



Advances in Media Filtration

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Meeting New Challenges with an Old Technology

- Walnut Shell Filtration is an adsorption and media filtration process which has been used for decades to efficiently remove oil and solids from a variety of produced water, including heavy oil.
- Traditionally the WSF's has been used as a tertiary “polishing” treatment step to achieve less than 5 mg/l dispersed oil.
- The industry experience and perception is that the Walnut Shell filters seems be less effected by changes in the inlet conditions compared to enhanced gravity based separation.
- Siemens has refined their WSF system and media technology for offshore in the innovative **Monosep™ High Flow Shell Filter** and **PerforMedia™**.



High Flow Shell Filter Technology Improvements



- Internal backwash design eliminates external scrubber, scrub pump and associated valves and piping
- Reduced weight and footprint by 20% - 40%
- Increased flux rate with black nutshell media (by min 40% to max 100%) to as high as 66 m³/h/m²
- A reduction in backwash water volume (by 50-70%) to < 0.5 – 2.0%

- **Introducing a synthetic nutshell alternative**

4-5 X oil holding capacity

Ability to withstand upset surges

Ability to handle inlet concentrations 5 – 10 time higher

Robust on higher temperatures (media has <5% degradation per year at 80°C)



High Flow Shell Filter Backwashing System



Siemens design:

- Compact internal scrubber design with no moving parts
- Fully automated backwashes with raw produced water which can be customized for each application
- Robust backwash allowing recovery from upset conditions
- Reduced backwash volume (< 0.5 - 2%)
- Backwash every 24 hours (duration 22 minutes)
- No chemicals required

High Flow Shell Filter Performance with Black Walnut Shells

Influent to the WSF



94 ppm free Oil

Effluent from the WSF



4 ppm free Oil

Free Oil & Grease

- Inlet < 50 mg/L / Outlet < 5 mg/L (< 2 mg/L at slightly lower flux rate)
- Inlet > 50 mg/L / Outlet < 5 mg/L (subject to backwash frequency/flux)

Suspended Solids

- Inlet < 100 mg/L / Outlet < 5 mg/L (<2 mg/L subject to inlet conditions and loading rates)
- Inlet < 100 mg/L / Outlet 98% of all particles >10 micron (90% > 5 micron)

Flux 33 m³/hr/m² - 66 m³/hr/m²

Typical Produced Water Treatment

Primary separation

API

Corrugated Plate Separator



Typical effluent quality:

- OiW < 100-200 mg/L
- Solids 98% removal > 10 μ

Secondary separation

Induced & Dissolved Gas Flotation

Chemical Aid



Typical effluent quality:

- OiW < 30 mg/L

Tertiary separation

Media & Nutshell Filters

Cartridge & Coalescing Filters

Ceramic / organic membranes

Process & chemical driven systems



Typical effluent quality:

- OiW < 2-5 mg/L
- TSS < 2-5mg/L
- Solids 95% removal > 5 μ

Improved and Simplified Produced Water Treatment

Primary separation

API

Corrugated
Plate Separator



Typical effluent quality:

- OiW < 100-200 mg/L
- Solids 98% removal > 10 μ

Secondary separation

Tertiary separation

PerforMedia™
Filter

OiW < 5 mg/L
TSS < 2-5mg/L
Solids 95% > 5 μ



- Secondary and tertiary step in one treatment optimizes CapEx, footprint, weight and utilities required.
- Removal of free oil and solids in the same process
- Chemical free process and no rotating parts gives lower OpEx and less maintenance

Test Results with Black Walnut Shells and PerforMedia™



High Flow Shell Filter Pilot Test on API 11 Crude- **Black Walnut Media**

- Test treated 68,000 barrels of produced water over 35 days in Colombia 2013
- Feed to pilot unit was WEMCO® IGF Effluent
- Three fluxes tested
33 m³/h/m² - 47.5 m³/h/m² - 66 m³/h/m²
- Feed oil concentration averaged 25 mg/L
- Feed TSS concentration averaged 11 mg/L
- **Effluent averaged 0.2 mg/L OiW and 0.7 mg/L TSS over ENTIRE duration of testing**



