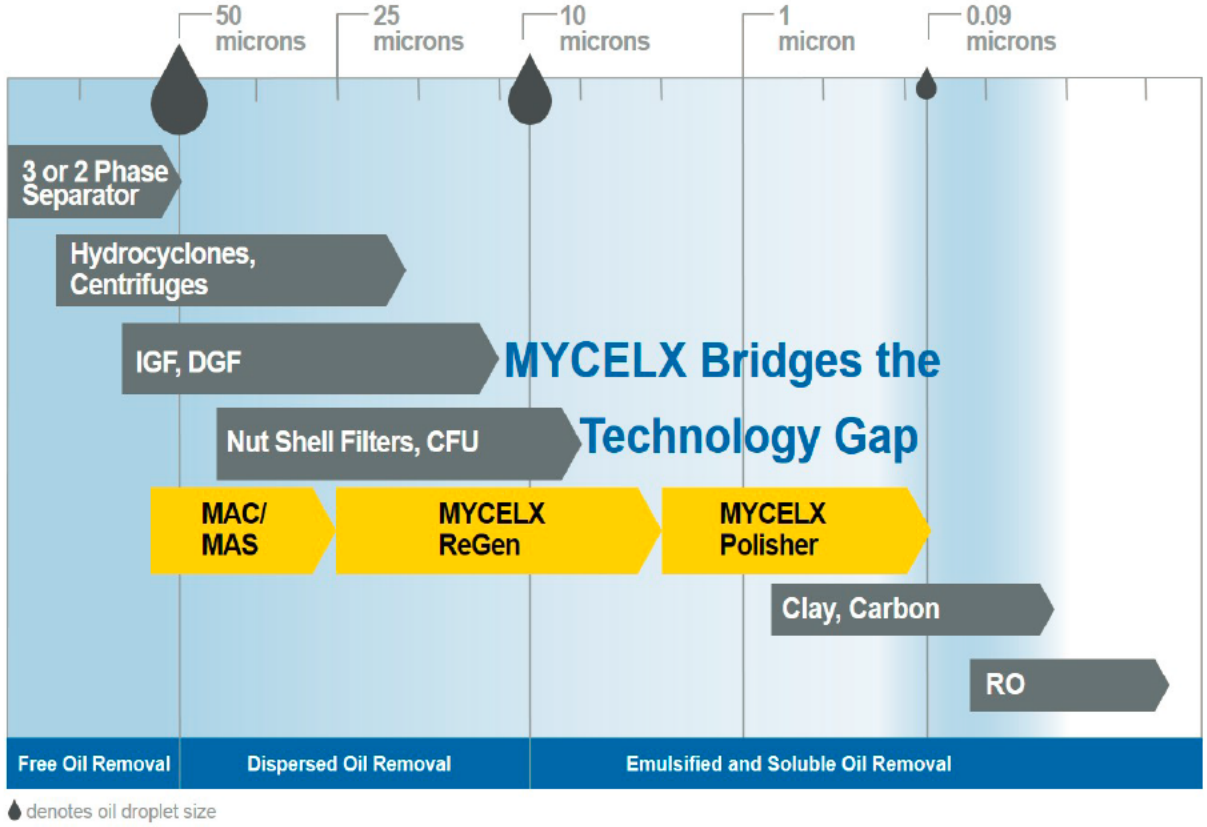


Outlet that consistently meets client's requirements

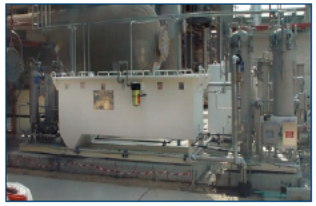
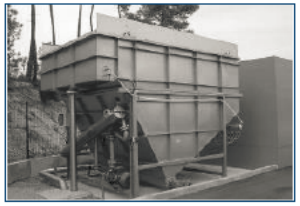
BRIDGING THE TECHNOLOGY GAP

The key differences between MYCELX and other oil removal processes are:

- Instant and permanent oil removal at any flow rate
- Broad oil removal spectrum – free oils to Emulsified oils
- Small footprint available, lower capital cost, highest efficiency
- Enables water reuse
- Reduces need for chemical or biological treatment
- Guaranteed no visible oil sheen in effluent



COMPARISON TO CONVENTIONAL TECHNOLOGIES


Parameters	MYCELX System	API/CPI Separator	Float Cells	Hydrocyclone	Walnut Shell
Oil Droplet Size Removal	Removes all oil droplets >1 micron	Removes all oil droplets >50 microns	Removes all oil droplets >20 microns	Removes all oil droplets >30 microns	Removes oil droplets >10 microns
Oil in Water Discharge Capability	0 – 1 ppm	80 – 400 ppm	50 – 150 ppm	60 – 250 ppm	5 –10 ppm
Waste Generation	Recovers oil byproduct for reuse or resale	30-50% oil in water waste generated	50-60% oil in water waste generated	30-50% oil in water waste generated	30-50% oil water waste with chemicals generated
Footprint	Small	High Residence Time of 10 – 15 minutes	Large	Small but cannot remove dispersions/ emulsions	Medium but cannot remove emulsions

MYCELX EQUIPMENT

Superior Performance and Smaller Footprint

MYCELX

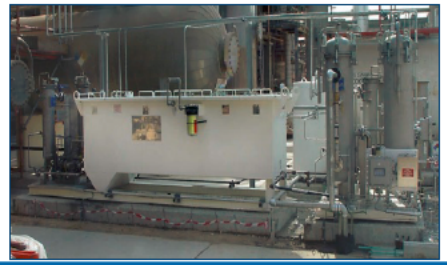
MYCELX TREATMENT TRAIN VS CONVENTIONAL

	PRIMARY TREATMENT *From 10,000+ppm → 200ppm*	SECONDARY TREATMENT *From 200ppm → 50ppm*	TERTIARY TREATMENT *From 50ppm → >5ppm*
CONVENTIONAL	Hydrocyclone-CPI	Induced Gas Flotation	NSF/CFU




Nutshell Filters claim to be capable of treating down to 5 or 10ppm, however this depends on oil droplet size

MYCELX




MYCELX Coalescer/MYCELX Separator
From 10,000+ppm to about 100ppm

MYCELX RE-GEN
From <1000ppm down to <10ppm
From >50 microns to <5 microns

MYCELX Polishers
From >50ppm to <1ppm

Easy to retrofit or potential to optimize the treatment train

FOOTPRINT SIZE & MOBILITY

Small Footprint

- Only requires 25 – 33% of footprint necessary for conventional solutions

Mobile Solutions

- Equipment can be placed on a skid or in a container and be transported to new areas of the petrochemical plant if required

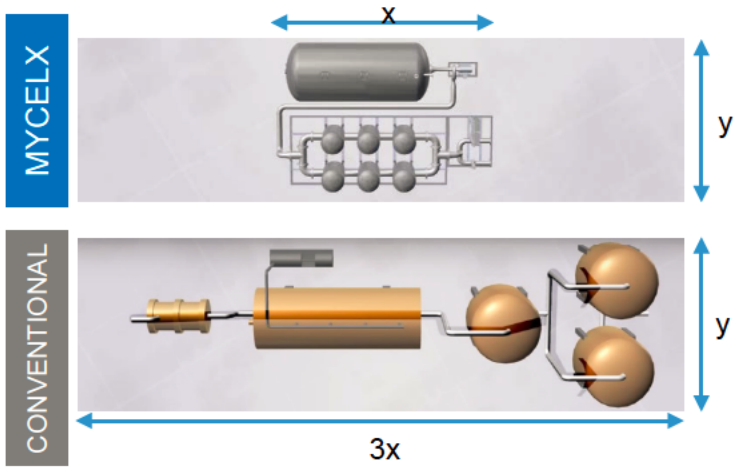
User friendly

- MYCELX equipment has been designed to make it user-friendly to allow simple change out procedures

Modular

- Our equipment is 'modular' in nature
- Can be inserted within an existing system or incorporate current equipment as part of the solution

EASY TO RETROFIT



EQUIPMENT: PRIMARY TREATMENT

Framed MAC and Polisher Skid

MYCELX Advanced Coalescer (MAC)

- Vertical pressure vessel fed from production treatment train by existing pressure
- No moving parts
- Incorporates proprietary MYCELX coalescing media packs to deliver superior coalescing and oil recovery vs. conventional API/CPI Separators.
- Effective at removing free oil greater than 50 microns.
- Higher single pass removal efficiency
- High purity oil is the recovered product

MYCELX Primary Treatment (MAC)	Standard API/CPI Separator
▪ MAC: Oil removal to less than 50 microns	▪ API: Oil removal when droplets > 100 – 200 microns ▪ CPI: Oil removal when droplets > 100 microns
▪ Removes free and some dispersed oils	▪ Removes only free oils
▪ Four-stage coalescing	▪ One or two stage coalescing
▪ Handles up to 10,000 ppm influent	▪ CPI handles only up to 3,000 ppm

EQUIPMENT: SECONDARY TREATMENT

MYCELX RE-GEN System

- MYCELX RE-GEN consists of a deep bed media in a filtration arrangement, mounted inside a pressure vessel.
- RE-GEN incorporates a proprietary mined mineral granular backwashable media modified with MYCELX chemistry
- Optimizes the efficiency of the MYCELX Polishers within the tertiary stage
- Economically viable treatment option to remove oils and oily solids to as low as 4 microns
- During backwash, all oil trapped on and between the media is recovered to the customer without any chemical denaturing

MYCELX RE-GEN	Walnut Shell / Multi-Media
▪ Oil and particle removal to 4 microns	▪ Oil and particle removal to 10 microns
▪ Removes free, dispersed and fractions of emulsified oils	▪ Removes free and some dispersed oil
▪ Handles fluctuations 50 – 2,000 ppm	▪ Cannot handle fluctuations in oil loading
▪ Does not require usage of pre-filtration chemical agents to meet stated efficiency	▪ Requires the use of pre-filtration chemical agents to meet state efficiency

EQUIPMENT: TERTIARY TREATMENT

MYCELX Polisher System

- Patented polishing media instantly and permanently removes oil and grease, never desorbing or saturating with water
- Consistently provide fail-safe protection against upset conditions
- Achieve critically low discharge levels – down to less than 1 ppm if required
- Capture efficiency and holding capacity are not negatively affected by dissolved solids or specific ions

MYCELX Polishers	Activated Carbon / Clay Filtration
▪ Complete oil removal to 0 – 5 ppm (free, dispersed and emulsified)	▪ Only economical for soluble oils (activated carbon)
▪ 2 – 4 x as many polisher skids fit into the space of one carbon or clay unit	▪ Large footprint and weight
▪ Robust to process upsets with fail-safe discharge	▪ Cannot handle process upset conditions
▪ Easy to install and operate ▪ Labour time required for media replacement on a 10,000 bbl/day system is 45 minutes for two operators without any mechanical equipment	▪ Labour and equipment intensive: ▪ Typical Labour time required for carbon/clay media replacement on a 10,000 bbl/day system is 8 – 12 hrs + mechanical equipment

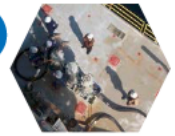
SUPERIOR SOLUTIONS – CASE STUDIES

Performance Enhancing & Significant Cost Reduction

MYCELX

LIST OF OIL & GAS CASE STUDIES

Upstream & Midstream

1.  ONSHORE PRODUCED WATER
2.  SHALLOW WATER PW
3.  DEEP WATER PW
4.  EOR PRODUCED WATER #1
5.  EOR PRODUCED WATER #2
6.  HEAVY OIL PRODUCED WATER
7.  HYDRAULIC FRACTURING
8.  WSO REMOVAL
9.  MERCURY REMOVAL
10.  STORAGE & TERMINALS WASTE WATER

Downstream

11.  QUENCH WATER
12.  TURNAROUND WATER
13.  OIL RECOVERY SYSTEM
14.  COOLING WATER
15.  RAPID RESPONSE
16.  STORMWATER/ GROUNDWATER
17.  BTEX REMOVAL
18.  PRE – RO PROTECTION

CASE STUDY 1:
ONSHORE PRODUCED WATER – NO SHEEN

OVERVIEW

Customer: Anadarko Petroleum Corp
Location: Vernal, Utah, USA

OBJECTIVES

- To treat the free and emulsified oil from the outlet of the walnut shell filters to meet the no-sheen regulation
- Achieve discharge concentration of less than 10ppm of oil and grease

KEY METRICS

Inlet concentration:
- Oil & Grease: 20 – 150 ppm

Target Outlet concentration:
- Oil & Grease <10 ppm

Flow Rate:
- 4 x 10,000 bpd systems

MYCELX DELIVERED:

Discharge reliably less than 10 ppm

No visible sheen on the discharge pond

Low operating cost

Treated >60m barrels consistently since Oct '06

Robust system to handle upset conditions

Modular & Scalable system

CHALLENGE

- Anadarko is generating 10,000 barrels per day of produced water on four sites in Vernal, Utah.
- The produced water has light fuel condensate that has the tendency to form strong emulsions as well as high concentrations of iron sulphides that pose a unique challenge in treating the produced water.
- The existing multimedia system could not handle the lower micron oil droplets or the emulsified oil in the water.
- As a result the outlet of the multimedia system was fluctuating from 20 ppm to 150 ppm depending on the degree of emulsion.
- A system was required that could remove the highly emulsified oil without becoming plugged with the higher concentration of the solids
- The system also needed to continuously discharge less than 10 ppm to meet the no-sheen criteria required by the EPA

CASE STUDY 1:
ONSHORE PRODUCED WATER – NO SHEEN

SOLUTION

- MYCELX designed, fabricated and delivered a tertiary retrofit treatment system that reduced the oil and grease concentration of 20 – 140 ppm at the inlet to less than 10 ppm on a continuous basis.
- The polisher system was designed with multiple stages with each stage utilizing MYCELX polisher media to remove the emulsified oil.
- The filters were able to handle fluctuations in the emulsified oil concentration as well as the specific emulsion from the effluent of walnut shell filters.
- The system is very compact and is 1/6th of the foot print of the multimedia filter system and could fit into the existing building without additional infrastructure.
- The filters were specially designed to deliver higher efficiency for emulsified oil but with the ability to allow solids through the filters.
- This custom design enabled the MYCELX system and cartridges to experience a longer run time without becoming saturated or plugged with the solids present in the stream.
- The project was nominated as one of the finalists for the "Engineering Project of the Year" award at the 2009 Platt's Global Energy Awards.

