

SPE 107674

A Multi-Parameter Methodology for Skin Factor Characterization: Applying Basic Statistics to Formation Damage Theory

Presented by

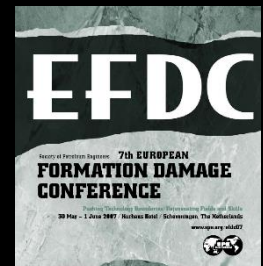
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7th SPE EFDC, The Hague, May 31st , 2007



Background

Oil Producer

- Sandstone Reservoirs
- Natural Production & Miscible Gas Injection
- Active Tectonic Environment
- Cemented & Perforated Liner (~ 70% Hydraulically Fracced)

- BHT ~ 265 degF
- Initial ResP ~ 6200 psi
- $4200 < P_{sat} < 5200$ psi

- $38 < API < 42$

> 50000 scf/bbl GOR

Gas Injector

~ 70% CH₄
~ 5% CO₂

M

B

G

Retrograde Gas Condensate

Compositional Fluids
Behavior

Nat Fracs

Volatile Oil

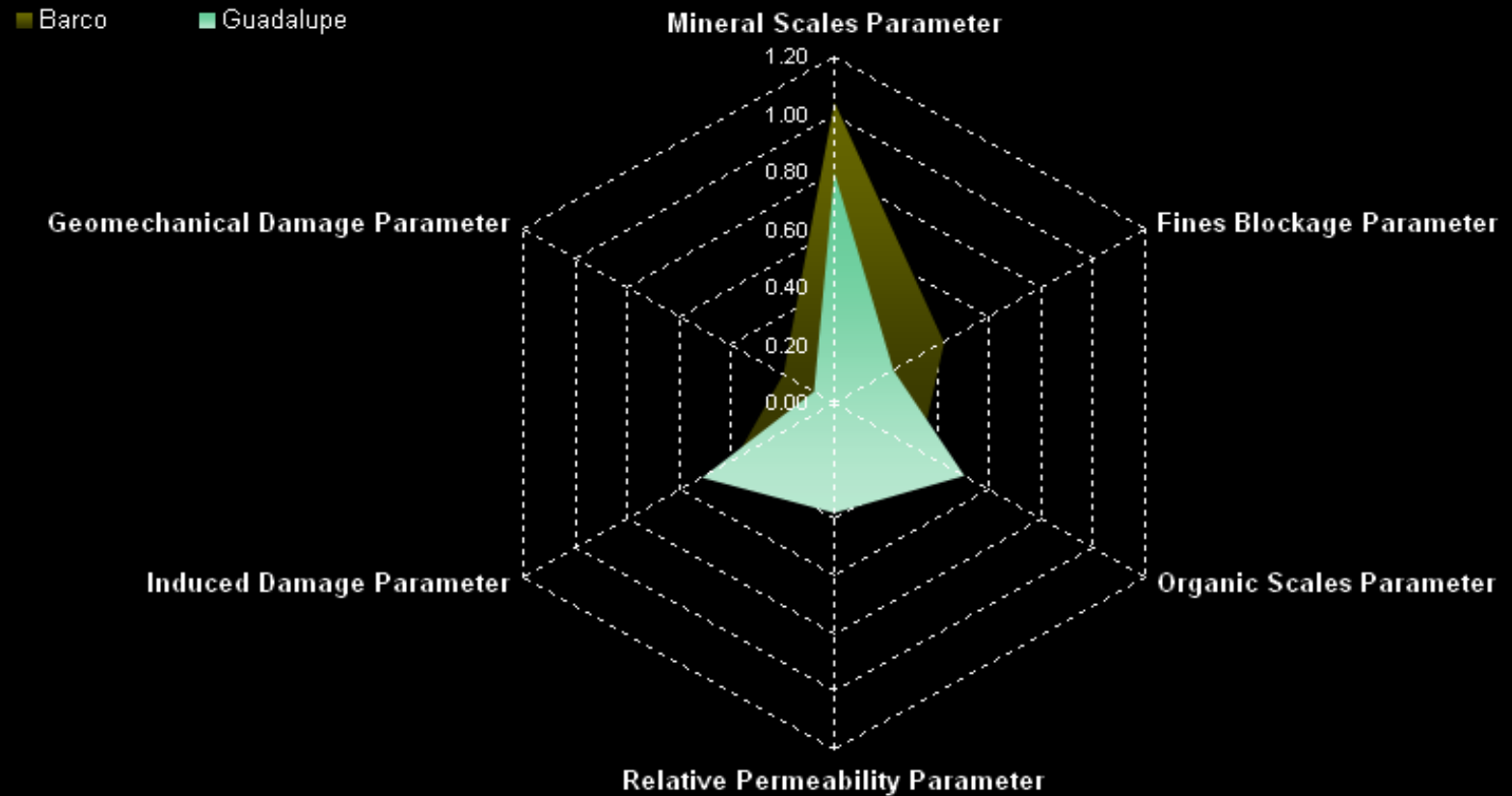
< 3000 scf/bbl GOR

- Different sources of water

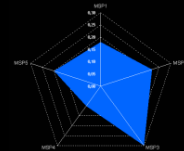
The Environment

Description of the Method

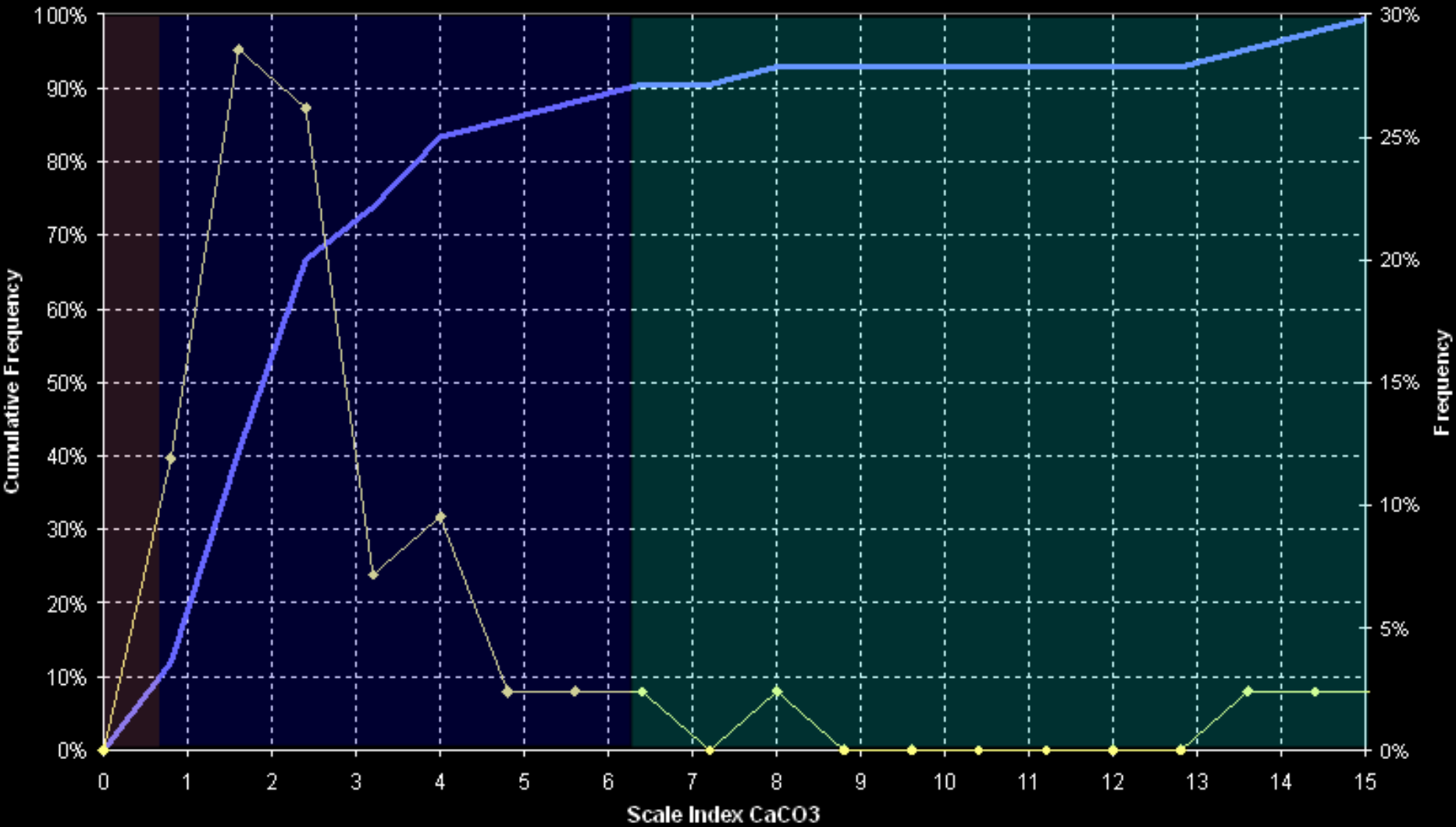
Skin Characterization Diagram_Cup Q6_Aug2007



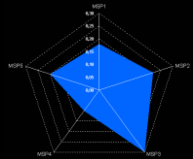
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Scale Index CaCO3 - Cumulative Frequency



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1 Mineral Scaling Parameter, MSP