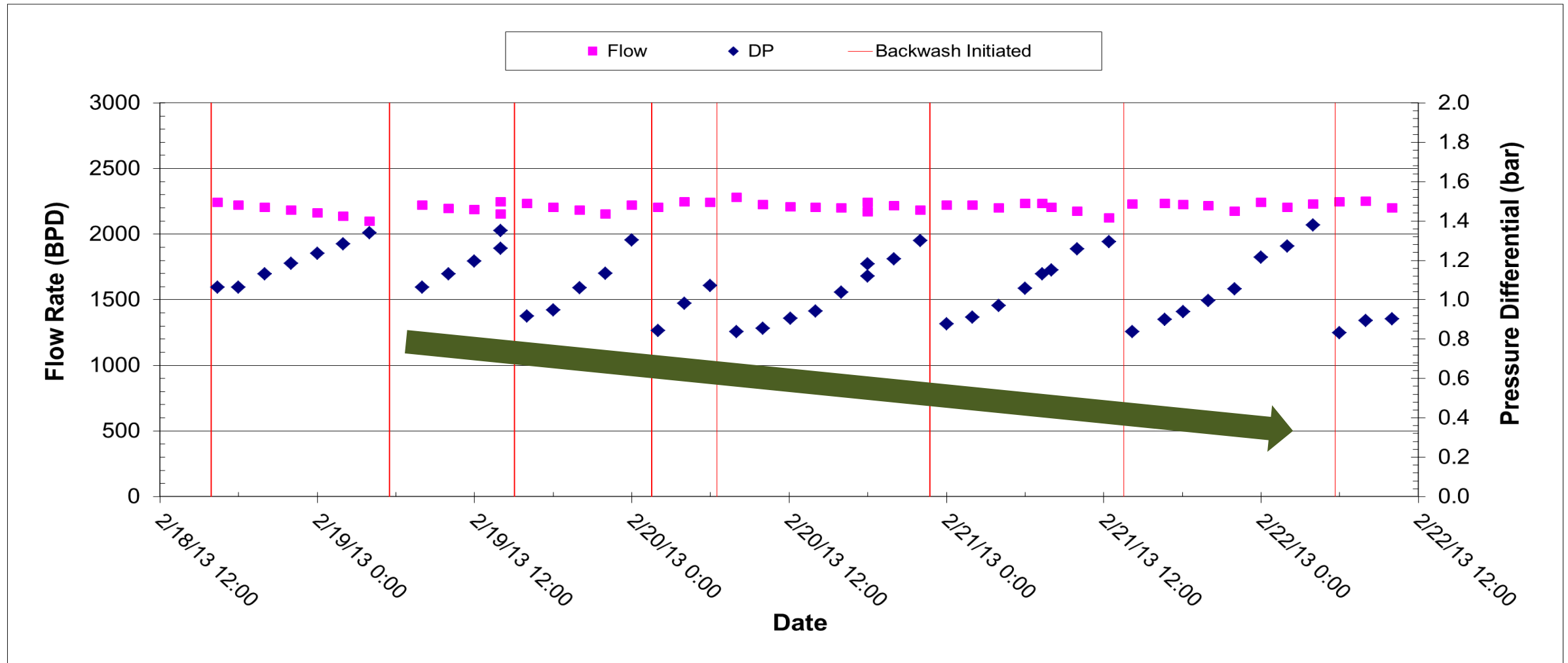
High Flow Shell Filter Pilot Study Results - **Black Walnut Media**

Test	Flux (m3/h/m2)	Max ΔP (bar)	Avg Oil ¹ IN (mg/L)	Avg Oil ¹ OUT (mg/L)	Avg TSS ² IN (mg/L)	Avg TSS ² OUT (mg/L)
Baseline Test ¹	47.5	1.4	22	<1	14	1.0
2	33	1.8	60	<1	12	0.6
3	47.5	1.8	28	<1	9	0.2
4	47.5	1.4	9	<1	9	0.9
5	66	1.7	16	<1	11	0.5
Baseline Test ⁶	47.5	1.4	16	<1	8	0.0