Performance data of the produced water treatment system

Outlet of condensate recovery tanks	Outlet of API seperator/ coalescer	Outlet of walnut shell filter	Outlet of polisher system
O&G, ppm	O&G, ppm	O&G, ppm	O&G, ppm
48	21	18	< 2
149	145	121	< 5
14	13	8	< 5

SUPERIOR PERFORMANCE

- Reliable, consistent discharge to meet any regulatory or internal goals down to less than 1 ppm
- The chemical attraction of the MYCELX Polymer ensures reliable performance and minimizes the impact of varying feed conditions on downstream processes.
- MYCELX system can recover oil in water up to 95% of the inlet oil concentration through the primary and secondary systems
- MYCELX removes all phases, free, dispersed and emulsified oil
- Mobile units that are easy to move and operate
- Full automation of oil removal system for unmanned sites
- Customized polisher media can remove oil in the presence of iron sulfates.
- Consistent oil removal from produced water from shale, condensate fields, and coal bed methane

CASE STUDY 2:
SHALLOW WATER PRODUCED WATER

OVERVIEW

Customer: Independent Producer
Location: Niger Delta, Nigeria

OBJECTIVES

- Obtain Department of Petroleum Resources (DPR) approval so that customer could discharge in to the shallow water
- Must consistently meet <15 mg/L OIW

KEY METRICS

O&G	Average (mg/L)	Max (mg/L)
Inlet	250	2000
Outlet	<15	

Operating Conditions:

- API 19, Asphaltene laden crude
- 20,000 bbls/day water treatment needed
- Small footprint – system had to fit in available space on FSO

MYCELX DELIVERED:

Only technology approved by Nigerian Regulators to be used for discharge into the Niger Delta

Modular system that could fit in small footprint available

Scalable solution for customer's future growth plans

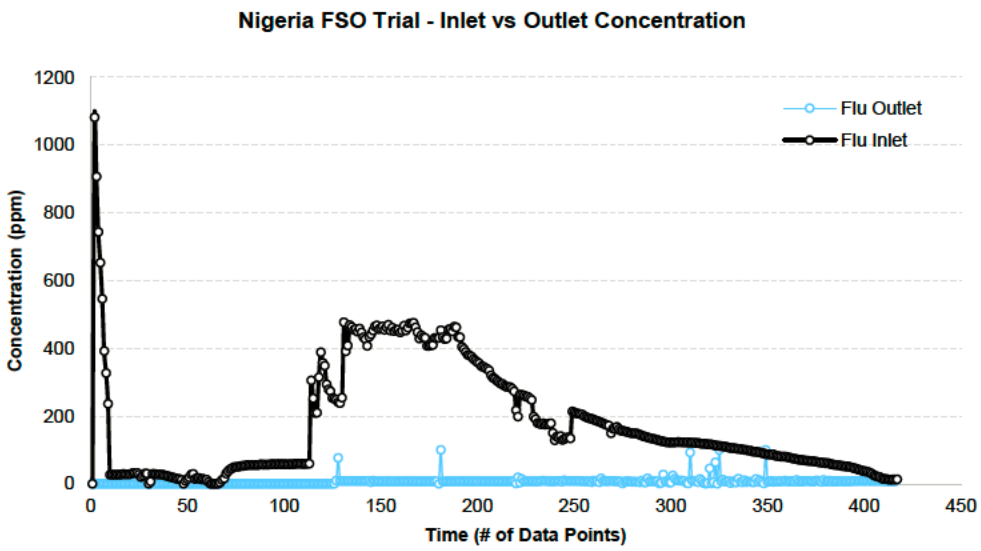
CHALLENGE

- Niger Delta is one of the most oil polluted regions in the world following an estimated 4000+ oil spills since 1960
- As a result the Nigerian regulators now impose strict rules on sea discharge
- A production facility had added on wells resulting in increased water generation which overwhelmed their existing water treatment system
- The customer was offloading the produced water to a local FSO for storage which would then be used to separate the oil and then barging the water (containing 50 – 150mg/L OIW) out to international waters which generated a high operating and environmental costs
- The oil in question had high asphaltene content which formed neutrally buoyant dispersions at 8 micron droplet size. The TSS issue at the site was due to soured wells and SRB and a poor biocide campaign in FPSO tanks.
- Objective of the project was to design a produced water system that could be placed on the FSO and treat all the produced water such that the produced water could be discharged into the shallow water environment
- The system needed to:
  - Deliver <15mg/L OIW for near shore discharge
  - Modular system that could fit in the available space onboard the FSO
- **Prior to this trial – no technology had been proven to reliably to treat below 15ppm and thus no permits had been issued to producers in the region for sea discharge**

CASE STUDY 2:
SHALLOW WATER PRODUCED WATER

SOLUTION

- MYCELX trialled the system to ensure that it would consistently meet the 15 mg/L standard required for near shore sea discharge
- The system had to be able to continue to perform during stress conditions of upto 2,000 mg/L OIW emulsions
- The MYCELX system consisted of a MAC, RE-GEN and Polishers
- The RE-GEN was able to meet the discharge requirements under normal conditions and would consistently achieve <20 mg/L outlet under stressed conditions (i.e. 2,000 mg/L inlet)
- During those excursions the MYCELX polishers would ensure that final outlet conditions met the Nigerian regulations



IMPACT

- MYCELX is the only technology to have received DPR pre-approval for the treatment of produced water for near shore sea discharge
- **Other technologies could not cope with the wide operating envelope**
- MYCELX's complete water system will be deployed to cost effectively solve any water challenges faced currently and in the future, as the operator progresses to use water injection and enhanced oil recovery techniques to further increase production and reserves

CASE STUDY 3:
INLAND PRODUCED WATER

OVERVIEW

Customer: Independent Producer
Location: Inland Niger Delta, Nigeria

OBJECTIVES

- Reliably treat water leg of 3 phase separator to near shore discharge standards
- Must consistently meet <10 mg/L OIW

KEY METRICS

O&G	Average (mg/L)	Max (mg/L)
Inlet	6,850	19,750
Outlet	<10	

Operating Conditions:

- API 21,
- 40,000 bbls/day water treatment needed
- Handle transient emulsions caused by chemical upset

MYCELX DELIVERED:

Complete turnkey plant, including on site erection service

Modular system that could fit in small footprint available

Average discharge 6.5 mg/L

CHALLENGE

- Many local independent producers are locked into export pathways via old pipelines
- Export availability issues are forcing alternative routes of export via barging
- Separating water from the crude form dry crude, and < 10 mg/L oil in water is key to ease of alternative transport

- The customer invested in infrastructure to switch producing field from 2 phase separation, with fluid export via pipeline, to true three phase production with water treatment, allowing export to their own FSO terminal offshore.
- Integrate with existing production separators and crude dehydrators
- Meet future requirements on suspended solids (< 5 mg/L) for reservoir water flood
- Low installed weight due to swampy foundation difficulties

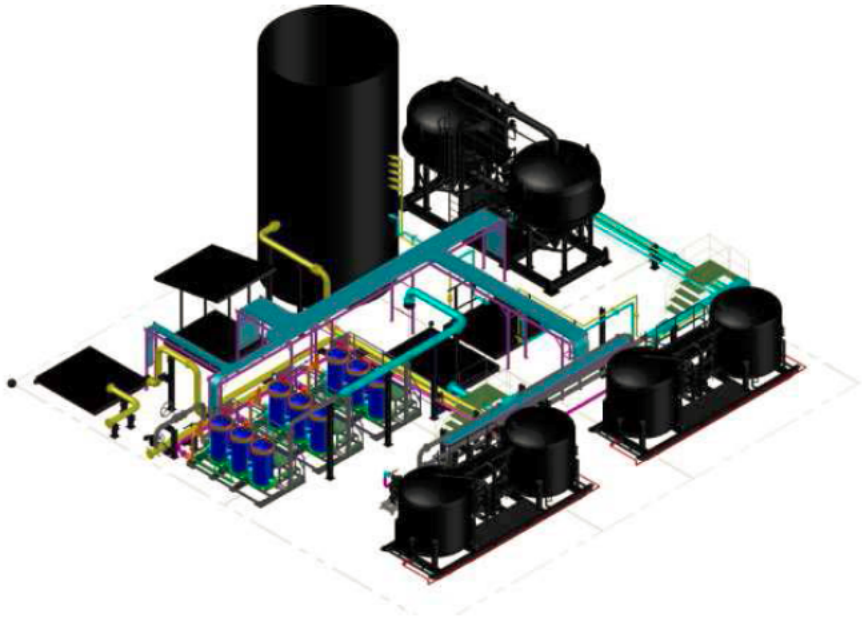
CASE STUDY 3:
INLAND PRODUCED WATER

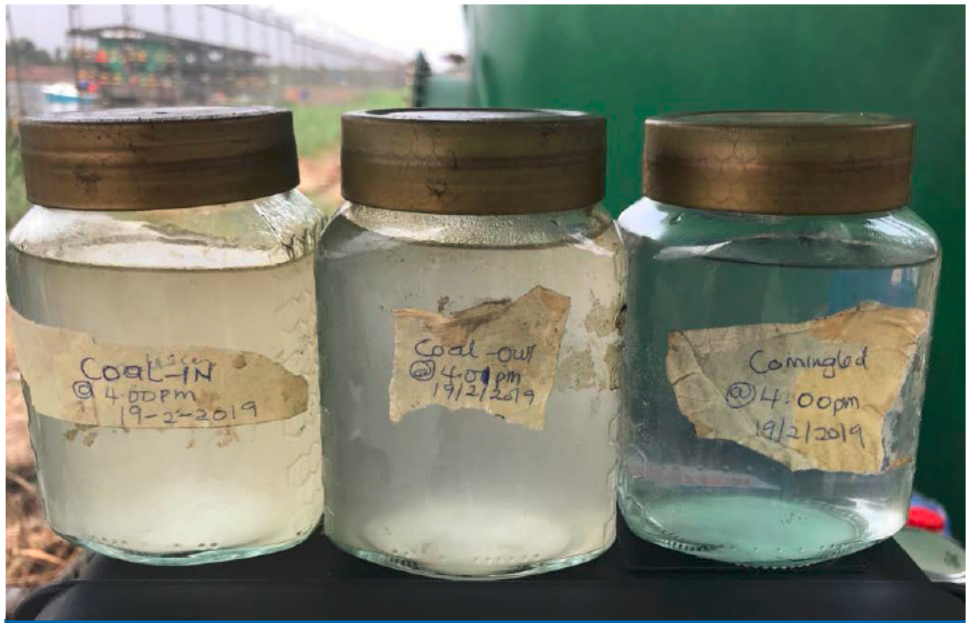
SOLUTION

- Design, Fabrication, Erection and Commissioning including Operator Training of 40,000 bwpd complete facility with
  - Advanced Coalescer Primary Treatment
  - REGEN Media Filter Secondary Treatment
  - Polisher Filter Tertiary Treatment (in use only as required)
- The system had to be able to continue to perform during stress conditions of up to 200,000 mg/L or 20% by volume OIW emulsions
- 26 weeks total time from PO to first flow including sea shipment

IMPACT

- Average discharge of 6.5 mg/L requires no water treatment chemicals like other technologies
- Used no consumables (tertiary filtration) in first 12 months of operation
- **Other technologies could not cope with the wide operating envelope**
- Allowed for operator to export and market their own crude via alternative export pathway we no issues due to water treatment