MSP1_Scale Index of CaCO_3

MSP2_Scale Index of BaSO_4

MSP3_Scale Index Iron Scales

MSP4_Calcium concentration on back flowed samples

MSP5_Barium concentration on back flowed samples

P90 = 6.2; **P50 = 1.8**; P10 = 0.6. Parameter = 15

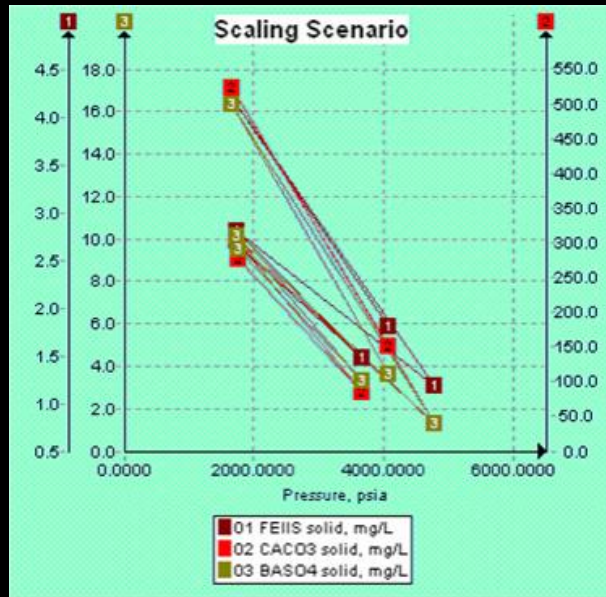
P90 = 5.3; **P50 = 1.7**; P10 = 0.7. Parameter = 12

P90 = 4.0; P50 = 0.10; P10 = 0.05. Parameter = 26

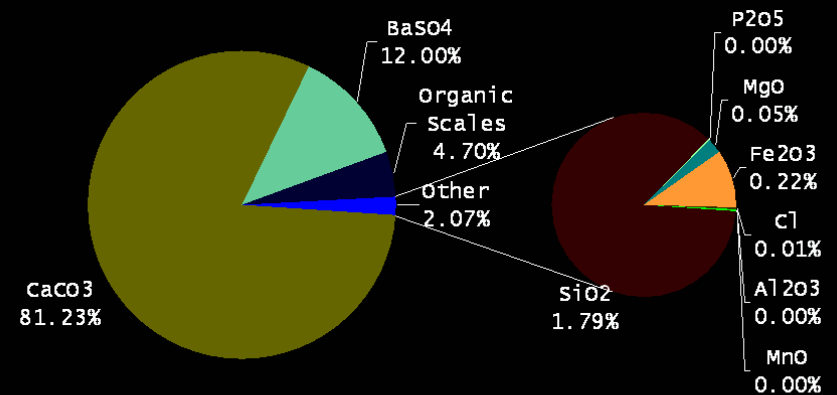
P90 = 2200 ppm; **P50 = 1100 ppm**; P10 = 500 ppm. Parameter = 4400 ppm.

P90 = 26 ppm; **P50 = 8.0 ppm**; P10 = 5.2 ppm. Parameter = 46 ppm.

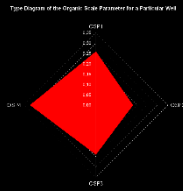
MSD ~ Scale Mass, Scale Tendency*



COMPOSITION OF A RECOVERED SCALE SAMPLE



Norm: CHS



2 Organic Scaling Parameter, OSP

OSP1_CII factor

OSP2_Chemical alterations factor

OSP3_Compositional factor

OSP4_Res P

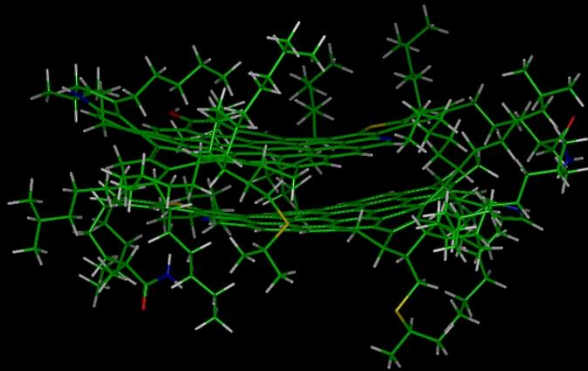
P90 = 6.5; **P50 = 4.0**; P10 = 2.0. Parameter = 10.

P10 and P50 = 0; P90 = 300 bbl. Parameter = 550 bbl.

P90 = 176K MMSCF; P50 = 54K MMSCF; P10 = 8K MMSCF. Parameter = 260K MMSCF

P90 = 3300 d; **P50 = 2800 d**; P10 = 2300 d. Parameter = 4400 d.

OSD ~ (Asphaltene Stability) ⁻¹

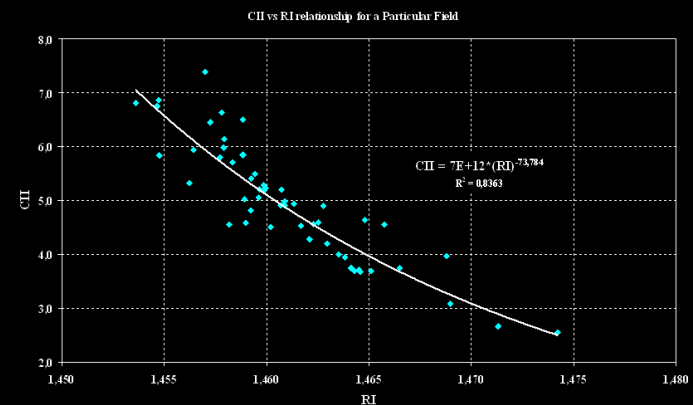


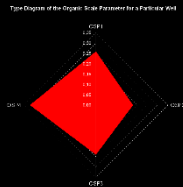
As stability ~ $\frac{P, \text{ Density}}{[\text{CH1}], \Delta \text{pH}}$

But.....precipitation does not necessarily implies deposition !

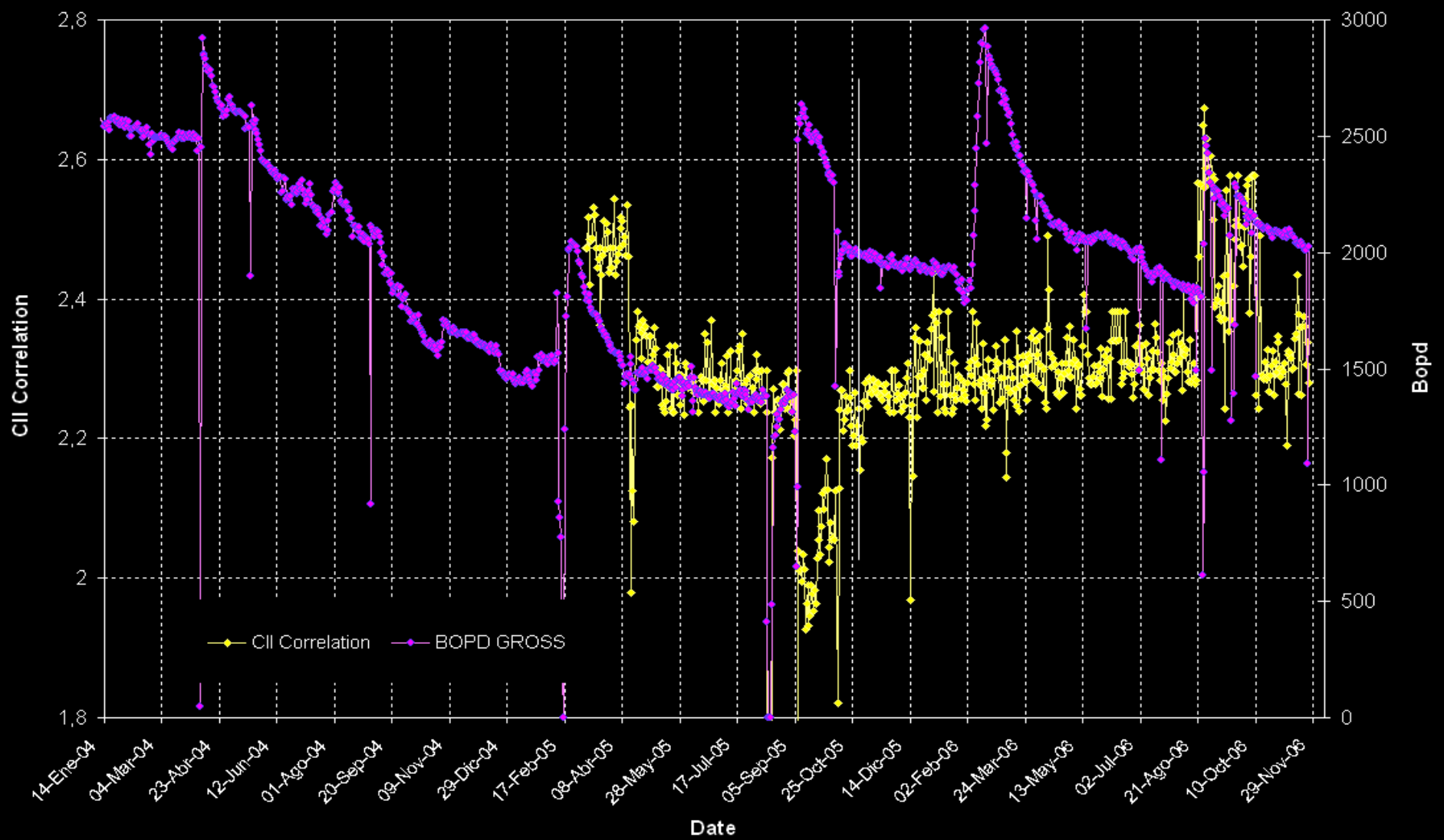
$$\text{CII} = (\text{Sat} + \text{As}) / (\text{Res} + \text{Ar})$$