¹In-field analysis using TD500 D oil in water fluorescence analyzer

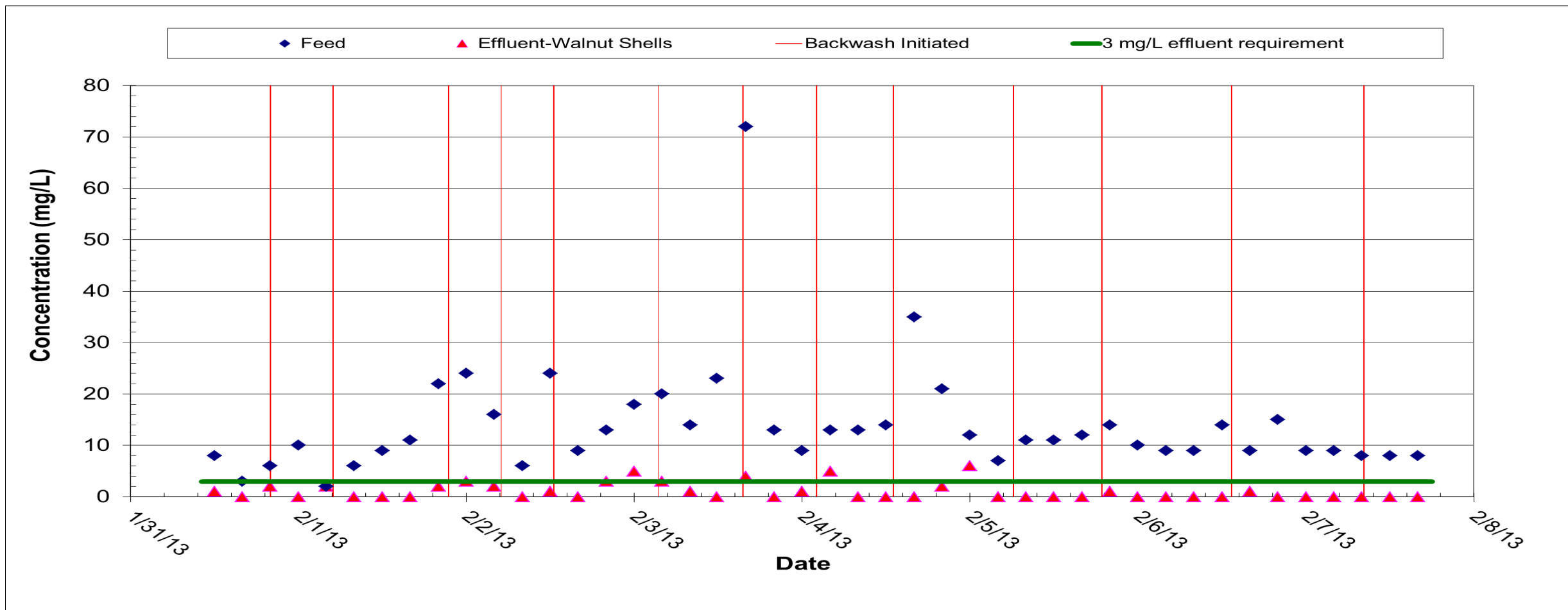
²In-field analysis using HACH method 620