TYPICAL WATER QUALITY INTO SYSTEM, FROM LEFT TO RIGHT, INLET, OUTLET OF COALESCER, OUTLET OF REGEN (NO POLISHER IN USE)

UPSET WATER QUALITY INTO SYSTEM, FROM LEFT TO RIGHT, INLET, OUTLET OF COALESCER, OUTLET OF REGEN, OUTLET OF POLISHER

OVERVIEW OF OML 42 SYSTEM PLOT

CASE STUDY 3b:
DEEPWATER PRODUCED WATER FOR DISCHARGE

OVERVIEW

Customer: Super Major
Location: Gulf of Mexico, USA

OBJECTIVES

- Obtain National Pollutant Discharge Elimination System (NPDES) permit for discharge to open sea (<29ppm monthly average, <42 ppm 24 hr average)
- Customer set internal target of <10ppm

KEY METRICS

O&G	Min (ppm)	Max (ppm)
Inlet	25	150
Outlet	10	

Operating Conditions:

- Temperature: 1400F/ 600C
- Pressure: 30 psi
- Flowrate: 22,500bwpd
- Footprint restricted to 10'x14'
- Full redundancy

MYCELX DELIVERED:

Significant cost savings

Reduction in maintenance

Consistent performance as per NPDES

No loss in production due to water treatment issues despite regular upset conditions

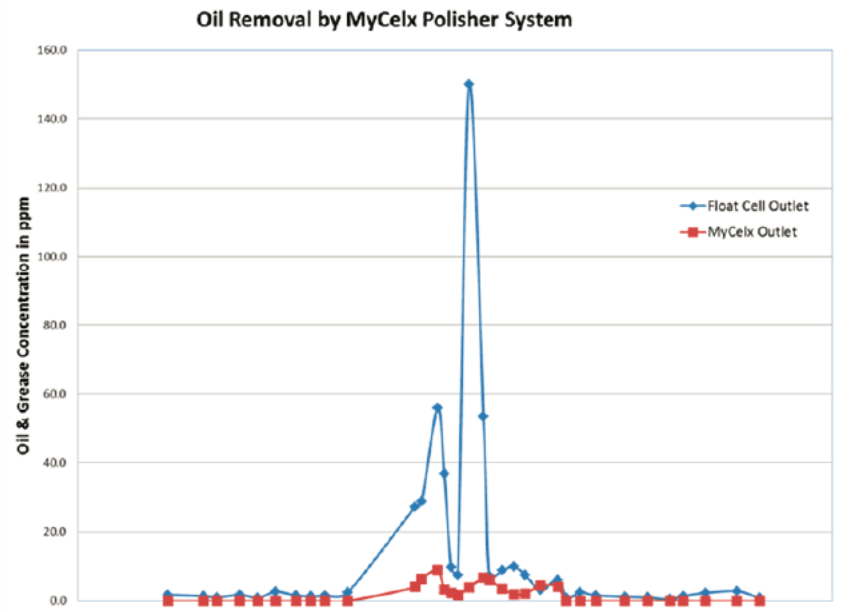
CHALLENGE

- A super major oil and gas company operating in the Gulf of Mexico on a deepwater FPF hub servicing wells at depths of 7,000 feet needed a tertiary treatment solution to intermittently support the primary and secondary treatment equipment.
- The hub experienced process upsets due to the addition of production chemicals (LDHI and hydrate inhibitor), well and platform shut-ins, new wells on line, compliance checking, well testing and production rate adjustments.
- Their existing tertiary treatment system was large and cumbersome, requiring large lift plans for monthly servicing, and two dedicated operators to be housed on board.
- The customer desired a more cost-effective and compact solution to fit within the 10'x14' deck space (see image above)
- The new system needed to be easily maintained using simple hand tools while allowing existing operators to perform all necessary functions.
- Other requirements included unlimited turndown capacity and 100% spare capacity for 22,500 bwpd at less than 10 psi of pressure drop with an overboard discharge of less than 10 ppm oil and grease (EPA 1664 method).

CASE STUDY 3b:
DEEPWATER PRODUCED WATER FOR DISCHARGE

SOLUTION

- Two custom designed, independent process trains of MYCELX polishers were installed. Both trains consisted of three vessels each housing patented oleophilic filtration media elements to attract, recover and remove various oil types at varying concentrations.
- The MYCELX Polisher system was designed for tertiary treatment of inlet concentrations of 40 ppm to enable discharge at 10 ppm. Proprietary characterization techniques were utilized to correlate the performance of the polisher system to the regulatory analytical standard.
- MYCELX systems are designed per ASME, NACE and ABSA requirements on the pressure vessels, instrumentation and skids.
- Even during upset conditions MYCELX continued to deliver an outlet of 10ppm



IMPACT

- During the first year of operation, using only the MYCELX polisher as the tertiary treatment, operating costs amounted to $135,000.
- MYCELX polishers were active a total of 16% of the total time the platform was operating
- The platform experienced 18 water treatment upsets upstream, with an average duration of 25 hours greater than 30 ppm inlet into the MYCELX polisher. The average discharge for this period was 3.8 ppm.
- During the second year of operation using the MYCELX polisher, operating costs were lowered to $70,000.
- Cost reduction was attributed to concise trending data which helped operators accurately judge when to activate the tertiary treatment
- MYCELX Polishers were active a total of 10% of production time and an average discharge of 4.3 ppm was achieved
- Only 30 man hours utilized to maintain the system when 15 upsets were experienced
- After 28 months of operation with the MYCELX polisher and 33 upstream upsets, the deepwater FPF never violated NPDES regulations for water discharge nor experienced loss of oil and gas production because of water treating issues.

CASE STUDY 4:
EOR PRODUCED WATER #1

OVERVIEW

Customer: Major Oil & Gas Company
Location: Alberta, Canada

OBJECTIVES

- Removal of oil and suspended solids from produced water to less than 10 ppm to enable produced water to be reused for polymer re-injection

KEY METRICS

Parameter	Inlet (ppm)	Outlet (ppm)
Oil	500 – 2500	<10
TSS	2 – 101 ppm	<10

Operating conditions:
- Temperature: 30°C – 45°C
- Pressure: 75 psi
- Flowrate: 200 gpm

MYCELX DELIVERED:

98% oil recovery

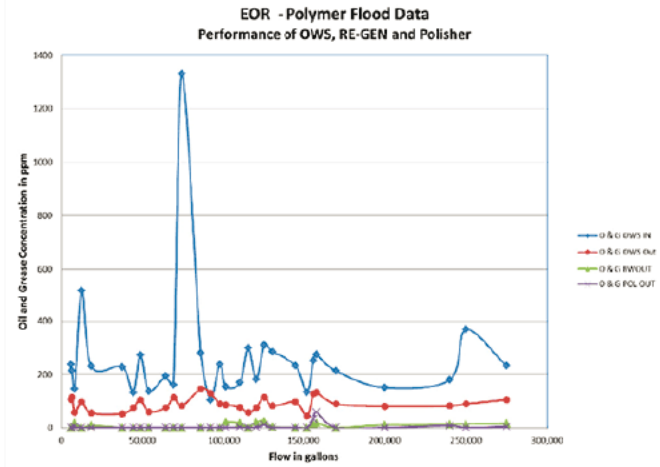
Consistently delivered outlet of <10ppm

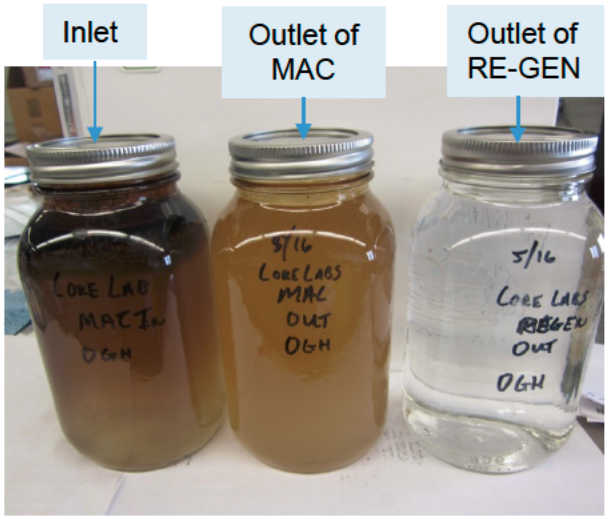
Robust system able to deal with upset conditions

Reduce chemical usage and reuse polymer

CHALLENGE

- A major oil and gas company in North America implemented an Enhanced Oil Recovery (EOR) process in a mature field with medium-heavy oil.
- EOR technologies utilized were polymer flooding and Alkaline Surfactant Polymer (ASP) flooding.
- While this increased production rates significantly, it resulted in highly emulsified produced water with higher concentrations of oil from the free water knockout outlet.
- The produced water from the free water knockout system was emulsified with oils, solids and residual polymer from the EOR process. It contained 200 ppm – 2500 ppm of oil and grease with 50 ppm – 1000 ppm of solids; all with varying viscosities.
- The high levels of oil and suspended solid concentrations resulted in increased consumption of chemicals to maintain production levels and these concentrations also contributed to process reductions or plugging of the reservoir formation.
- Conventional filtration technologies were unable to consistently treat the water to less than 10 ppm necessary for recycling the produced water and minimizing the usage of chemicals required for polymer flooding.





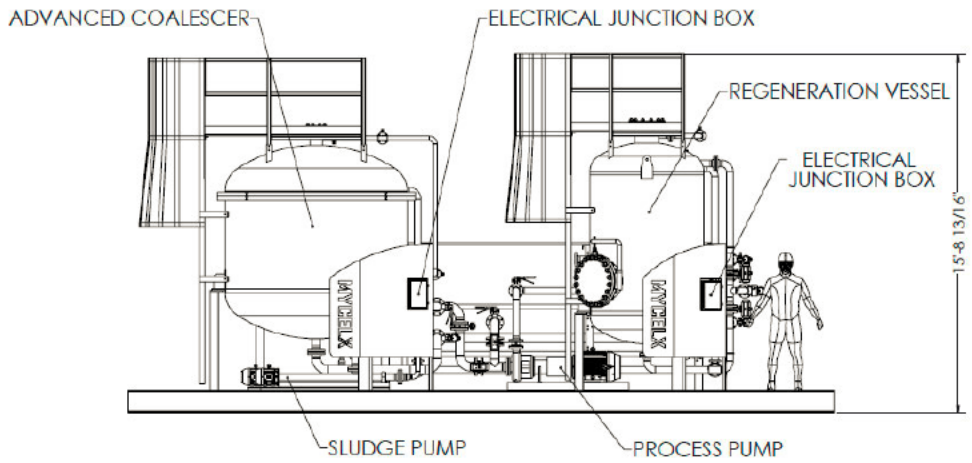
CASE STUDY 4:
EOR PRODUCED WATER #1

SOLUTION

- The MYCELX solution was customized to solve the unique challenges identified through characterization techniques during the pilot trial. This enabled MYCELX to provide a robust, compact solution - a combination of a MYCELX Advanced Coalescer and RE-GEN to remove inlet oil of 2500 ppm to less than 10 ppm.
- The system utilized patented oleophilic filtration media to attract, recover and remove various oil types at varying concentrations.
- MYCELX systems are custom designed to remove oil from water for recycle even with varied emulsion strengths, concentrations and viscosities. Systems can consist of three stages:
  - Primary: MYCELX Advanced Separator (MAS)
  - Secondary: MYCELX RE-GEN
  - Tertiary: MYCELX Polishers
- Trial work demonstrated to the customer that the RE-GEN solution would deliver outlet specs that more than satisfied their targets, therefore the system was optimised to only utilise two stages
- MYCELX systems are designed per ASME, NACE and ABSA requirements on the pressure vessels, instrumentation and skids.