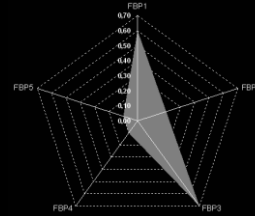
Norm: Petrophysics, CHS or Inhibition





Tracking of CII based on API / CII Correlation





3 Fines Blockage Parameter, FBP

FBP1_Aluminum Concentration on Produced Water

FBP2_Silicon Concentration on Produced Water

FBP3_Critical radius factor

FBP4_Mineralogical factor

FBP5_Crushed proppant factor

P90 = 0.62 ppm; P50 = 0.3 ppm; P10 = 0.05 ppm. Parameter = 2.0 ppm

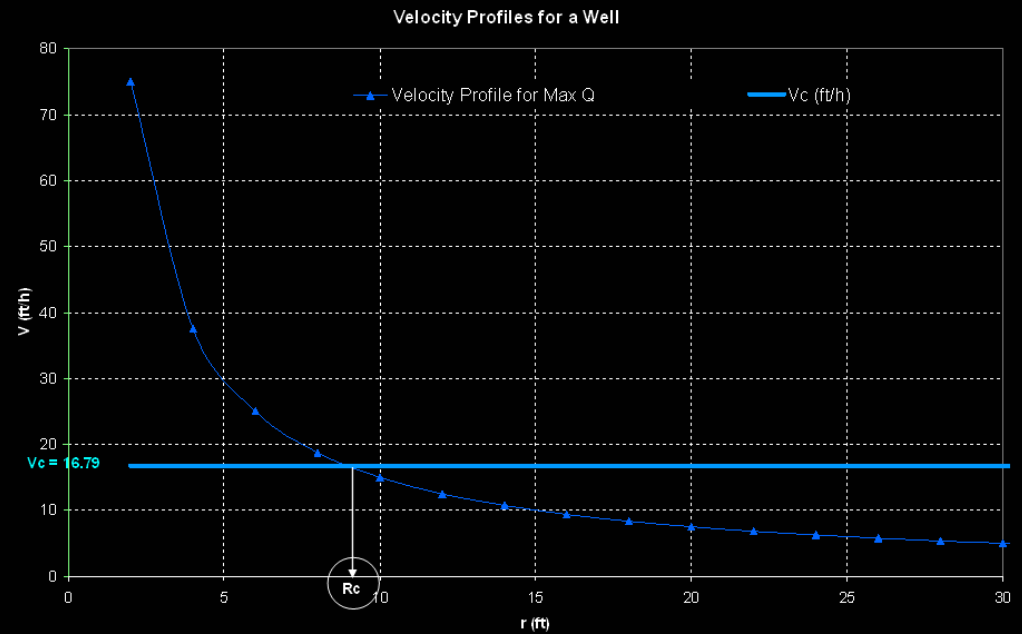
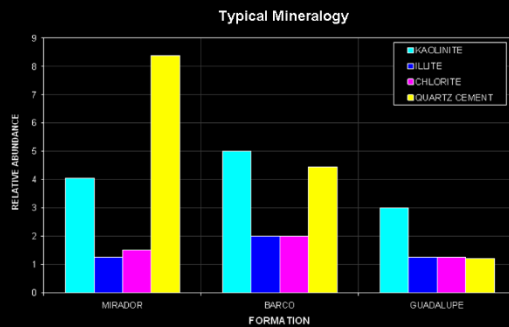
P90 = 38.5 ppm; **P50 = 20 ppm**; P10 = 6.0 ppm. Parameter = 50 ppm.

P90 = 10 ft; P50 = 3 ft; P10 = 0 ft. Parameter = 27 ft

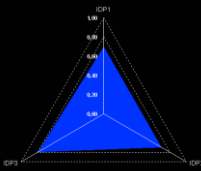
Barco = 1.0; Mirador = 0.75; Guadalupe = 0.5

P90 = 14000 lb; P50 = 0 lb; P10 = 0 lb. Parameter = 27000 lb.

FD ~ Clays, V, Crushing



Norm: Petrophysics



4 Induced Damage Parameter, IDP

IDP1_Mud damage factor

IDP2_Polymer damage factor

IDP3_Invasion fluids factor

P90 = 720 ft; P50 = 340 ft; P10 = 110 ft. Parameter = 1200 ft.

P90 = 2100 lb; P50 = 490 lb; P10 = 240 lb. Parameter = 3400 lb.

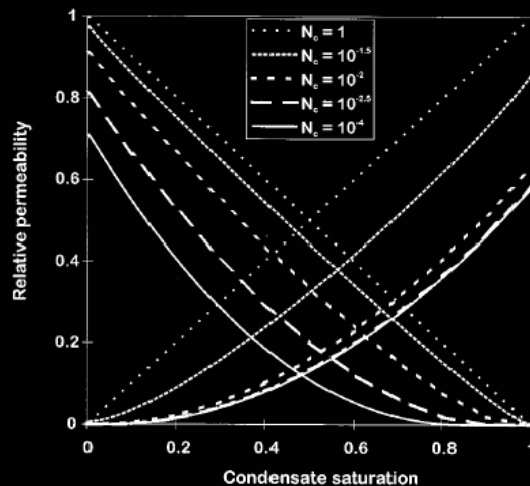
P90 = 3700 bbl; **P50 = 1700 bbl**; P10 = 100 bbl. Parameter = 5600 bbl.

ID ~ Mud, Polymer & Fluids Invasion*

Vol of Mud Dynamic Losses

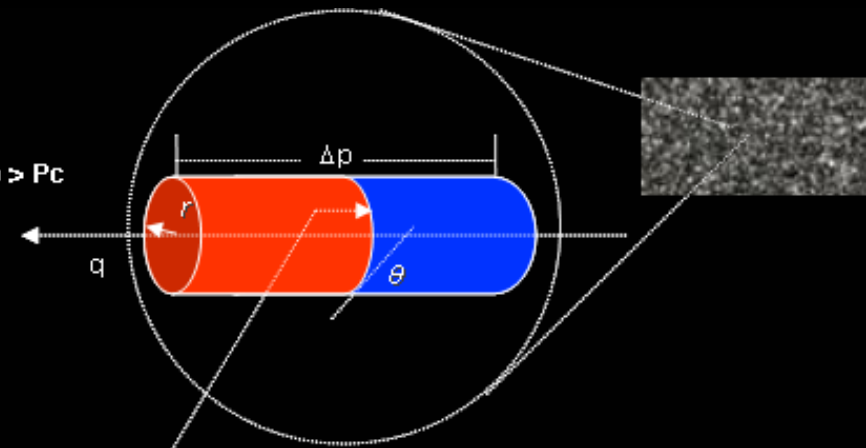
$Bbl = 0.145 * t \text{ (days)} * netH \text{ (ft)}$

10 days, 150 ft = 215 bbl



$$q = f(\Delta p)$$

$$q > 0 \text{ if } \Delta p > P_c$$



$$P_c = \frac{2\sigma \cos \theta}{r}$$

$$N_{ca} = uV/g\sigma$$

$$\sigma = f(\text{fluids in contact})$$

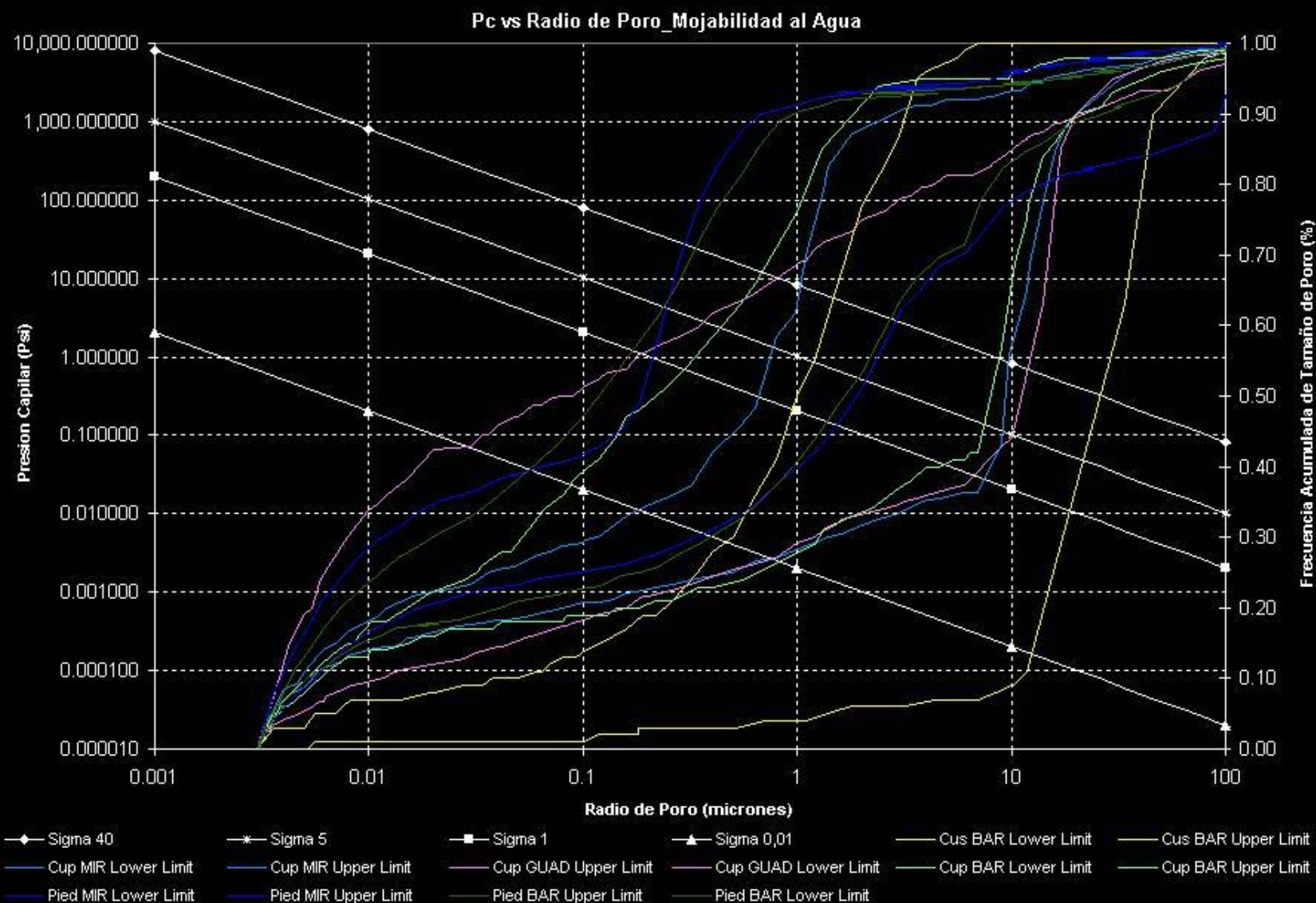
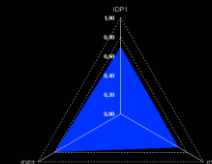
$$\theta = f(\text{wettability})$$