High Flow Shell Filter Recovery Test - **Black Walnut Media**

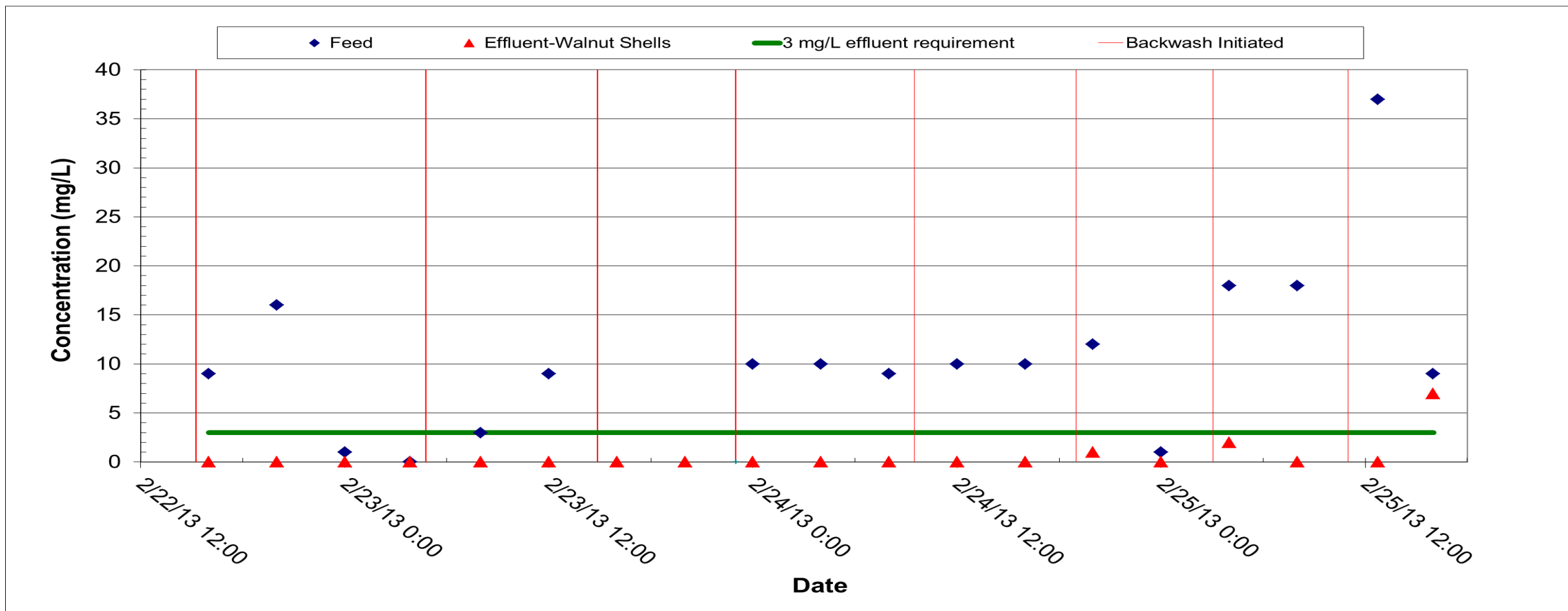


High Flow Shell Filter
47.5 m³/h/m² - **Black Walnut Media**

D&S



High Flow Shell Filter 66 m³/h/m² - **Black Walnut Media**



High Flow Shell Filter

Backwash Performance in Pilot Test - **Black Walnut Media**

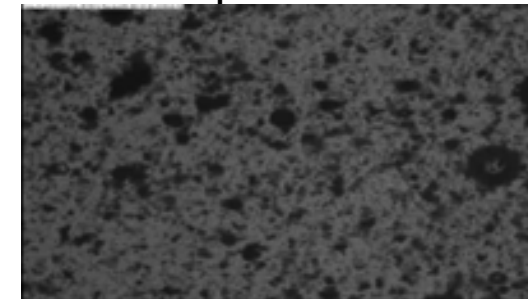
47.5 m³/h/m²

- Backwash volume 1.0-1.7%
- Pressure Differential (ΔP) set point = 1.4 bar
- Returned to ΔP of 0.8 – 0.82 bar after backwash

66 m³/h/m²

- Backwash volume 1.6-2.2%
- ΔP set point = 1.7 bar
- Returned to ΔP of 1.29 – 1.38 bar after backwash
- Backwash volume could further be reduced by reducing the purge step duration