IMPACT

- Inlet to the MYCELX complete oil removal system varied between 200 ppm - 2500 ppm of oil with viscosities varying between 2 cP to 7 cP
- Oil recovery from produced water was up to 98% from the primary and secondary oil removal systems
- MYCELX system effectively removed oil in the produced water to customer specified levels of less than 10 ppm
- Easy to operate and low maintenance system; thus saving time and internal resources
- The MYCELX solution was able to handle upset conditions of the upstream production process



CASE STUDY 5:
EOR PRODUCED WATER #2

OVERVIEW

Customer: Major Oil & Gas Company
Location: Alberta, Canada

OBJECTIVES

- Removal of oil and suspended solids from produced water to less than 20mg/L to enable produced water to be reused for polymer re-injection

KEY METRICS

Inlet	Normal (mg/L)	Upset (mg/L)
Oil	150 – 300	1000 – 2000
TSS	75 - 150	-

Operating conditions:

- Oil Production Rate: ~20,000 BPD (used to be > 25,000 BPD)
- Produced Water Rate: ~55,000 BPD
- Viscosity <3.0cP

MYCELX DELIVERED:

Reliable 95% removal of OiW

Average outlet of 10mg/L

Consistently delivered outlet of <20mg/L

A solution that will work even if viscosity rises to >10cP

CHALLENGE

- Canadian operations are required to limit the volumes of freshwater used for injection
- Polymer Flood facility is currently injecting 150 – 300 mg/L OiW and 75 – 150 mg/L TSS
- Poor quality injection water → issues maintaining the injection volumes required to produce at desired levels due to plugging/fouling of injection wells
- Work-overs to restore injection pressures and volumes can cost up to $500,000 per instance

- Production losses due to downtime and poor injection quality → search for superior water treatment solution
- Engineering department determined the optimal re-injection specification of <20mg/L OiW and minimal suspended solids
- As a result of successful collaborative research with SNF Floerger, MYCELX was selected to trial a RE-GEN solution at the customer's site

CASE STUDY 5:
EOR PRODUCED WATER #2

SOLUTION

- MYCELX was trialled on two different scenarios – normal operating conditions and simulated upsets
- In both cases, MYCELX was able to deliver the required outlet specifications as seen in the sample data below:

Typical Operating Conditions

Inlet to RE-GEN (ppm)	RE-GEN Outlet (ppm)	Viscosity (cP)
269	0	2.9
229	7	1.9
147	3	1.4

Stress Test Conditions

Inlet to RE-GEN (ppm)	RE-GEN Outlet (ppm)	Viscosity (cP)
800	11	2.2
800	4	1.3
1250	0	2.2

- Average runtime of approximately 18 hours before oil break through (i.e. backwash frequency)
- Average inlet OiW concentration of 196 mg/L
- Average outlet OiW concentration of 10 mg/L vs Target of 20 mg/L

IMPACT

- **Successful pilot** that was able to meet <20mg/L OIW water quality specifications under both normal and stressed conditions
- Trial results supported the investigation to a permanent scalable commercial solution
- **Not limited by viscosity:** Pilot encountered viscosity levels of between 1.5cP – 2.5cP because the field has not transitioned to a full field polymer flood.
- In the event that it does transition, the viscosity levels will likely increase to 5 – 10cP which will be a challenge for separation-based technologies, but will pose no issue for MYCELX RE-GEN as demonstrated in the white paper produced in collaboration with SNF Floerger
- **Superior results** compared to other competing technologies trialled by customer

CASE STUDY 6:
HEAVY OIL PRODUCED WATER

OVERVIEW

Customer: Major Oil Company
Location: South Eastern Europe

OBJECTIVES

- Remove oil and suspended solids from produced water to less than 10 ppm to enable produced water to be reinjected.

KEY METRICS

Inlet conc.	Inlet (ppm)	Outlet (ppm)
O&G	100 - 2500	<10
TSS	50 - 800	<10

Operating conditions:
- Flow Rate: 15,000 bpd
- Temperature: 60^{0}C
- Operating pressure: 75 psi

MYCELX DELIVERED:

98% oil recovery

Consistently delivered outlet of <10ppm O&G and <10ppm TSS

Robust system able to deal with upset conditions due to asphaltenes and diesel range organics

CHALLENGE

- A major oil company with operations in South Eastern Europe was generating 15,000 bpd of produced water from its heavy oil production facility. The API of the oil was 5 – 9 and the produced water was approximately 60°C with appreciable concentrations of diluents that emulsified the oil.
- The oil had very high concentrations of asphaltenes and Diesel Range Organics (DRO) with solid concentrations fluctuating from 50 to 800 ppm.
- The oil and grease concentrations, as well as the degree of emulsion, fluctuated greatly during production.
- The presence of asphaltenes rendered conventional oil removal technologies less efficient. The presence of high salinity required the material of construction to be stainless steel 316 or higher to withstand the corrosive nature of the water.
- The water treatment discharge requirement was less than 10 ppm of oil and grease for reinjection, recycle and reuse.

CASE STUDY 6:
HEAVY OIL PRODUCED WATER

SOLUTION

- MYCELX provided a complete, robust solution that included primary, secondary and tertiary oil removal systems to remove inlet oil of 2500 ppm to less than 10 ppm.
- The primary MYCELX solution is an Oil Water Separator (OWS) which is custom designed to coalesce and recover a wide range of heavy oil droplets from 100-2500 ppm.
- The secondary MYCELX solution is a RE-GEN (back-washable) system which is designed to treat heavy oil in dispersed and emulsified form up to 1000 ppm and solids up to 800 ppm.
- The tertiary MYCELX solution is a polishing system with a gradient filter approach to remove the trace contamination of oil to less than 10 ppm.
- The system included automatic controls to respond to fluctuations in flow rates and pressure drop. Due to the corrosive nature of the water, a sacrificial Anodic Protection (AP) was utilized to prevent corrosion of the system.
- MYCELX systems are designed per ASME, NACE and ABSA requirements on the pressure vessels, instrumentation and skids.

IMPACT

- Inlet to the MYCELX complete oil removal system varied between 100 ppm – 2500 ppm of oil
- Consistent removal to less than the customer specified level of 10 ppm
- Oil recovery from the produced water was up to 98% from the primary and secondary oil removal systems
- MYCELX system effectively removed oil from the produced water in free, dispersed and emulsified phases
- Consistent performance on large fluctuations of asphaltenes and diesel range organics
- Removed Total Suspended Solids (TSS) to less than 10 ppm
- Easy operation and maintenance for the complete oil removal system

CASE STUDY 7: HYDRAULIC FRACTURING

OVERVIEW

Customer: Multiple customer sites
Location: New Mexico & Texas, USA

OBJECTIVES

- Treat hydraulic fracturing produced water for reuse and surface water containment storage
- Ensure Sheen-free water
- Enable customers to recycle water for slickwater fracs economically

KEY METRICS

	O&G	TSS	Total Iron
Average Inlet	202.4 ppm	195ppm	84.2 ppm

Target effluent concentrations:

- Oil & Grease ≤10ppm (Actual achieved 2.7ppm)
- TSS ≤ 25 ppm (Actual: 14.2ppm)
- Total Iron ≤5ppm (Actual 1.38 ppm)
- Flow Rate: 3,000 – 28,000 bpd

MYCELX DELIVERED:

720,000 bbls of water previously unrecoverable now made reusable

Recovered sellable skimmed oil

35-55% savings vs conventional treatment

Mobile solution provided added operational flexibility

CHALLENGE

- Three hydraulic fracturing sites required fail-safe solutions for no oil sheen and lower production costs through recycling produced water.
- According to New Mexico Rule 34 oil sheen compliance requirement, 19.15.34.13 Operational Requirements for Recycling Containments, states that "The operator shall remove any visible layer of oil from the surface of the recycling containment."
- The customers were sourcing water from equalisation tanks on pad sites
- The customers were on a large shale formation that necessitated horizontal drilling but fresh water sourcing was limited and expensive with costs ranging from $2.00 - $3.50 per bbl including delivery to the site.
- All the operators produced high salinity water from their operations.
- The MYCELX system removed TSS and iron so that the customers could effectively reuse the water as frac supply for both slick and cross-linked fluid systems.
- In order to store and recycle 125,000 and 350,000 bbl of water, TSS and O&G particulates, iron and VOCs had to be reduced for regulatory compliance.
- One customer in Texas' Cline Shale was constrained by their lease from bringing new fluids to the site and was not able to drill a water well as originally intended or use disposal wells.
- Operator had to recycle 4,000-4,200bpd produced and flowback water to do slickwater fracs in their vertical wells.

CASE STUDY 7: HYDRAULIC FRACTURING

SOLUTION

- Working with oilfield service providers, MYCELX engineered site specific sustainable water treatment approaches
- These solutions allowed producers to recycle and reuse produced water and/or flowback, thus preserving water sources while minimizing the deterioration of roads.
- MYCELX employed its RE-GEN systems which incorporates a MYCELX proprietary granular backwashable media and optimizes the efficiency of the MYCELX Polishers.
- The polishers instantly and permanently removed oil and grease without desorbing or becoming water saturated.
- An oxidative chemical precipitation of iron was also administered, providing a high quality brine at a lower cost than freshwater, brackish water or other water sources.

IMPACT

- MYCELX reclaimed a combined site total of over 720,000 bbls of water for reuse that was once considered unrecoverable.
- The Cline Shale installation has recovered 190 bbls of sellable skimmed oil out of 115,000 bbl of produced and/or flowback water processed to date.
- Total solutions costs for the Delaware Basin and Cline Shale sites ranged from 35 - 55% savings over conventional water.
- MYCELX's modular system implementation coupled with fast-to-market rental fleet capabilities eliminates transportation costs to operators that have water routing networks on their leases.

CASE STUDY 8:
WSO REMOVAL ON DEEPWATER FPF

OVERVIEW

Customer: Major Oil & Gas Company
Location: Gulf of Mexico, USA

OBJECTIVES

- Remove WSOs and discharge less than 15 ppm Total Petroleum Hydrocarbons (TPH) to enable overboard discharge within the National Pollutant Discharge Elimination System (NPDES) regulatory limits.

KEY METRICS

Inlet conc.	TPH	WSO
Inlet	24-65 ppm (avg 35ppm)	17 – 26 ppm (avg 21 ppm)
Outlet	0 – 30 ppm (avg 9ppm)	0 – 24 ppm (avg 6 ppm)

Target effluent concentrations:

- Temperature 140^{0}F
- Flow Rate: 66 m3/hr (10,000bpd)
- Operating Pressure: 35 psi

MYCELX DELIVERED:

73% removal efficiency of WSO

Linked high WSOs concentration fluctuations to loss in LDHI injection.

Smaller footprint than previous carbon bed

CHALLENGE

- A major oil company producing 35k bpd and 160 MMCF/D experienced slight overages in discharges averages for compliance under the NPDES monthly discharge averages.
- The deepwater production region was beginning to show higher water cut and concentration of WSO compounds.
- Gas Chromatography/Mass Spectrometry (GC/MS) analysis showed a mixture of low molecular weight organic acids (C6-C10) and medium molecular weight naphthenic acids.
- Traditional treatment equipment was unable to reduce these, causing a water treatment process production bottleneck on the platform resulting in monetary loss.
- With a limited time frame and space available for equipment testing, concurrent production chemical testing was required in order to find a solution.
- In order for the platform to see their five year estimated production growth of 100k bpd come to fruition, a robust system was required to handle WSO presence and current and future flow rates.

CASE STUDY 8:
WSO REMOVAL ON DEEPWATER FPF

SOLUTION

- MYCELX deployed a temporary demo system at 10k bpd to treat one quarter of the platform flow. The system measured 8' x 4' x 8', weighing 2,200 pounds and consisted of a single train of MYCELX polishers and specially developed WSO media.
- Three phases of testing determined the removal efficiency, specific capacity and operating feasibility. This included stationing two engineers at the site for six weeks to perform a data gathering campaign comprised of over 150 data points with backup analysis from EPA certified labs.
- MYCELX provided a detailed report of contaminants detected, operating and capital cost of full-scale equipment and footprint required. As a result, the MYCELX polishing system for tertiary treatment was adopted; providing a smaller footprint than the previous carbon bed.
- MYCELX systems are designed per ASME, NACE and ABSA requirements on the pressure vessels, instrumentation and skids.

IMPACT

- 73% removal efficiency of WSO demonstrated at one quarter of the full platform flow
- Removed over 20% TPH and 18% of WSO from the full stream by slip streaming 25% of the flow through the treatment process
- Linked high WSOs concentration fluctuations to loss in LDHI injection. This resulted in reformulation of LDHI; removing 40% of WSOs from water phase
- MYCELX polishing system for tertiary treatment was adopted providing a smaller footprint than the previous carbon bed

CASE STUDY 9:
MERSEP – Capillary Mercury Capture Technology

Current Technology & Challenges

- Up to now, the approach to reducing mercury vapor concentrations has been to utilise regenerable and non-regenerable media to react or amalgamate with presumed gaseous mercury
- Previously, MYCELX conducted very detailed work on aerosolisation in industrial and government applications
- When working on the mercury issue in natural gas applications, it became obvious that a significant fraction of the mercury was aerosolised and therefore in a coalescable state
- MYCELX developed an element capable of converting finely aerosolized mercury into a bulk liquid

Verification:

Field Trials

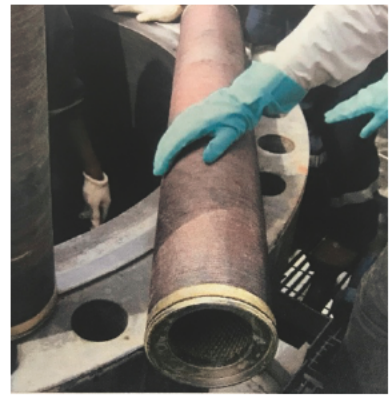
- Field trials of MERSEP were conducted over a 2 year period at a 280mm cfpd facility with high levels of mercury
- Between 1 – 3 lbs of mercury were coalesced daily
- Gas phase mercury concentrations decreased from 100 mg/Nm^3 to 10-15 ng/Nm^3

Laboratory Tests

- Conducted coalescence trials under laboratory conditions at Battelle Labs
- Laboratory trials verified the field results
- MERSEP coalescer demonstrated 100% efficiency in converting aerosol mercury to bulk phase liquid

Conclusions:

- Gaseous, aerosol and bulk liquid phase mercury are in dynamic equilibrium within the gas plant and/or refinery
- The gas phase mercury concentration can be significantly reduced by eliminating or preventing the presence of liquid or aerosol mercury within the system
- MYCELX reduced the vapor phase mercury from an average of 100 mg/Nm3 to 10-15 ng/Nm3 thereby allowing the remaining liquid mercury to be dealt with by conventional adsorbent or reactive media



CASE STUDY 10:
STORAGE & TERMINALS WASTE WATER

OVERVIEW

Customer: Large Greenfield Installation

Location: Houston Ship Channel, USA

OBJECTIVES

- Discharge to the Houston Ship Channel in accordance with the EPA's NPDES permitting program and Coast Guard Authority requirements as follows:
- Oil and Grease: less than 15 mg/L
- Chemical Oxygen Demand: less than 150 mg/L
  pH: from 6 to 9

KEY PERFORMANCE DATA

First 10 months averages:

- O&G: 0.47 mg/L with one peak instance of 11.7mg/L
- COD: 40.5 mg/L with one peak instance of 88 mg/L
- pH: 7.304

MYCELX DELIVERED:

Automated solution required very minimal supervision

Online analysers ensured compliance with regulations

Consistent performance despite off spec inlet OiW of up to 3% and 1,000 mg/L of TSS

CHALLENGE

- A storage and terminal facility with a capacity of over 7 million barrels was under construction near the Houston Ship Channel and needed a wastewater treatment system.