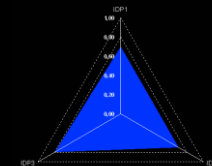
$$r = f(\text{porosity, psd})$$

Norm: Petrophysics, CHS, Velocity

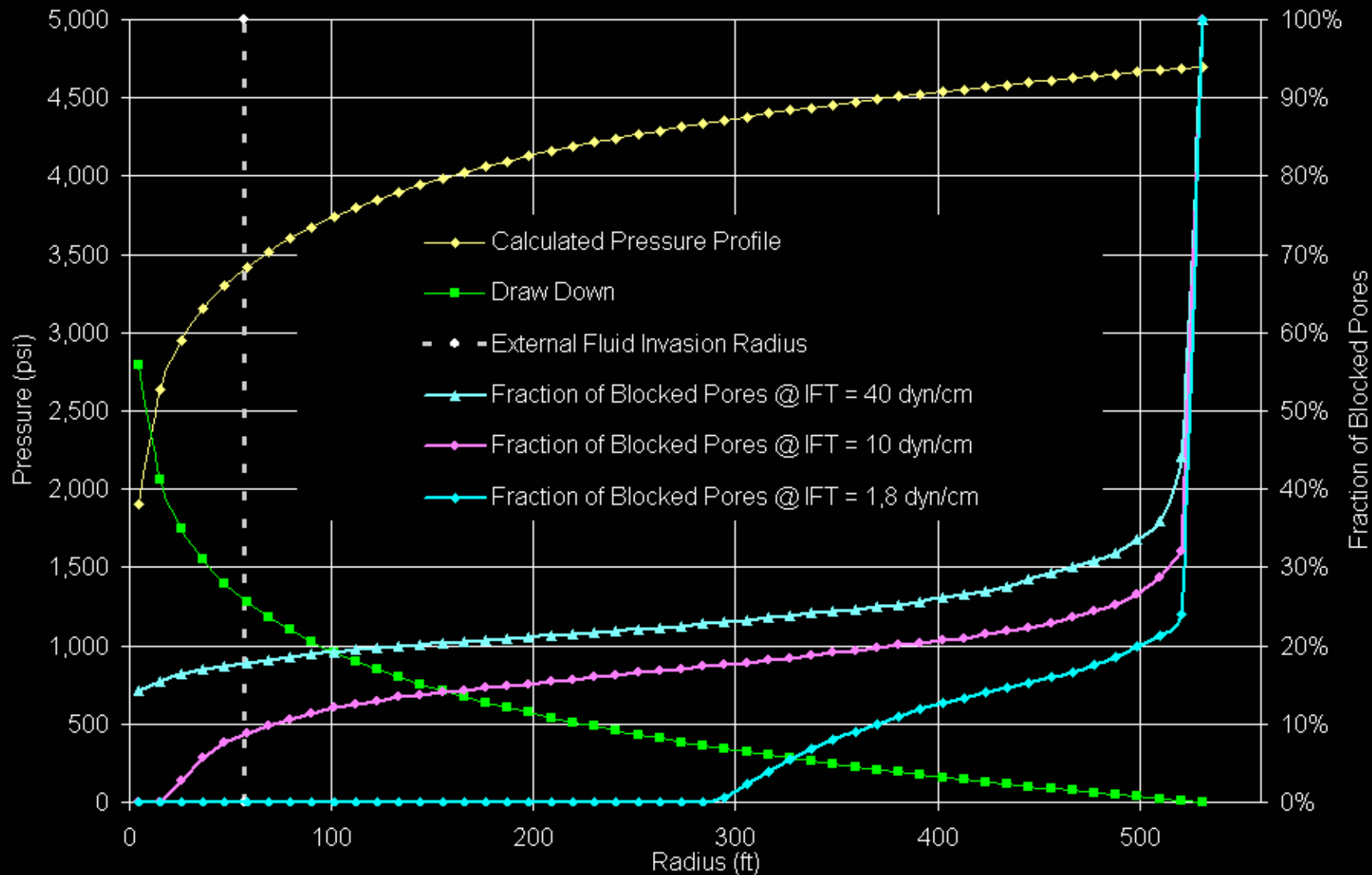
*QAQC practices preventing sludge, emulsions and clay destabilization

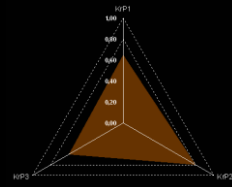
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SCHEMATICS OF FLUID BLOCKAGE ESTIMATED IMPACT





5 Relative Permeability Parameter, KrP

KrP1_ Reservoir pressure

KrP2_Delta pressure from saturation pressure

KrP3_Water Intrusion factor

P90 = 3300 d; P50 = 2800 d; P10 = 2300 d. Parameter = 4400 d.

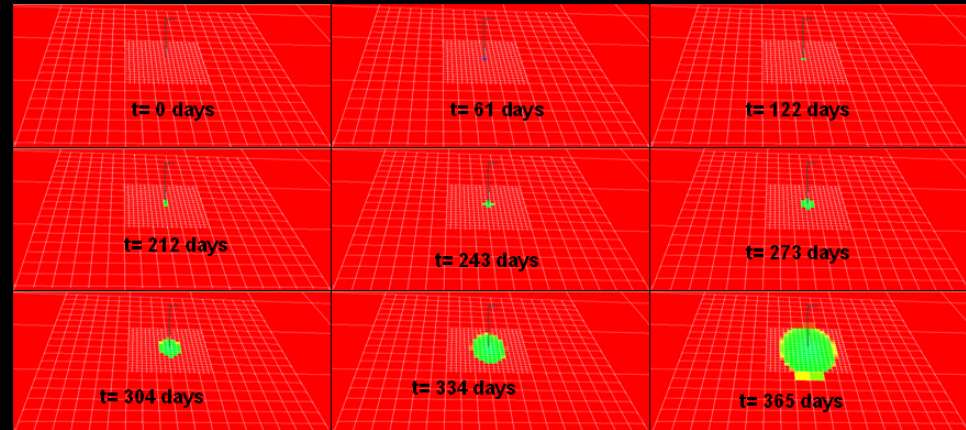
P90 = 1600 psi; **P50 = 950 psi**; P10 = 520 psi. Parameter = 1880 psi.

P90 = 3 MM bbl; P50 = 0.5 MM bbl; P10 = 0.2 MM bbl. Parameter = 20 MM bbl.

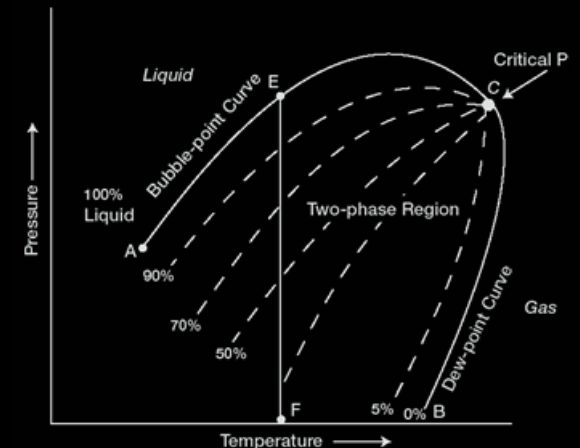
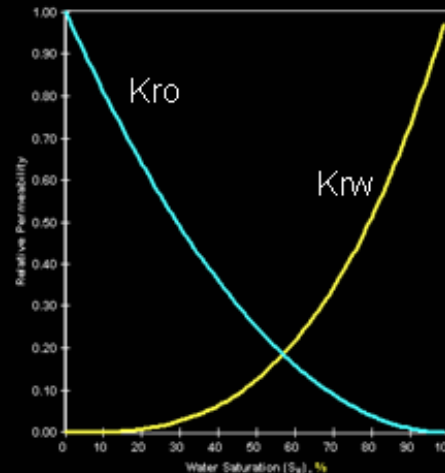
KrD ~ Phase saturations