First step of backwash

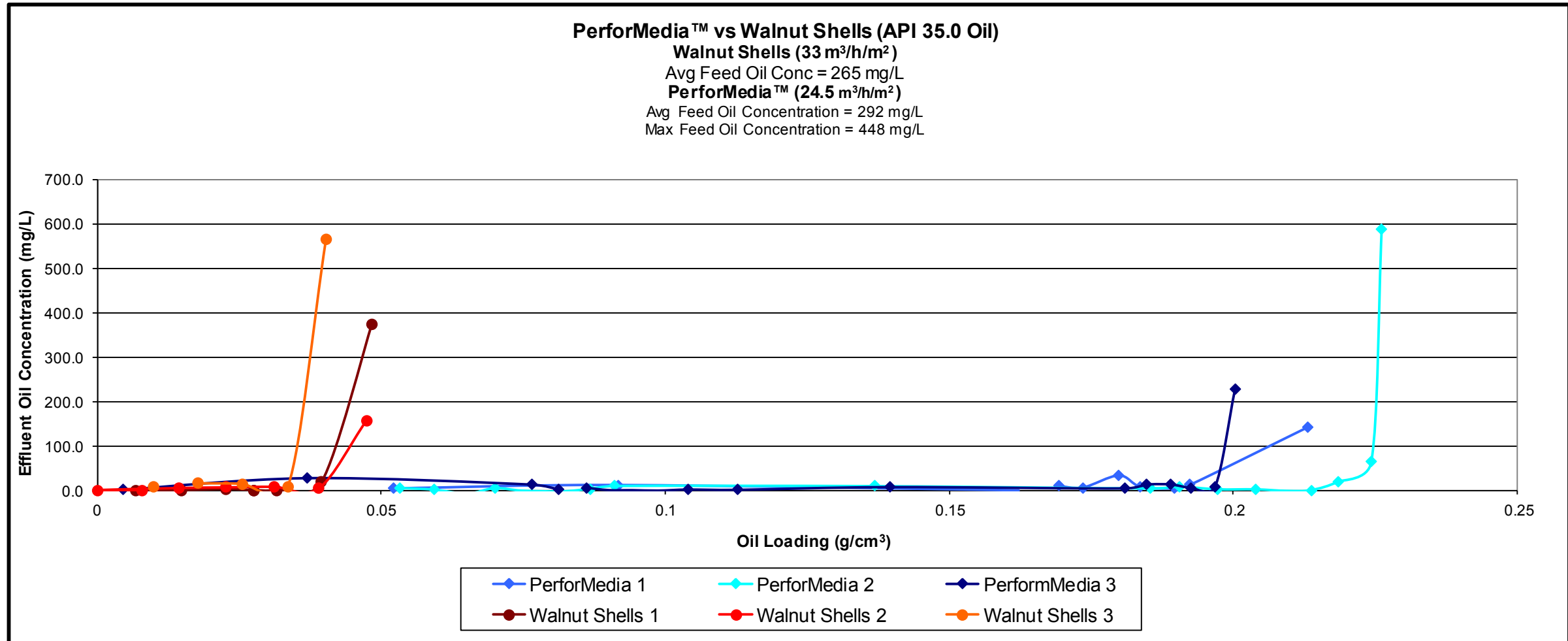


Last step of backwash



High Flow Shell Filter

PerforMedia™ Loading Capacity vs. Black Walnut Shells

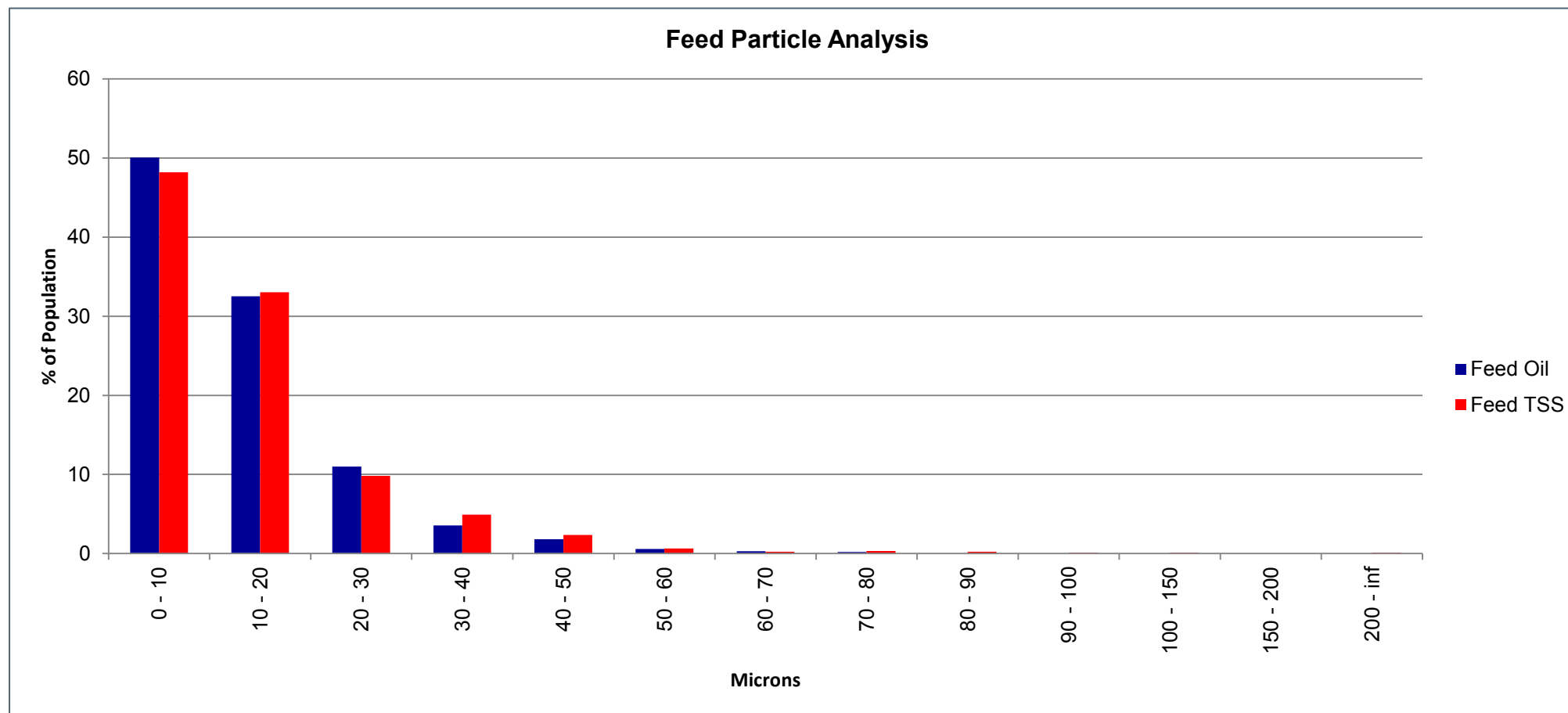


High Flow Shell Filter Pilot Test on API 11 Crude - **PerforMedia™**

- PerforMedia™ Pilot Study conducted in Columbia 2014 treated over 25,000 barrels of produced water over 16 days
- Use same pilot as for Black Walnut Shell study to prove media's ability to be backwashed with current draft tube design
- Feed to pilot unit was CPI effluent **prior to chemical addition** CPI Effluent to determine if the media can displace secondary treatment
- Feed oil averaged 375 mg/L and consisted of small oil covered solid where oil and TSS sizes ranged from 0-50 micron. Most of particles in feed were <20 micron
- **Effective at filtering at a flux rate of 12 m³/h/m² with effluent oil averaged 3.1 mg/L**