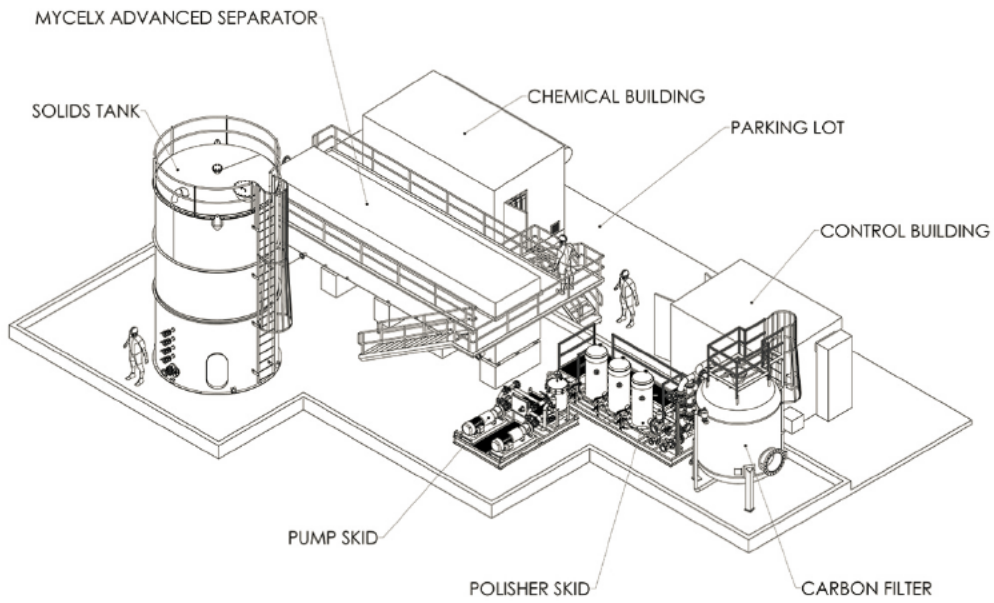
- The 185 acres site anticipated it would generate over 400,000 bbls of wastewater per year
- The wastewater would come from condensate return lines, tempering, stormwater, tank washing and spills.

- The mechanical agitation and recirculation within the wastewater loop would further emulsify the oil into the water which would make it difficult for standard technologies to effectively treat
- Due to its proximity to the Houston Ship Channel, the client set out to find an adaptable on-site automated water treatment solution that would allow them to discharge directly to the waterway.
- Permits are very restricted and must meet the Environmental Protection Agency (EPA) discharge limits of less than 15 ppm of oil and grease per EPA 1664B (or no sheen condition at discharge), less than 200 ppm of Chemical Oxygen Demand per EPA 410.4, and pH from 6 to 9 per EPA 150.1 and benzene below 0.5 ppm.
- Additionally, wastewater storage tanks could not exceed over two-thirds capacity in order to prevent contaminated water overflow into the nearby bird estuary and channel because of hurricanes and torrential rains.

CASE STUDY 10:
STORAGE & TERMINALS WASTE WATER

SOLUTION

- MYCELX customized a terminal wastewater system to treat two 20,000 bbls storage tanks which contained a combination of stormwater runoff, boiler condensate, tempering and collection sump water.
- The system deployed consisted of a solids settling and pH equalization tank, MYCELX Advanced Separator, MYCELX Polisher, a carbon stripper unit and state-of-the-art analytical equipment for continuous monitoring.
- The MYCELX solution optimally utilized the appropriate technology in varying stages to minimize cost while meeting discharge requirements.
- Media life was further extended by implementing oil content and COD monitors to divert flow around the MYCELX polishers and carbon filter when the water was less than the discharge range.



IMPACT

- MYCELX automated solution required very minimal supervision from the operations staff. The robust MYCELX terminal wastewater system easily handled very high fluctuations of inlet oil and grease concentrations while continuously meeting discharge requirements.
- Inlets of the system ranged up to 3% oil in water and 1,000 mg/L of Total Suspended Solids (TSS) while maintaining consistent outlet result below required limits.
- Proprietary system utilized bypass flow around consumable media to avoid premature consumption, thus saving operational costs.
- Automatically diverted any non-compliant water back to the front of the wastewater recycling loop process via online analyzers.

CASE STUDY 11:
QUENCHWATER: ACHIEVING >365 DAYS REBOILER RUNTIME

OVERVIEW

Customer: SABIC Affiliate Olefins Plant
Location: Jubail Industrial City, KSA

OBJECTIVES

- To maintain low oil loading in quench water by managing high loading upset conditions and heavy emulsions
- To maintain on-spec wastewater for the quench water system, achieving RCER 2015 standards
- To reduce waste generation by minimizing blowdown rates from the quench water loop
- To increase capacity utilization of the quench water system by eliminating unscheduled maintenance activities on the quench water reboilers

OIL LOADING DATA

- Average inlet oil concentrations of 2,100 ppm with upset conditions as high as 184,000 ppm
- Design effluent concentration is 20 – 100 ppm, with up to 150 ppm maximum allowable concentration
- Flow Rate: Design: 100 m^3/hr, Actual: 140 m^3/hr
- MYCELX average oil discharge concentration is 75 ppm

MYCELX DELIVERED:

Improved On-Stream Factor
Reduced DSG Blowdown
Reduced DSG Oil Loading
Higher Quality Steam
Improved Capacity Utilisation

CHALLENGE

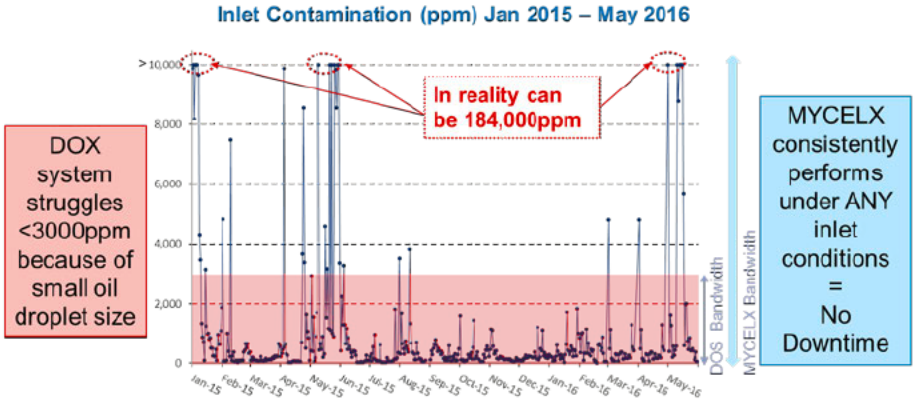
- The petrochemical facility deployed a Dispersed Oil Extraction (DOX) process to remove oil from the closed loop quench water system to prevent fouling of the Dilution Steam Generator (DSG) system.
- This oil-free water is used to generate high-quality steam for use in the cracking furnaces.
- During upset oil loading conditions or in the presence of strong emulsions the quench water system struggled to achieve the required balance with the downstream DOX unit, resulting in poor oil removal efficiencies.
- Ultimately the customer saw significant negative impacts to their capacity utilization as frequent reboiler maintenance reduced on-stream factors and compromised production rates.
- Major increases in water usage and wastewater generation from high DSG blowdown rates were preventing energy and water efficiency goals from being met.
- In order to address the above issues and meet increasing production demands for oil-free water and high quality steam, the plant sought to replace the existing DOX process.
- This alternative process needed to be a robust system capable of removing high oil loading and handling upset conditions of strong emulsions.
- Key performance parameters included:
  - Discharge <150ppm O&G in the system effluent
  - Increase Reboiler Runtime >180days
  - Improve flow rates and oil loading in the DSG blowdown

CASE STUDY 11:
QUENCHWATER: ACHIEVING >365 DAYS REBOILER RUNTIME

SOLUTION

- MYCELX designed, engineered and delivered a customized multi-stage treatment solution driven by patented technologies for an optimized solution.
- The primary MYCELX Advanced Coalescer (MAC) system removes bulk oil and recovers high purity skim oil and settles out large solids.
- The secondary MYCELX RE-GEN system uses a media depth bed to remove remaining bulk and dispersed oils and captures 98% of suspended solids >5 microns. Periodic regeneration of the media bed is performed to maintain high efficiency.
- The MYCELX Polisher system removes emulsified oils and fine solids to meet effluent requirements.
- Daily analysis of outlet water samples by a third party lab is used to generate reports to the customer.
- Water characterization expertise is used to troubleshoot unique quench water upset conditions such as high concentrations of green oil and heavy emulsions.
- The MYCELX solution provided a robust and continuously operating system capable of handling major upset conditions with inlet concentrations as high as 184,000 ppm (see right).
- The MYCELX system is continuously optimized for varying feed compositions and oil loading

Severe Upset Conditions (i.e. contamination >3,000ppm)



CASE STUDY 11:
QUENCH WATER – EXCEEDING GOALS SET

IMPACT

- The MYCELX oil removal solution delivered enormous benefits by drastically improving DSG and reboiler performance. Successful handling of upset oil conditions resulted in significant reductions in wastewater generation:

Improved on-stream factor:

- DSG reboiler on-stream factor significantly improved with run lengths increased from the previous average of 25 days to over 365 days

Reduced Blowdown:

- DSG blowdown wastewater flowrate reduced by 56%

Reduced Oil Loading:

- Oil loading in DSG blowdown wastewater reduced from average of 1,308ppm to an average of 84 ppm from MYCELX system

Reduced Coke Waste:

- Reboiler coke waste generation reduced by 88% in DSG reboilers, contributing to improved S.H.E. Metrics

Improved Capacity Utilization:

- Improvements to reboiler run time and DSG blowdown resulted in quench water system meeting or exceeding goals for capacity utilization

High-quality steam provided to furnace crackers

KEY PERFORMANCE METRICS

	Before	MYCELX	%
Reboiler Runtime	21 Days	>365 Days	15x
DSG Blowdown	90m³/hr	40 m³/hr	56%
Oil Loading	7,500ppm	58 ppm	99%

	TARGET	MYCELX
OIW in Effluent	<150ppm	58 ppm
Reboiler Maintenance	180 days	>365 days
Stabilize Flow rate	140 m³/hr	140 m³/hr
Discharge Regulation	RCER 2010 compliance	✓

WATER TREATMENT THAT UNLOCKS A PLANT'S FULL POTENTIAL

ALL TARGETS MET OR EXCEEDED

CASE STUDY 12:
COMPLEX TURNAROUND WATER

OVERVIEW

Customer: GCC Petrochemical Facility
Location: Qatar

OBJECTIVES

- Handle fluctuating flow rates and concentrations
- Treat complex streams with multiple contamination sources
- Continuously characterize inlet and optimize the treatment solution
- Consistently meet the discharge requirements.