$$K_o \sim \frac{S_o}{S_g, S_w}$$

$$K_g \sim \frac{S_g}{S_o, S_w}$$



Norm: CHS, Velocity,
Petrophysics





5 Geomechanical Damage Parameter, GDP

GDP1_Fraction of Net Pay Exhibiting Natural Fractures

GDP2_Drawdown Factor

GDP3_kH from logs / kH from PBU Relationship

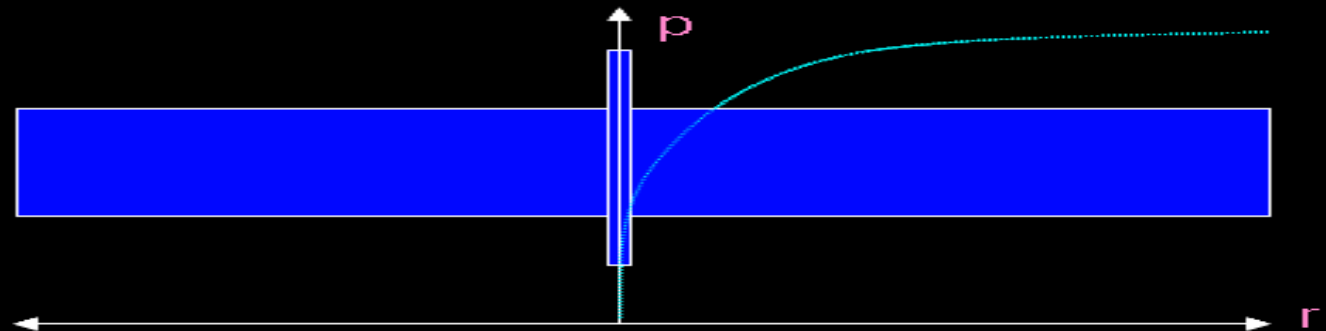
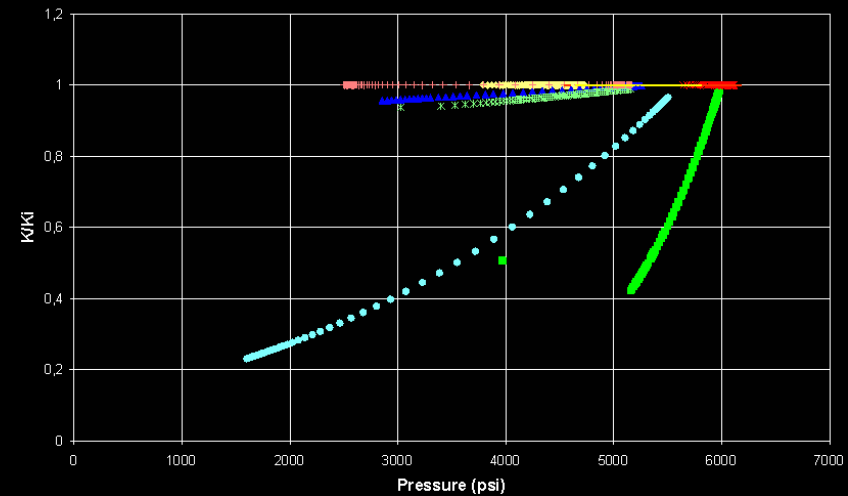
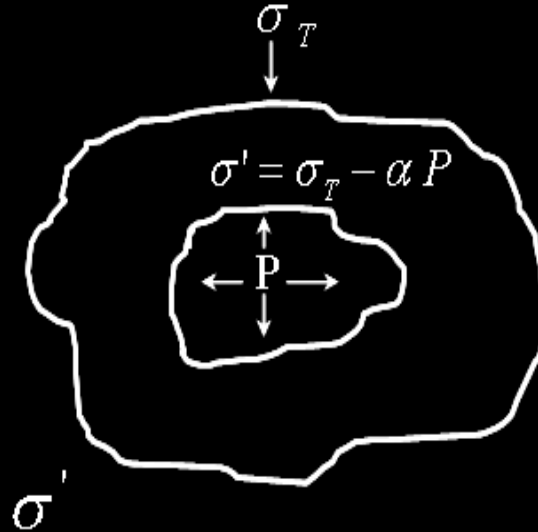
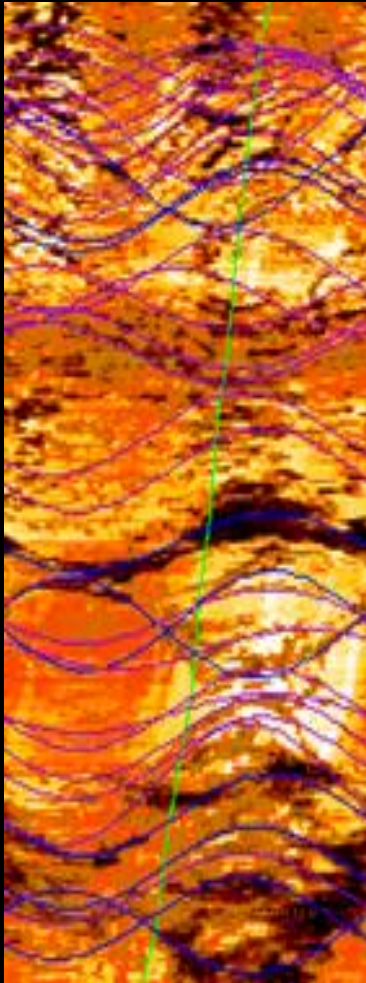
GDP4_Perm permeability Module Factor

P90 = 0.8; P50 = 0.3; P10 = 0.1

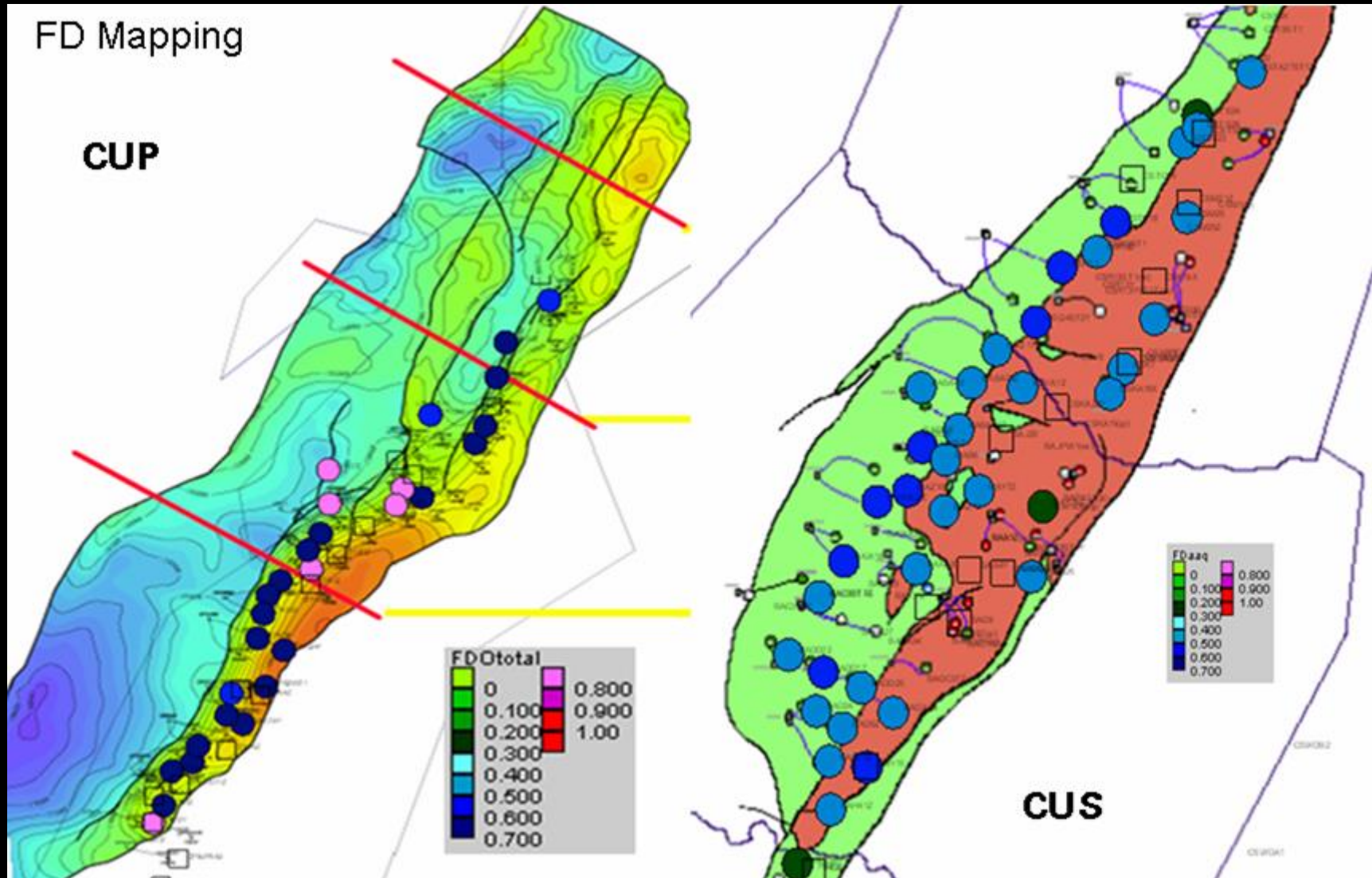
P90 = 1200 psi; P50 = 3000 psi; P10 = 5900 psi