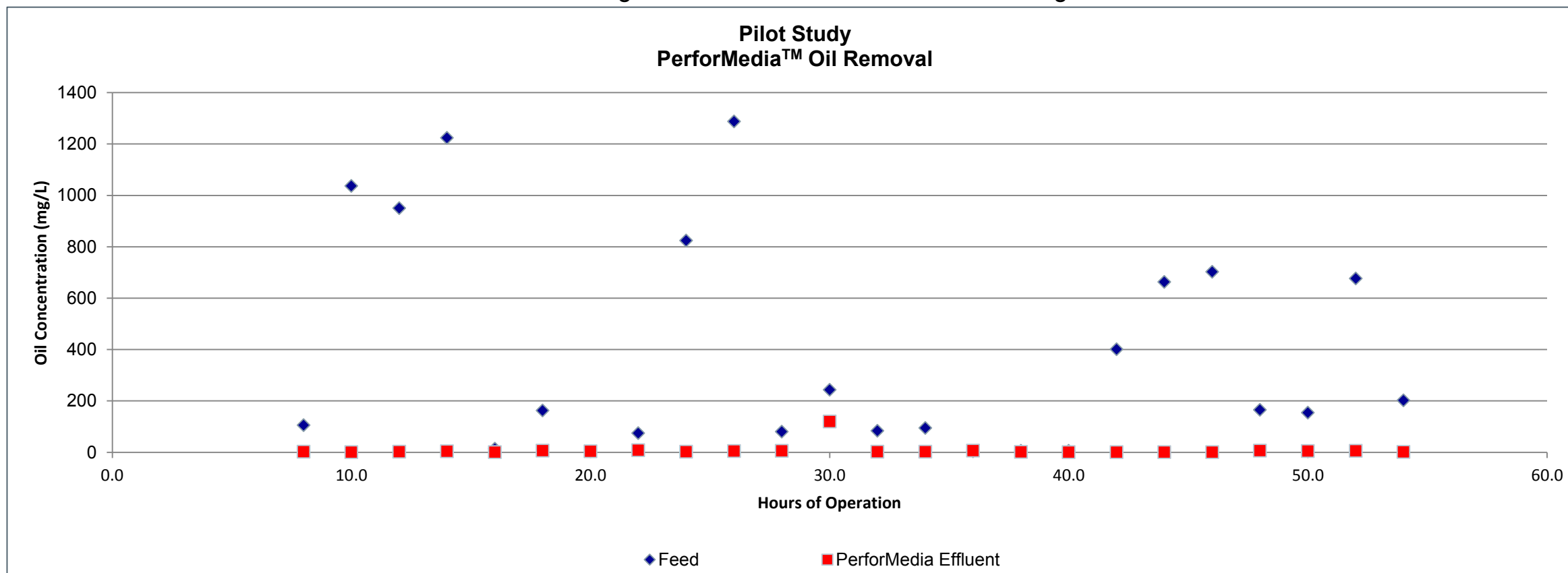


High Flow Shell Filter Pilot Study – Feed Particle Analysis - PerforMedia™



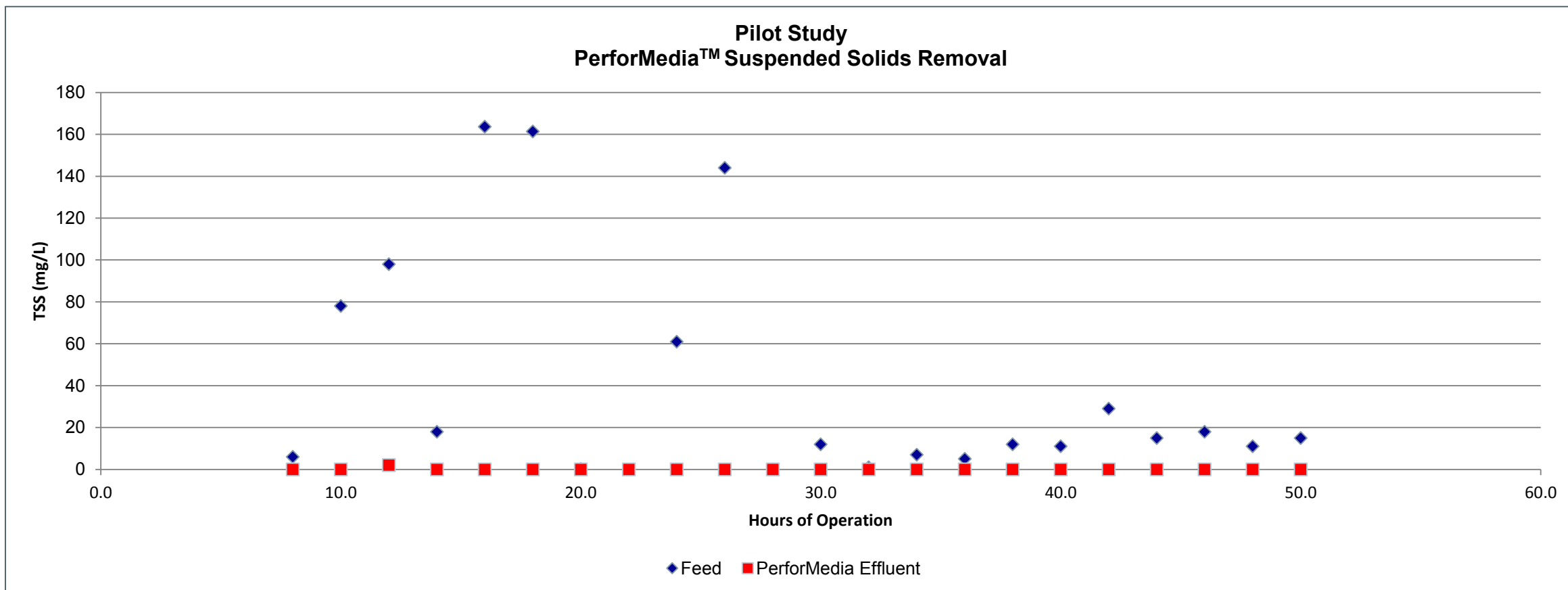
High Flow Shell Filter w/ PerforMedia™ Pilot Study – Oil Removal

Flux = 12 m³/h/m² (5 gpm/ft²)
Average Feed OiW = 375 mg/L
Maximum Feed OiW = 1288 mg/L
Average PerforMedia™ Effluent OiW = 3.1 mg/L