OPERATING CONDITIONS

- Treatment scope: quench water, storm water and other process wastewater from turnaround activities
- Fluctuating Flow rate: 10 m^3/hr (minimum during high upset conditions) to 50 m^3/hr with normal inlet conditions
- 22,000 m^3 highly contaminated water to be treated

Parameter	C9+ and Quench	Other	Discharge Required
pH	10.2	8.8	6-9
TSS	19.800ppm	617.4ppm	50 ppm
O&G	15,095ppm	112.8ppm	10 ppm
COD	34,400ppm	880.7ppm	150 ppm
Benzene	9,045ppm	539.3ppm	0.05 ppm

CHALLENGE

- A petrochemical refinery in Qatar conducts regular turnarounds every five years which requires a full facility closure to perform maintenance activities, process and system upgrades, optimize the existing processes, de-bottleneck operations and deinventory equipment.
- In the past, turnaround water would be trucked or hauled-off with costs dependent upon the composition as well as concentration of contaminants.
- The turnaround water, which was characterized by high fluctuations and concentration of oil, benzene, TSS and COD, presented some of the most complex waste water treatment challenges in the petrochemical industry.
- The customer's existing conventional treatment system was designed to handle normal plant operational contamination and flow rates but could not handle the complex turnaround water.
- This 1.3 million MTA ethylene cracker petrochemical facility in Qatar required an integrated turnaround solution with continuous field monitoring and engineering services.

MYCELX DELIVERED:

Provided full turnaround solution

Treated total volume in 42 days vs 60 day target

On-site team ensured consistent performance at 24/7 operation

50-75% cost saving vs haul off

CASE STUDY 12: COMPLEX TURNAROUND WATER

SOLUTION

- MYCELX provided a robust, fail-safe, on-site water treatment system that could handle upset conditions with extreme fluctuating concentrations that are associated with turnaround operations. A complete turnaround solution was designed with engineering field services provided. This included transportation, start-up and commissioning, decommissioning and servicing from local operators.
- Continuous water characterization analysis was performed by proprietary analytical and testing methods throughout the turnaround to allow for real-time treatment adjustments which enabled optimized water treatment of turnaround operations.
- MYCELX deployed a full spectrum of proprietary solutions and patented technologies in a staged approach to handle various complex emulsion scenarios. 950 m^3 of highly contaminated C9+ and quench water were treated separately from the 21,000 m^3 of less contaminated process water. This approach provided additional savings by optimizing the MYCELX chemistry and media in each stage to best handle incoming contamination.

IMPACT

- The MYCELX full-service solution delivered enormous savings over haul-off and the project was completed on-time.
- Savings of 50 – 75% over contaminated water haul-off costs. Furthermore, the plant did not have to coordinate haul-off trucks which contributed to further logistical and operational resource savings.
- MYCELX treated upset conditions 3 – 10 times worse than the client anticipated.
- On-site treatment with continuous monitoring and optimization met discharge requirements on a continuous basis, regardless of upset conditions.
- No harmful VOC or liquid waste.
- Provided additional water characterization expertise and treatment of their stormwater pond to meet discharge to sea requirements.

Parameters	MINIMUM Estimated Inlet Concentrations	MAXIMUM Estimated Inlet Concentrations	ACTUAL Average Inlet Concentrations	MYCELX Average Outlet Concentrations
O&G	50 ppm	80,000 ppm	15,095 ppm	< 5 ppm
TSS	20 ppm	10,000 ppm	19,800 ppm	< 40 ppm
Benzene	10 ppm	35,000 ppm	9,045 ppm	< 0.05 ppm
COD	200 ppm	35,000 ppm	34,400 ppm	< 150 ppm
TOC	50 ppm	6,500 ppm	3,300 ppm	< 50 ppm
pH	2	13	10.2	6 – 9

CASE STUDY 13:
OIL RECOVERY SYSTEM – FROM WASTE TO WORTH

OVERVIEW

Customer: SABIC Affiliate Olefins
Location: Jubail Industrial City, KSA

OBJECTIVES

- Accountable solution to recover oil from oily waste water
- Treat the water to meet Marafiq standards
- Remove the need for any haul off

KEY METRICS

Inlet conc.	Min	Max
OiW Design	10%	40%
Actual	40%	75%

Target effluent concentrations:
- Oil & Grease ≤120ppm
- Flow Rate: 10 - 20 m^3/hr

MYCELX DELIVERED:

MYCELX system charges on a m^3 volume treated basis

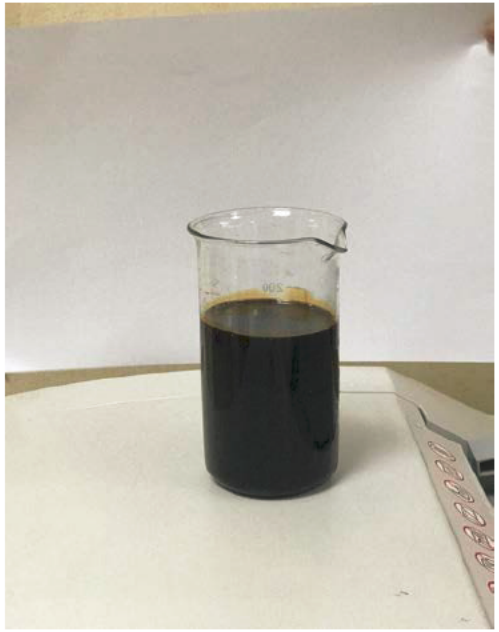
Greater volume of oil recovered

Superior price received for oil recovered

Turns Waste Water from a cost into a profit centre

CHALLENGE

- Oily waste water is typically considered a costly expense which is often just hauled off
- Sometimes the waste treatment company will return some of the value of the oil content back to the client
- The amount of oil credited back to the customer is questionable – recovery happens off site and typically the OiW assumption is around 20-40%
- Requires significant numbers of vacuum truck journeys which have to be scheduled and overseen
- Customer was after an accountable solution that would return the oil to them for reuse or resale



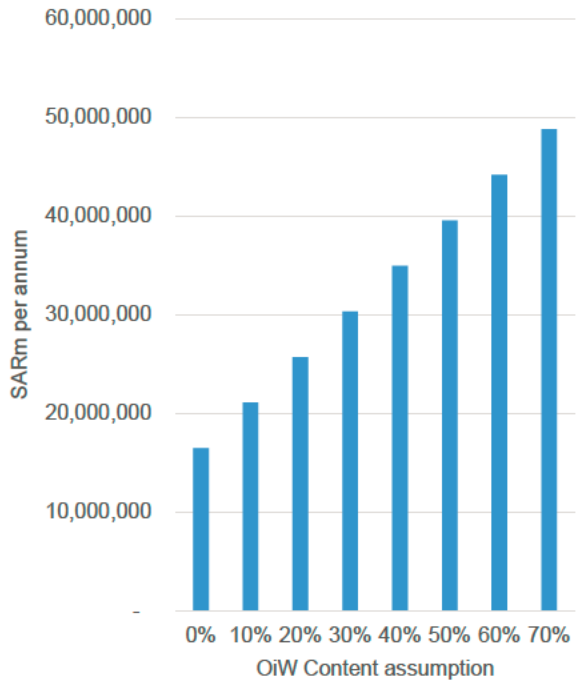
ACCOUNTABLE SOLUTION

- MYCELX system solves this with:
  - An onsite system that is accountable to site operators
  - True OiW content of the waste water is recorded – 40-75% OiW encountered vs. standard 20% OiW assumption used by haul off companies
  - Oil recovered can be sold as pure oil - oil recovered during operation was 99.1 – 99.3% pure
  - Removes the requirement for vacuum truck journeys

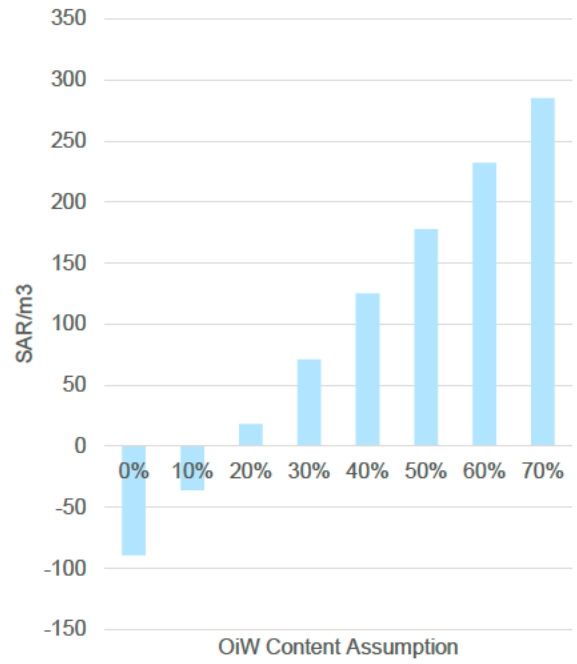
CASE STUDY 13:
OIL RECOVERY SYSTEM – FROM WASTE TO WORTH

- Assuming a 10m^3/hr system was installed :
  - Annual benefit of a MYCELX ORS could be ~SAR35m (assuming 40% OiW)
  - OiW content would only have to be 17% for ORS to start generating profit from wastewater
  - Significant cost saving vs haul off means that cost saving per unit ~SAR404/m^3

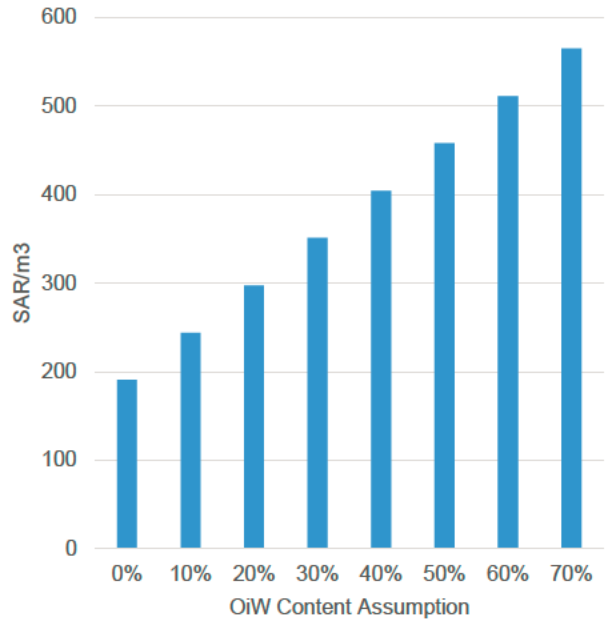
Total benefit per year (SARm)



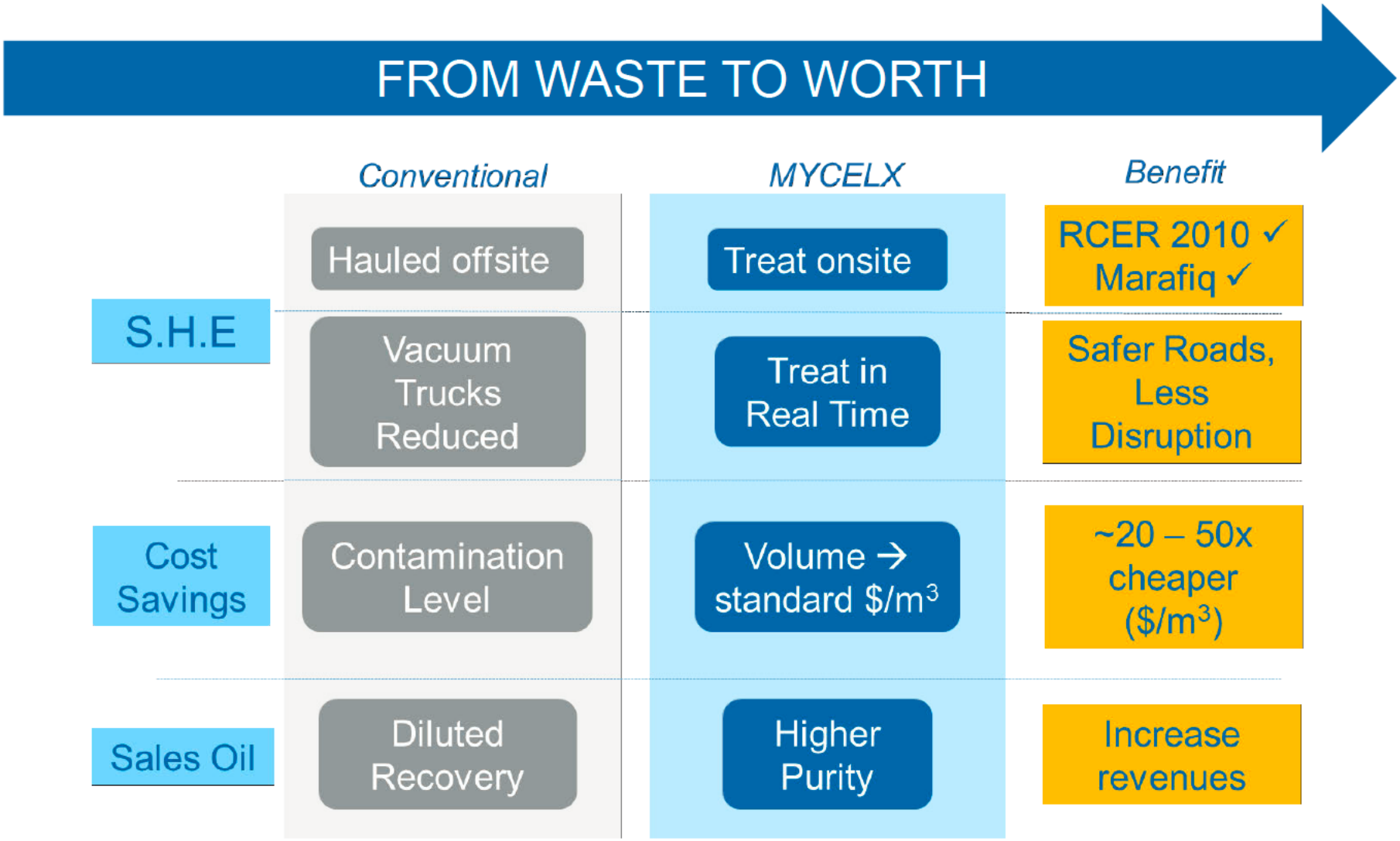
Cost to treat/Profit generated per m^3



Benefit per m^3 treated
(Oil recovered + Cost Savings)