P90 = 1; P50 = 3; P10 = 20

P90 = 0.95; P50 = 0.3; P10 = 0.1



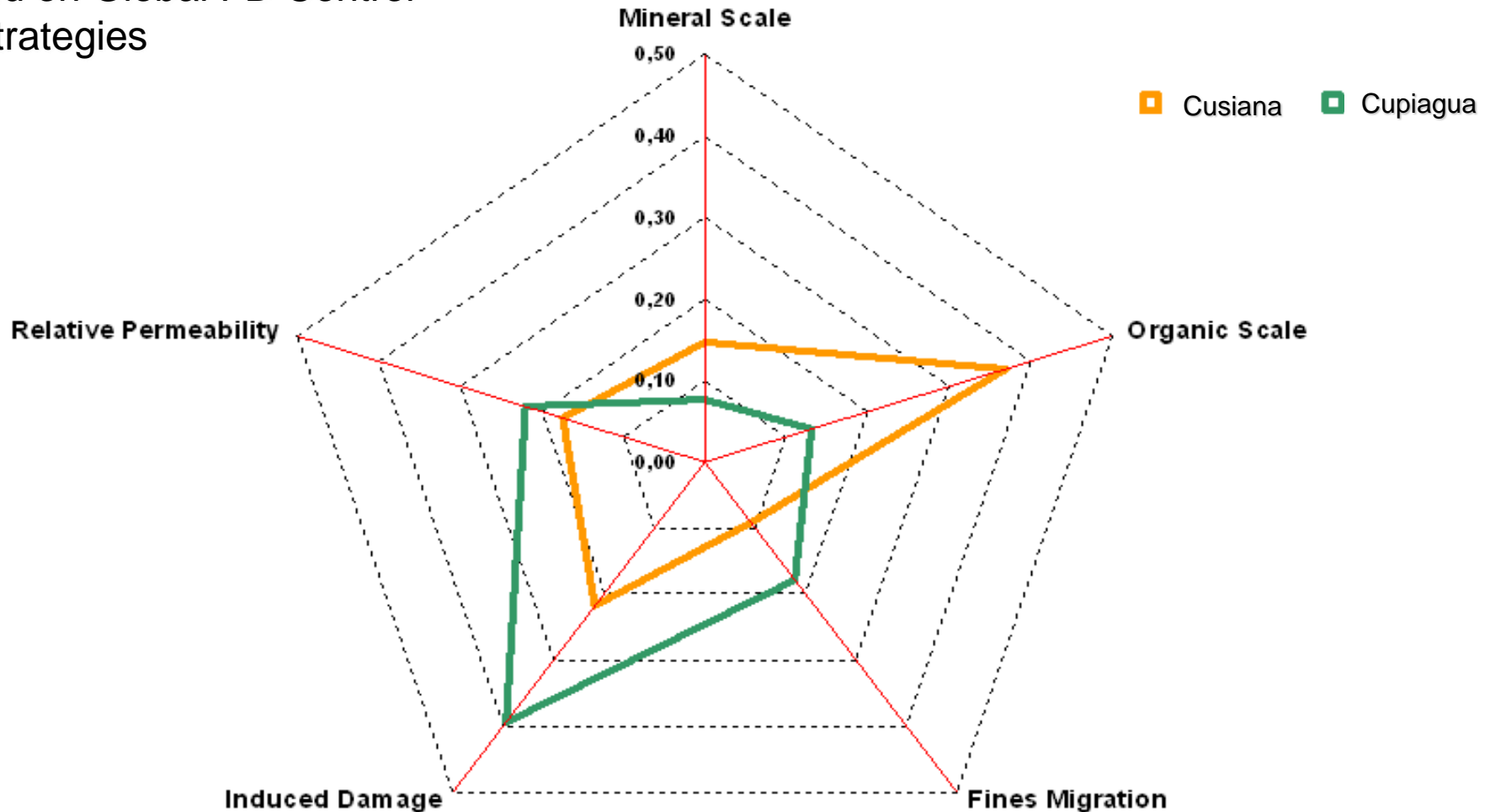
OUTPUTS AND APPLICATIONS



OUTPUTS AND APPLICATIONS

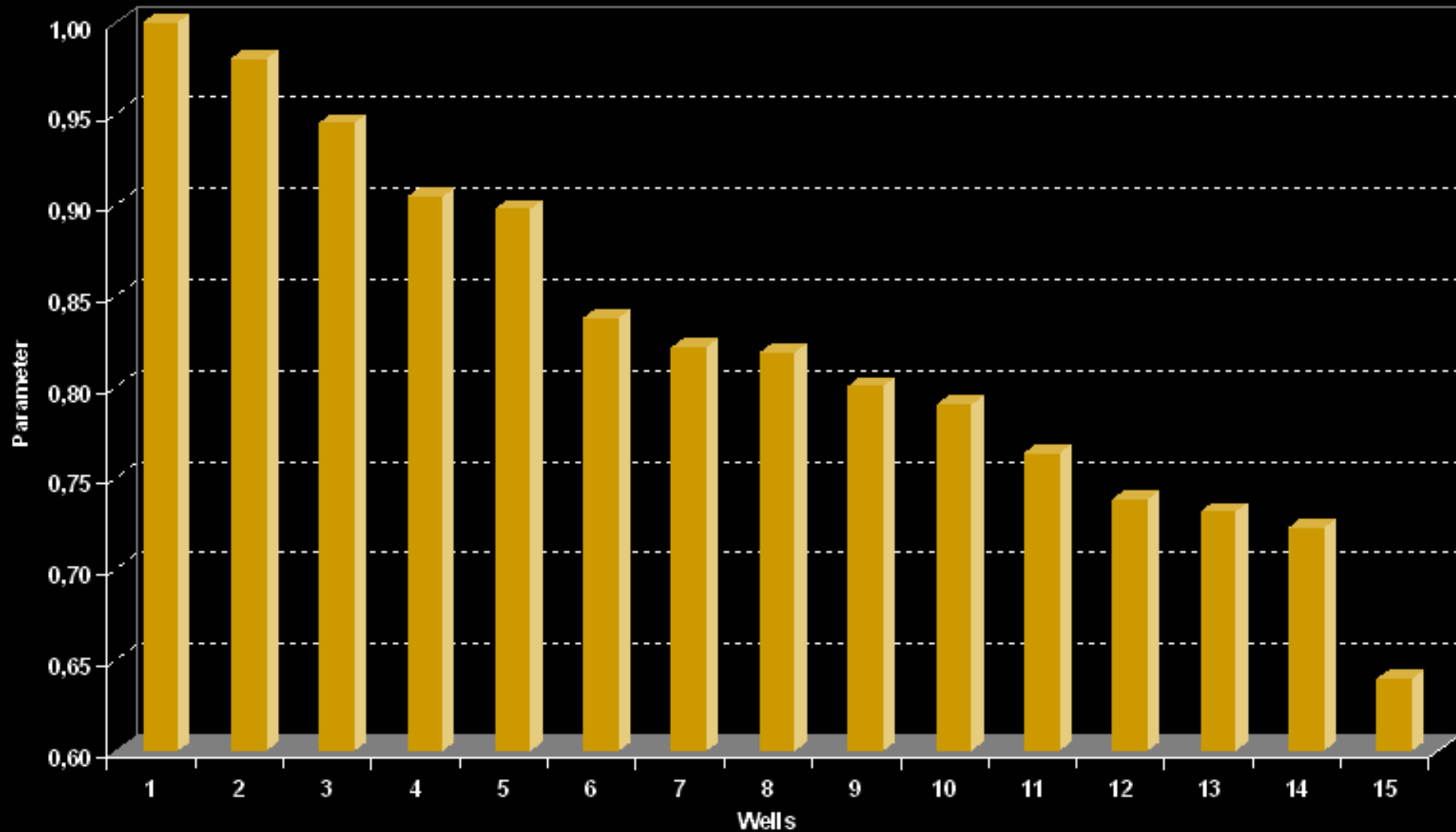
Average Skin Parameters per Field @ Jan 2007

Aid on Global FD Control Strategies



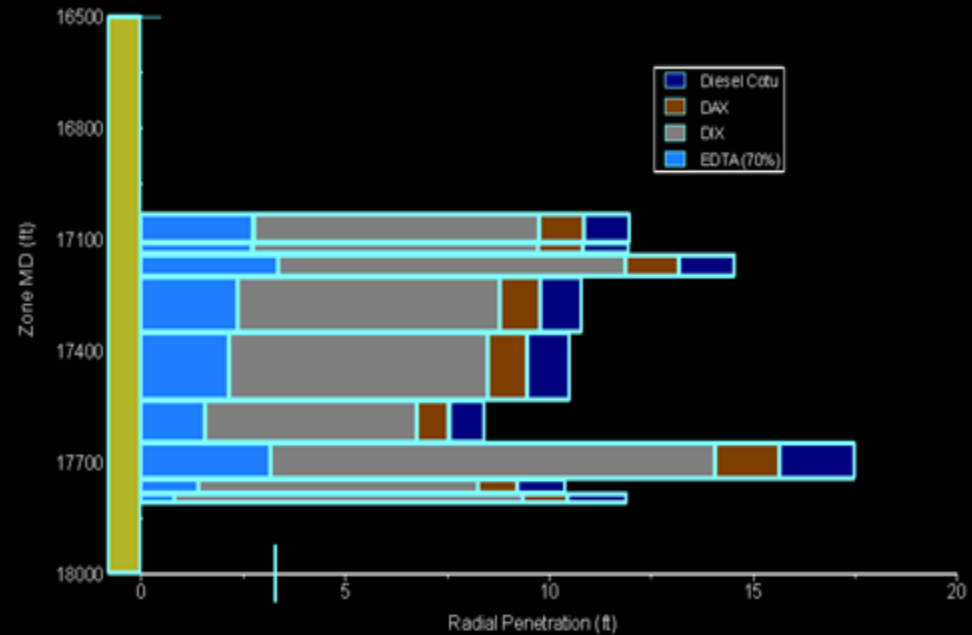
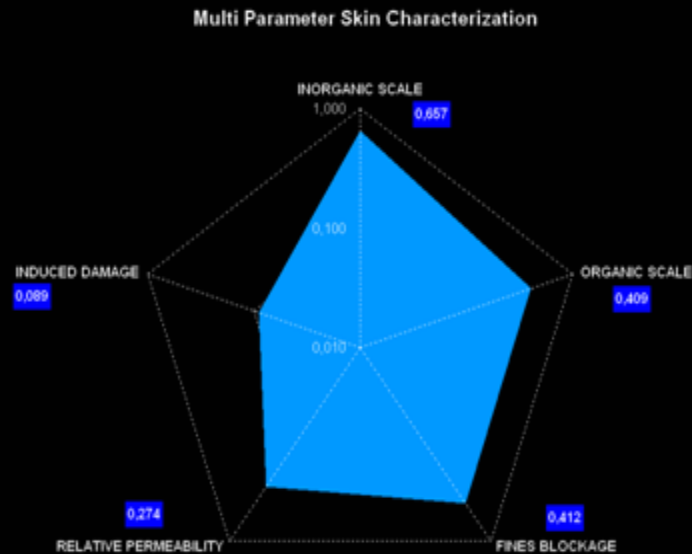
OUTPUTS AND APPLICATIONS