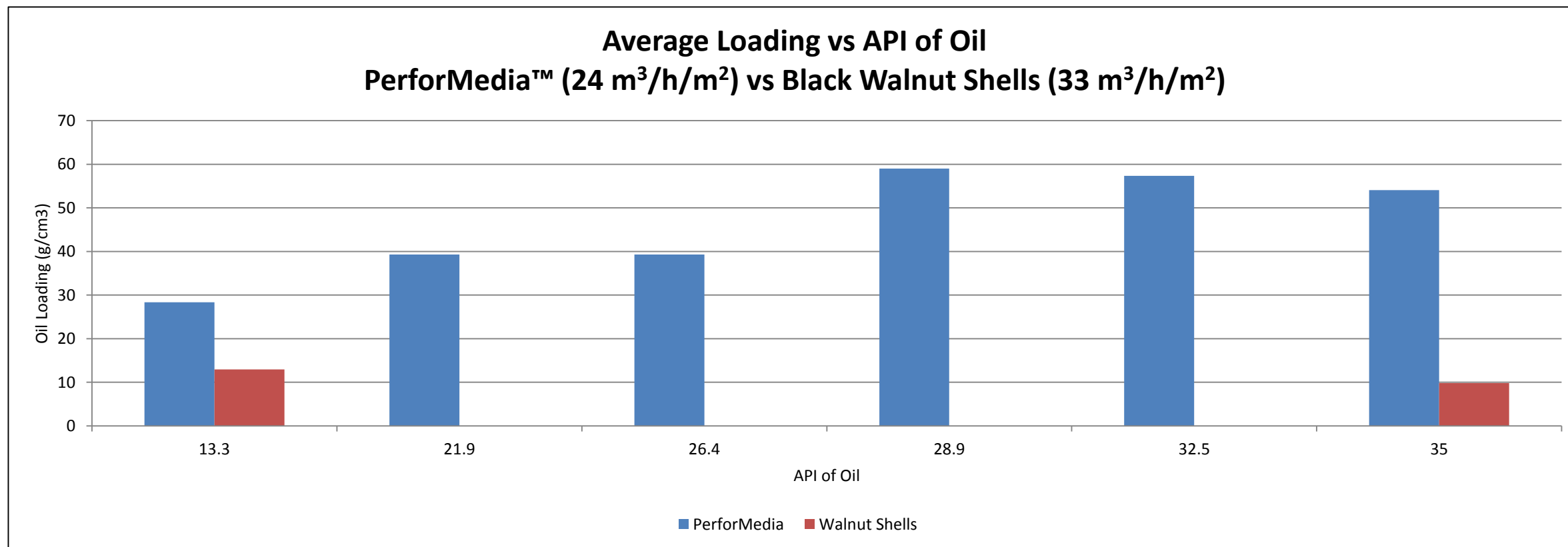
High Flow Shell Filter Pilot Study – TSS Removal - PerforMedia™

Flux = 12 m³/h/m²
Average Feed TSS = 41 mg/L
Average PerforMedia™ Effluent TSS = 0.1 mg/L



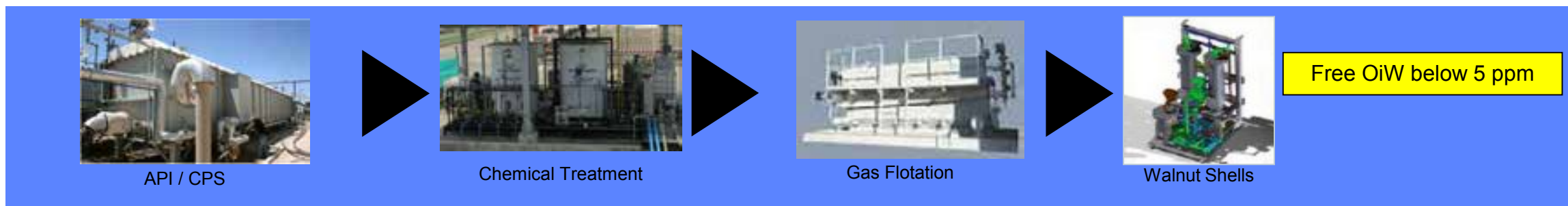
High Flow Shell Filter Loading Capacity vs API - PerforMedia™

- Trend : As API increases, the amount of oil PerforMedia™ can hold also increases
- Conclusion: Still significantly higher than walnut shells



Simplified Produced Water Treatment

Typical Produced Water Treatment Scheme



New Proposed Treatment Scheme



Conclusions

Pilot study with black walnuts

- Effective at filtering IGF Effluent at all flux rates
- Effluent averaged <1 mg/L OiW & TSS
- Double flux when compared to conventional WSF
- Internal Backwash effective at recovering ΔP
- No media degradation in hot produced water with heavy oil

Pilot Study with PerforMedia™

- Effluent oil averaged 3.1 mg/L
- Media able to load significantly more oil than black walnuts and handle high oil upset conditions
- Internal Backwash effective at recovering ΔP
- PerforMedia™ could potentially displace several upstream steps without sacrificing effluent quality

Eliminate equipment – CapEx/OpEx

Eliminate chemical consumption and costs

We are happy to answer your questions!