CASE STUDY 13:
OIL RECOVERY SYSTEM – FROM WASTE TO WORTH



CASE STUDY 14
COOLING WATER

OVERVIEW

Customer: Oman LNG
Location: Oman

OBJECTIVES

- To reduce the overall oil concentration in 70 m^3 total volume cooling water loop to less than 5 ppm
- To treat a side stream of the full flow continuously, giving constant improvement to cooling loop water quality
- To recover skim oil for laboratory identification of point sources oil leaks within the loop

OPERATING CONDITIONS

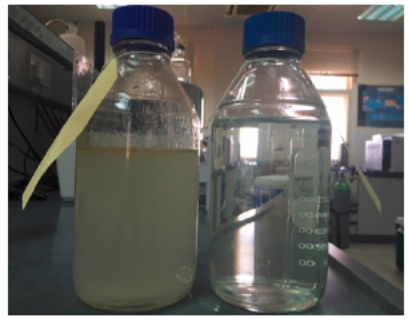
- The cooling loop was contaminated with seal and lube oil at
- an oil concentration of 1,500 ppm
- Water continuously discharged from MYCELX System at less than 5 ppm oil-in-water
- Despite ongoing oil leaks within the loop, MYCELX discharged at less than 3 ppm oil-in-water for 12 continuous days before achieving final levels of less than 4 ppm oil-in-water within the cooling loop
- Flow Rate: 5 – 10 m^3 /hr

MYCELX DELIVERED:

99% Oil Removal
Oil in Water Concentration <4ppm
Pin point source of oil leaks
Training for site team

CHALLENGE

- The LNG facility in Oman was facing oil leaks into several of their tempered cooling water loops.
- Controlling the surface fouling tendencies of contaminants in the loops is crucial to maintaining efficient operations of the associated process heat exchanger units.
- The particular loop trialled had experienced severe oil loading for 18 months despite the presence of a de-oiler system within the loop
- Nine previous attempts to provide a solution by other traditional technology providers had failed.
- Excessive fouling and associated issues caused by the high oil loading resulted in the plant production being reduced.
- To address the above issues, the customer sought to trial the mobile MYCELX equipment on the most contaminated loop as a proof-of-concept.
- Once proven, this technology can easily be moved around the plant to other cooling loops for treatment of existing or future oil contamination.
- The customer's main requirements for the system were easy and quick mobilization and operation by plant personnel, fast completion of the work, avoidance of any excessive burden on operations personnel, and minimal operational expense.



CASE STUDY 14: COOLING WATER

SOLUTION

- MYCELX provided a customized multi-stage Polisher treatment solution driven by patented technologies for an optimized solution.
- The MYCELX Polisher system removed emulsified oils and fine solids to meet effluent requirements using a gradient approach with multiple different types of filters.
- During the trial, the different configurations of filters were tested by MYCELX so that an optimal design could be provided to the customer for future cooling water contaminations.
- MYCELX was then able to successfully trial the technology in a timely fashion with a final report that would allow the customer to reduce filter and time requirements by 40% or more in the future.
- Daily analysis of outlet water samples by the customer's lab was used to generate reports for both solids and oil removal.
- The MYCELX solution provided a robust and mobile system capable of handling inlet oil concentrations greater than 1,500 ppm with unique filter configurations to address conditions in real time.
- MYCELX solution is also capable of handling higher flow-rates.
- An additional advantage of the MYCELX was the ability to extract skim oil which could be used by the customer to identify the point source of oil leaks, thus significantly reducing the time required for the customer to identify and fix existing and future leaks.

IMPACT

- The MYCELX oil removal solution delivered enormous benefits:

Oil Removal	▪ **99% oil removal** ▪ Reduction of cooling loop oil-in-water concentration from 1,500 ppm to **4 ppm**
Continuous Discharge	▪ **12 days of continuous discharge <3ppm oil-in-water** despite ongoing oil leaks into the cooling loop
Pinpoint source of leaks	▪ 50% of oil volume removed by skimming, which provided the customer with the option to test recovered oil to **determine type and point source of oil leak**
Cost effective	▪ **Optimal filter configuration** for future cleaning of cooling water loops, dependent upon level of oil contamination in the loop and final desired loop concentration
User Friendly	▪ **Complete training of the operations personnel** at the customer site, allowing the customer to operate the system as required for emergency oil removal

CASE STUDY 15:
RAPID RESPONSE FOR UTILITIES ETP

OVERVIEW

Customer: SABIC Affiliate Utilities Section
Location: Jubail Industrial City, KSA

OBJECTIVES

- Removal of oil and benzene from all waste water streams coming to effluent treatment
- Enable the customer to meet RCER 2010 for final discharge of wastewater

KEY METRICS

Inlet conc.	O&G (ppm)	Benzene (ppm)
System Design	450 ppm (avg) 2000 ppm (peak)	50 ppm (avg) 250 ppm (peak)
Actual	137 ppm (avg) 620 (peak)	368 ppm (avg) 30846 ppm (peak)

Target effluent concentrations:

- Oil & Grease ≤120ppm
- Benzene ≤ 0.056 ppm
- Flow Rate: 65 m^3/hr

MYCELX DELIVERED:

Rapid deployment

Consistently met RCER standards for >3yrs

Robust system able to deal with upset conditions (7x Benzene loading)

75% cost savings vs Haul Off

Achieved without any additional capex

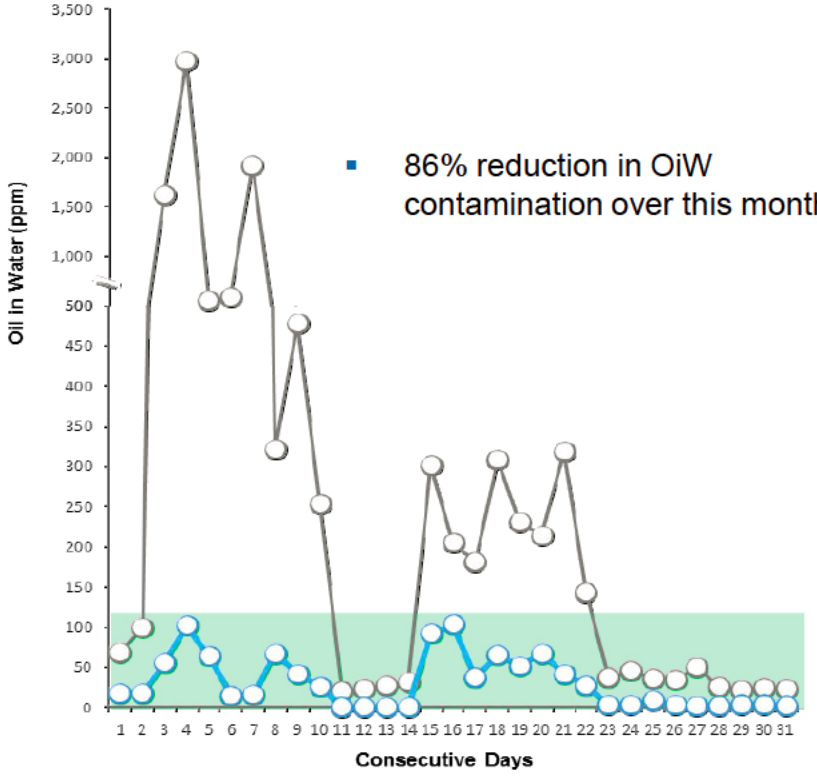
CHALLENGE

- A petrochemical facility in Saudi Arabia produced dozens of specialty chemicals and each of these processes generated heavily contaminated waste water streams which were all sent to a single processing facility.
- This effluent treatment plant relied primarily on chemical treatment to remove contamination from the combined waste streams. Due to the constantly changing composition and unpredictable loading of the wastewater, the designed treatment process was unable to meet RCER specifications or company internal goals
- Customer sought an immediate solution focussed on removing oil and benzene which were known to present extreme loading challenges.
- The solution needed to ensure there would not be any benzene vapor present and that benzene dissolved in the wastewater would be removed.
- After startup, MYCELX's robust system managed to continue to meet outlet specifications despite extreme benzene loading conditions far beyond the original design.
- This led to the customer integrating the MYCELX system as a key component of their water management system in order to meet the final discharge requirements and achieve company discharge goals.

CASE STUDY 15: SUPERIOR PERFORMANCE

Oil in Water Contamination

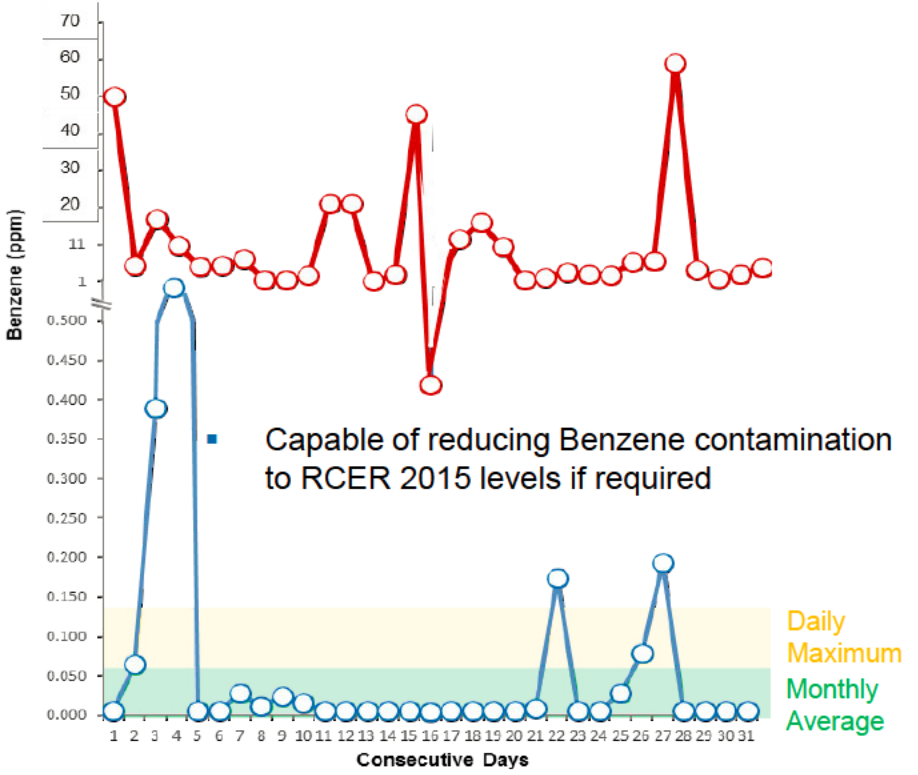
- Ensured outlet OiW met RCER 2015 regulations
- Regardless of inlet contaminations levels (max during 6 month campaign: 30,846ppm)



- 86% reduction in OiW contamination over this month

Benzene Contamination

- 95% reduction in Inlet Benzene during this month and 6 month campaign.
- Enables client's existing equipment to achieve waste water compliance



- Capable of reducing Benzene contamination to RCER 2015 levels if required

CASE STUDY 15
SUPERIOR PERFORMANCE & COST REDUCTION

SOLUTION

- MYCELX designed, engineered and delivered a multi-stage treatment solution using our patented technologies for an optimized solution. MYCELX was **able to rapidly deploy** this system within 2 months by incorporating our Mobile Treatment Plants.
- The primary **MYCELX Advanced Coalescer** system removed bulk oil and recovered high purity slop oil and settled out large solids.
- The **MYCELX Polisher system** removed any remaining free oils as well as dispersed oil, emulsified oil and fine solids. The Polisher also extended the life of the final stage of the treatment process – a non-regenerable media bed.
- The **MYCELX media depth bed** acted as the tertiary stage, reducing levels of BTEX and soluble oils to critically low discharge requirements.
- Daily analysis of outlet water samples by a third party lab was used to generate regular reports for the client. **Water characterization and engineering expertise** allowed MYCELX to troubleshoot unique upset conditions such as heavy benzene loading.
- The customer consistently met RCER discharge specifications despite inlet benzene loading concentrations that were 7 times higher than design specifications. MYCELX's solution **required no additional capex**, was able to easily fit into the existing infrastructure and **eliminated costly vacuum trucks**.