Ranking of Wells according to the Organic Scale Parameter, OSP



OUTPUTS AND APPLICATIONS

Improved CHS Design



Thanks

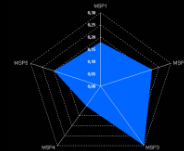
Questions

Back up

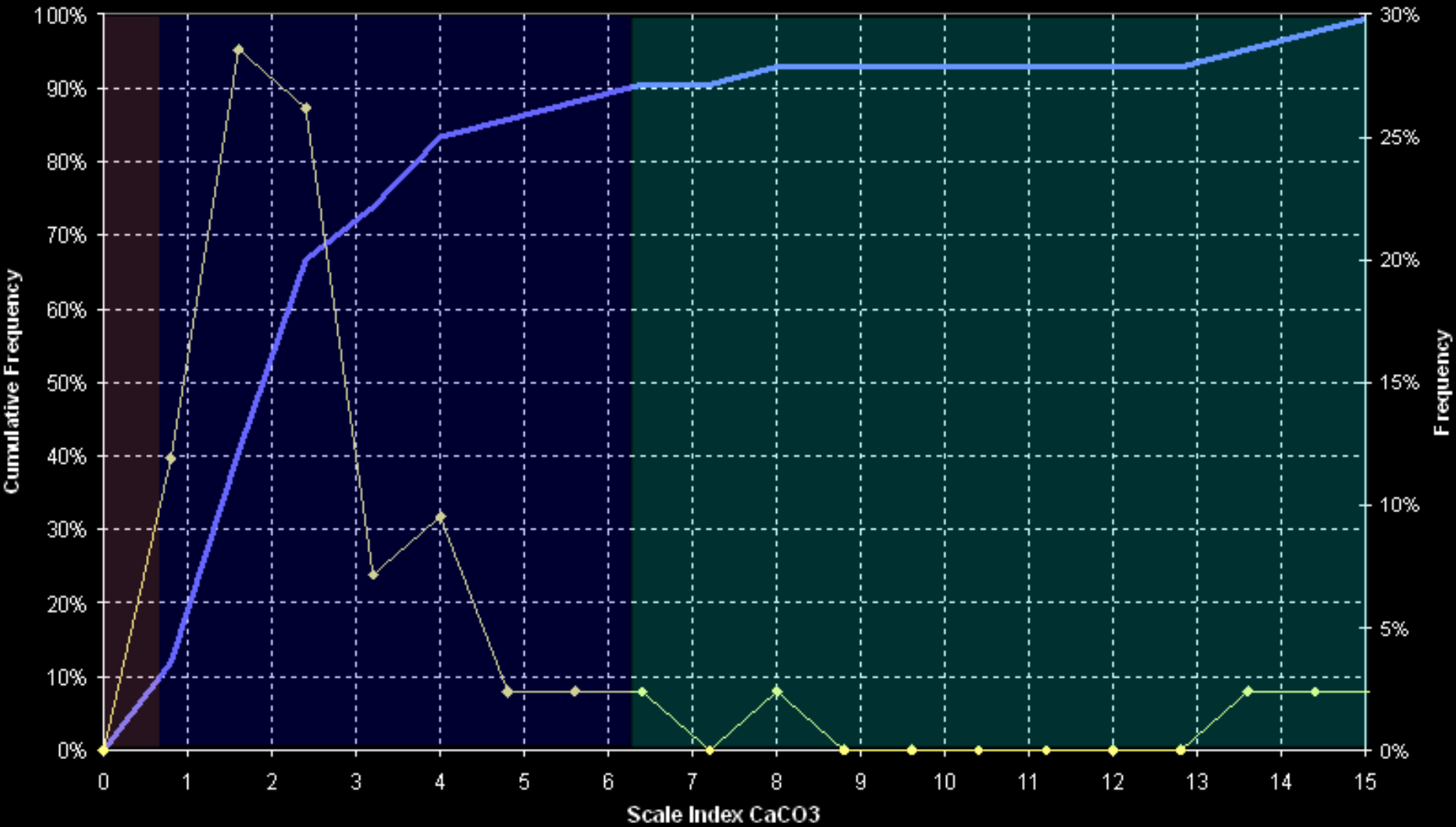


Backup your data
to the cloud

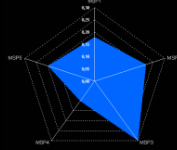
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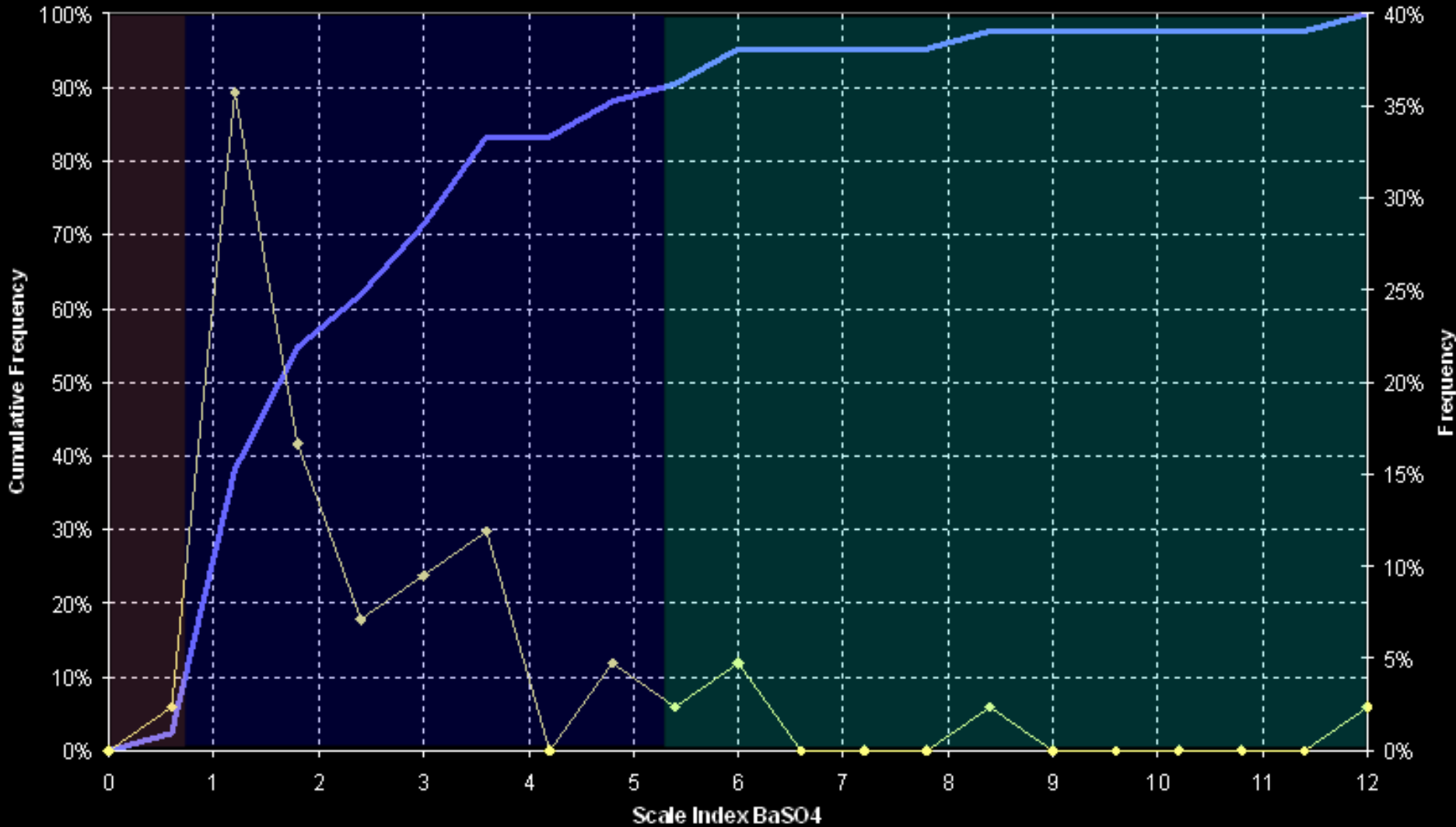
Scale Index CaCO3 - Cumulative Frequency

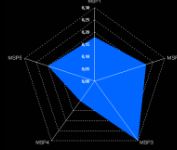


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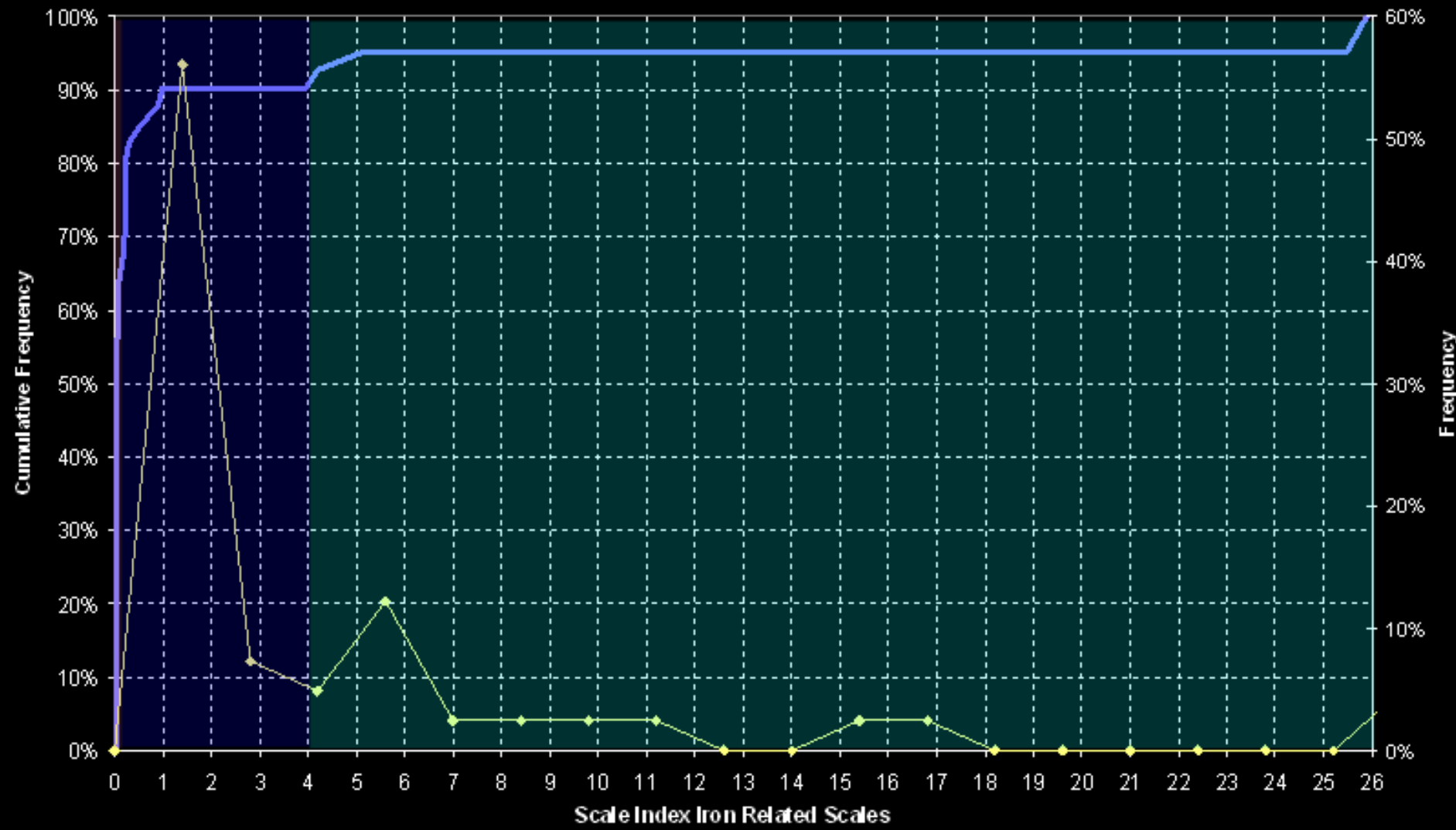