IMPACT

The MYCELX oil and benzene removal system ran continuously to significantly reduce contamination and manage intermittent upset conditions.

- **Continuous Operation for 2.7 years** despite periodic upstream upset and 2 turnarounds
  - >1,000,000m^3 of wastewater treated
- **RCER 2010 requirements met:**
  MYCELX's consistent performance enabled the customer to meet RCER discharge requirements despite high and variable contamination

Average inlet concentrations:	**Upset conditions:**
Oil and Grease: 137ppm	Oil & Grease: 620ppm
Benzene: 368ppm	Benzene: 30846 ppm

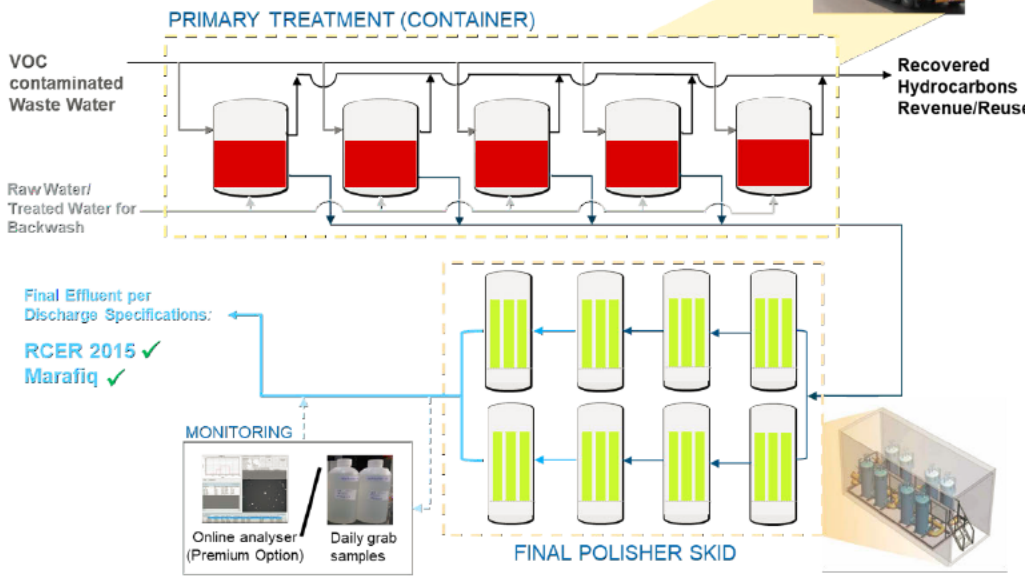
- **Significant cost savings:**
  - Up to 75% cost savings vs traditional haul-off disposal
  - >$20m cost savings per year
- **Eliminated the need for vacuum trucks**
  - Safety, Health and Environmental benefits of eliminating the need for vacuum trucks and providing an on-site solution
  - 300 vacuum trucks removed from site

CASE STUDY 15
MOBILE TREATMENT UNIT – DETAILS

MYCELX's Mobile Treatment Unit is our Rapid Response Solution that can be deployed to provide BTEX removal

Equipment Specifications

- Flow Rate: 10-170 m^3/hr
- Design operating pressure: 10 bar
- Operating Pressure Drop: 3 bar
- Max temperature: 130 deg C
- Materials of construction: coated carbon steel
- Certification: ASME Sec VIII
- Hazardous Rating: EX Rated- Class 1 Div 2
- Power Requirement: 3 PH, 460 V, 60 Hz
- Air Requirement: utility air – 90cfm, 100 psi Instrument air – 5 cfm, 100 psi
- Raw water requirement: per regenerations cycle of coalescer: 10-20 m^3
- Footprint required: 3x 40ft + maintenance space



Treatment Specifications

Design inlets:
- Oil: 1000ppm
- TSS: 100-200 ppm
- Benzene: 500 ppm
- TOC: 1000 ppm

Design outlet:
- Oil: 0-10ppm
- TSS: <2 microns
- Benzene: 0.05 ppm
- TOC: 0-100 ppm
- 75-99% removal of PAH

CASE STUDY 15:
RAPID RESPONSE VS ALTERNATIVES

	MYCELX	Chemicals	Other Treatment Options	Haul off to Third Party
Ability to remove: **1. Oils & Emulsions** **2. VOC/BTEX** **3. PAH** **4. Oil Coated TSS & Iron Sulfides**	**YES**	**NO** Specific to each type of contamination Requires frequent adjustments	**NO** Not reliable Susceptible to fouling and not effective to complex contamination	**N/A**
Flexible Operation: fluctuating flows and loading	**YES** Sustainable performance even at 5% design flow	**NO** Requires adjustments based on flow and concentration	**NO** Ineffective at lower than 30-35% design flow and >300ppm loading fluctuations	**N/A**
Cost comparison to same performance as MYCELX	**X**	**X – 3X**	**2 – 10X**	**3 – 10x** Large environmental Footprint

CASE STUDY 16:
REMOVING OILS & XYLENES FROM STORMWATER

OVERVIEW

Customer: Global Integrated Oil Company – Petrochemicals

Location: Southeastern USA

OBJECTIVES

- To reduce the oil and hydrocarbon concentration in the storm water run-off to less than 1ppm

KEY METRICS

- Inlet 5 – 100ppm of oil and light hydrocarbons
- Outlet: less than 0.5 ppm
- Flow Rate: Two separate systems with flow rates of 700 m^3/hr and 1300 m^3/hr

MYCELX DELIVERED:

Consistent performance since installation in 2005

Small footprint

Low waste generation

Significant cost savings

Low maintenance required (<30hrs per yr)

CHALLENGE

- Insufficient capacity to handle additional oil and hydrocarbon load during storm event (>1m gallons)
- Hazardous nature of these hydrocarbons combined with the high flow capacity and fluctuating loading rates (xylene loadings from 10 ppm –1000 ppm) posed significant treatment challenges for conventional technologies like activated carbon or biological systems.
- Needed a robust failsafe system with low maintenance requirements, low waste generation and small footprint

SOLUTION

Quick response:

- Installation of two systems (700 m^3/hr and 1300 m^3/hr) on site within record 9 months of signing contract

Consistent Performance:

- Reliable performance to date - no violations since installation in 2005

SIGNIFICANT COST SAVINGS

- **Small footprint** of 10 m x 5 m for 1300 m^3/hr unit and 5 m x 5 m for 700 m^3/hr unit.
- **Low cost to install:** No large infrastructure development costs in terms of site preparation, civil, utilities and foundations that would have been necessary for other treatment options
- **No additional pump capacity:** Low operating pressure requirement of 2 bar for the entire system meant there was no need for additional pumps
- **Lowest Capex of any alternate conventional treatment option**
- **Low waste generation** – 1/100th of any alternate conventional option
- **Low maintenance requirements** and associated costs – less than 30 man hours required for maintenance per year

CASE STUDY 17:
BTEX WASTEWATER TREATMENT THAT PAYS FOR ITSELF

MYCELX

OVERVIEW

Customer: SABIC Affiliate – IBN SINA

Location: Jubail Industrial City, KSA

Objectives of the Treatment

- Point source treatment of wastewater to prevent system-wide contamination
- Meet Customer's discharge requirement for oil loading and BTEX
- Convert toxic waste byproduct from process to value based product

Key metrics

Inlet conc.	Min (ppm)	Max (ppm)
Oil & Grease	1000	900,000
BTEX	20	220

- Target effluent concentrations:
- Oil & Grease: < 15 ppm
- BTEX: < 3ppm
- Oil consists of both very light and very heavy fractions

MYCELX DELIVERED:

Innovative Award-winning Solution

Reduced environmental footprint

Consistently meets RCER standards

Revenue generation from a waste product

CHALLENGE

- IBN SINA was generating wastewater from the degasser unit at a flow rate of 6m^3/hr with high concentrations of oil and grease, BTEX and gasoline range organics
- Degasser wastewater stream was less than 1% of the total wastewater generated but it was contaminating the entire waste stream
- IBN SINA was designed to send all of its wastewater to the Central Waste Water Treatment Plant but due to the degasser unit wastewater stream it was not meeting the required water quality acceptance standards set Marafiq.
- Without the ability to send wastewater to the CWWTP, IBN SINA was forced to either shutdown or dispose the highly contaminated wastewater via expensive haul off
- The high levels of hydrocarbons in the waste water caused emission levels to be higher than RCER standards.
- Furthermore, approximately 600m^3 per year of recoverable hydrocarbons that could be used as fuel was being lost in disposed wastewater.

CASE STUDY 17:
BTEX WASTEWATER TREATMENT THAT PAYS FOR ITSELF

SOLUTION

- MYCELX installed a pilot testing skid to accurately characterize the water at both high and low concentrations. The pilot trial led to a custom system design that combined an oil water separator and polishers. **The system was designed to handle the high concentrations of oil and emulsified oil and hydrocarbons**
- The oil water separator's unique particle treatment and coalescence capabilities reduced the high concentration of oil to low levels which could be removed by the polishing filters.
- The polishing filters had a preconditioning stage consisting of a MYCELX formulation, which was utilized to further coalesce the smaller droplets into larger droplets so that the last stage of polishing filters could remove them efficiently
- **The discharge from MYCELX's system was consistently below 5ppm despite the wild inlet fluctuations**
- The first stage oil water separator was working so effectively that the oil it collected was filling a 300 gallon tank in less than a day
- The volume of cumulative oil recovered per day led to a system redesign so that the oil collected could be directly pumped to the incinerator to serve as a source of fuel or sold to a third party
- **MYCELX's solution resulted in this highly contaminated by-product from CATOFIN dehydrogenation process, becoming a fuel source that generates US$240,000 per year**
- The project was voted a Finalist for Engineering Project of the Year award at the 2009 Platt's Global Energy Awards. The system was also recognised at the SABIC Technical Conference in 2010

IMPACT

Innovative solution:

- Most cost effective solution to handle CATOFIN dehydrogenation wastewater – first of its kind in KSA

Reduce environmental footprint:

- Point source Contamination Reduction facilitates water conservation through sustainable process water recycle and reuse

Consistently meets RCER standards:

- System allows the customer to consistently meet RCER discharge requirements

Safety, Health and Environmental (SHE) benefits:

- BTEX and aromatics odor reduction in the drains, sumps and wastewater collection ponds.
- Enable water conservation and reuse by contamination reduction at source.

From Waste to Worth:

- Conversion of carcinogenic wastewater to a revenue stream by selling 600 tonnes per year of oil recovered at 98% purity which would otherwise be disposed of as hazardous waste.

CASE STUDY 18: PRE-RO PROTECTION

OVERVIEW

Customer: Major Petrochemical Facility

Location: Midwest USA

OBJECTIVES

- To protect the R.O. membrane from
- oil fouling by removing the inlet
- water concentration of 5 ppm of oil
- and grease to less than 1 ppm

KEY METRICS

- Inlet less than 5 ppm of oil (both light and heavy)
- Outlet is less than 0.3 ppm
- Flow Rate: 400 m3/hr

MYCELX DELIVERED:

Greater understanding of the water contamination issues

Increased flow rate through R.O

Reduced unplanned downtime

Mobile Treatment Option

Low cost solution, no additional capex

CHALLENGE

- The inlet water to the R.O. unit contained trace amounts of hydrocarbons that foul the membranes that were designed to operate at 400 m3/hr.
- The flow through the membrane reduced to 150 m3/hr within two months of commissioning because of level of hydrocarbon fouling.
- The standard testing methods and protocols adapted to determine the concentration and type of oil that was fouling the R.O. produced inconclusive results leading the end user to believe oil contamination was not the source of the reduced flow through the membrane.
- The challenge was multi-faceted:
  - Identify and characterize the oil type that was present in the water.
  - Quantify the loading that was feeding into the R.O. system and causing the reduced flow.
- An additional consideration was that water in this kind of petrochemical facility can be contaminated with a unique mixture of low level hydrocarbons from the lighter to soluble range oils, depending on the location of the process

CASE STUDY 18: PRE-RO PROTECTION

SOLUTION

- MYCELX utilized its unique characterization technique to identify the hydrocarbons in the water and was able to calculate the amount of loading of oil contamination on the R.O. membrane during the pilot stage.
- Once the hydrocarbons were characterized and quantified, MYCELX proposed a solution that included a multi-stage mobile polisher system specifically configured to be easily moved from location to location.
- The multi-stage polisher system uses different types of filters in each stage that have strong chemical cohesion properties designed to remove the very low concentrations of oil and hydrocarbons in the water.

IMPACT

- Oil and grease treated to less than 0.3 ppm
- No appreciable concentration of hydrocarbons reaching the R.O. resulting in increased flow rate and decreased down time
- Low cost to treat
- Polisher system housed in mobile trailer that could be moved around the plant
- Utilizing the proprietary characterization technique, end user had definitive proof of contaminant loading on the R.O. membrane