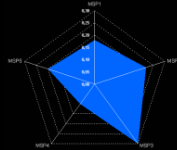
Scale Index BaSO4 - Cumulative Frequency



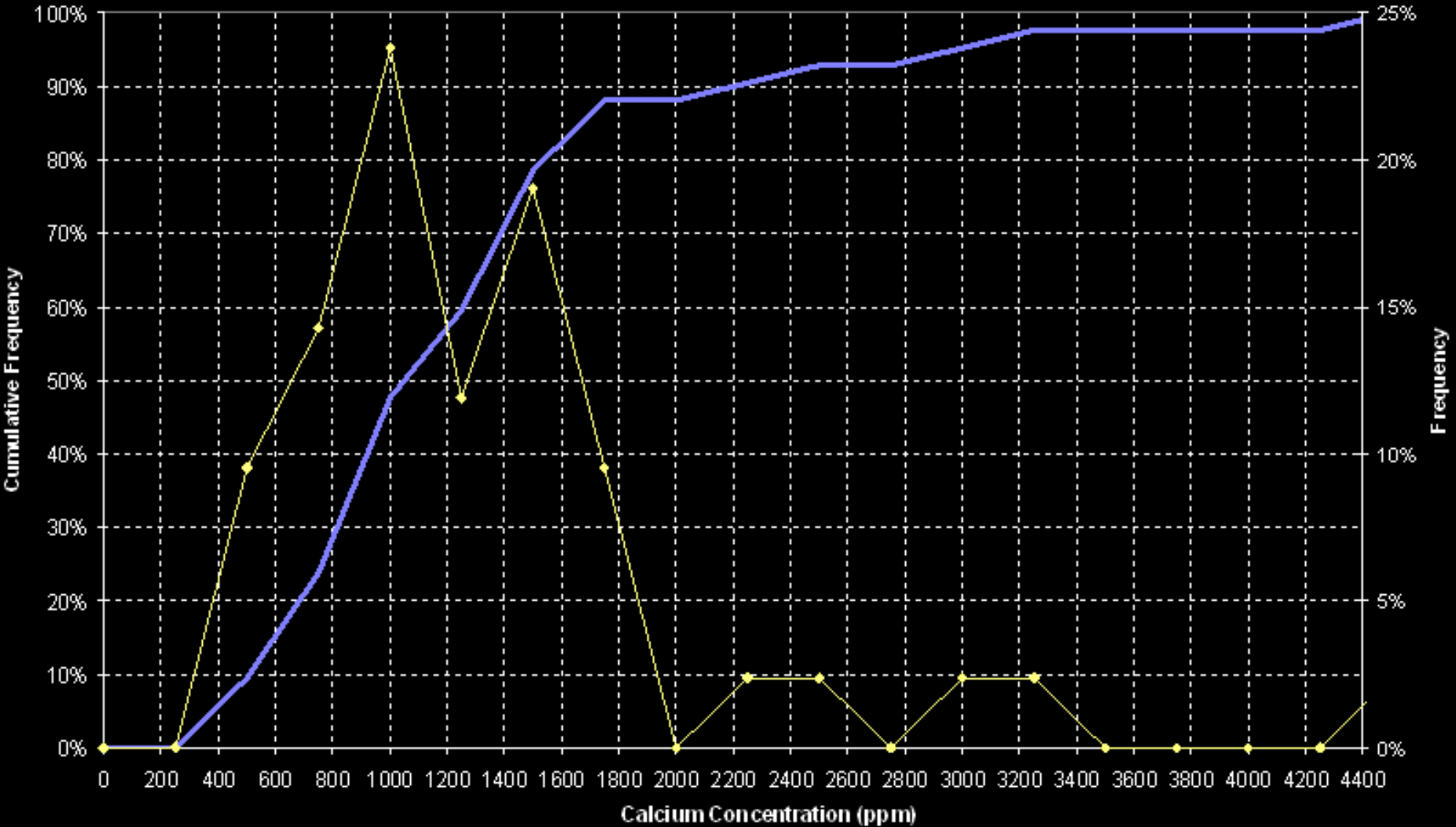


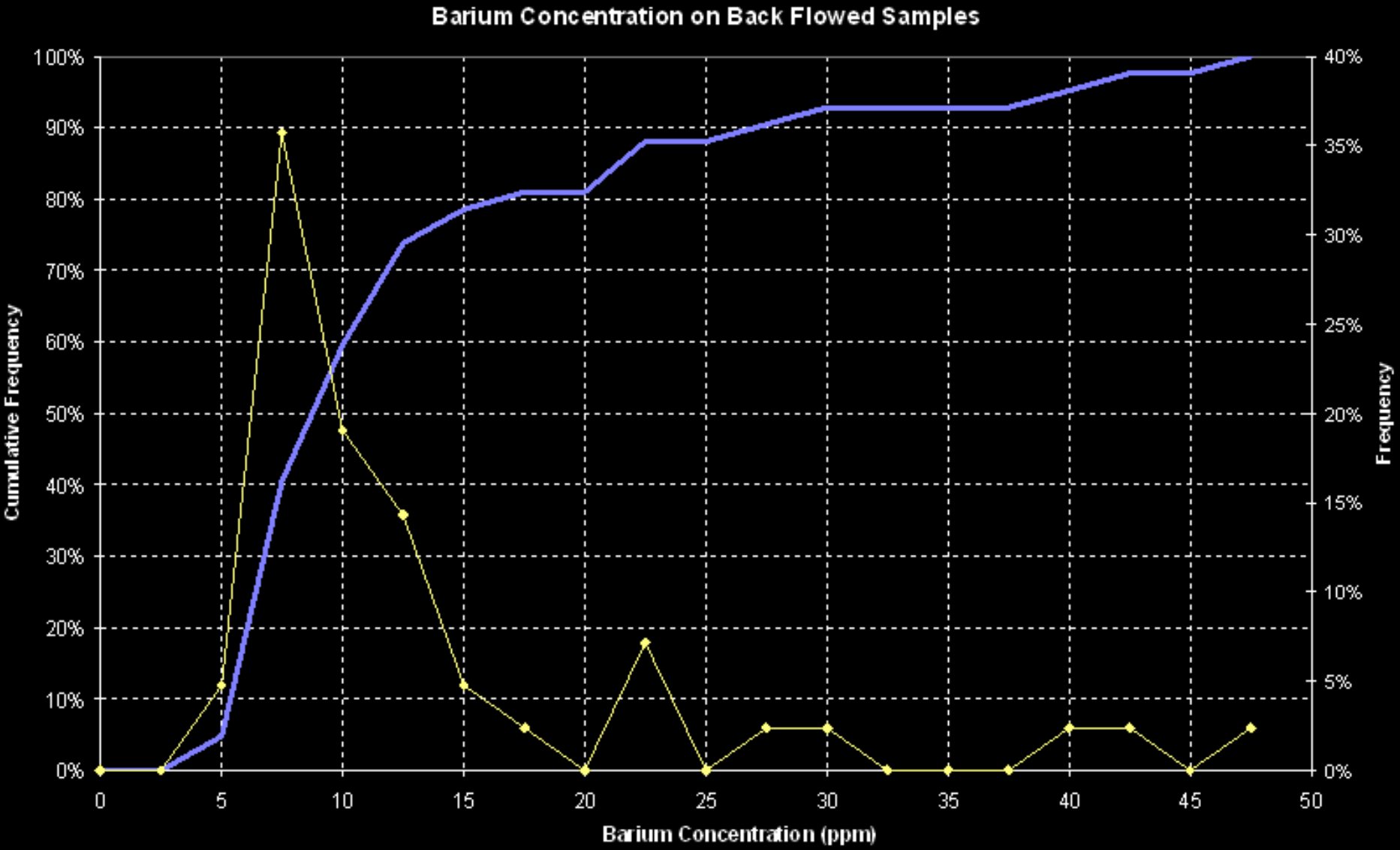
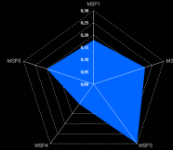
Scale Index Iron Related Scales



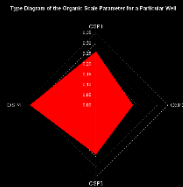


Calcium Concentration on Back Flowed Samples

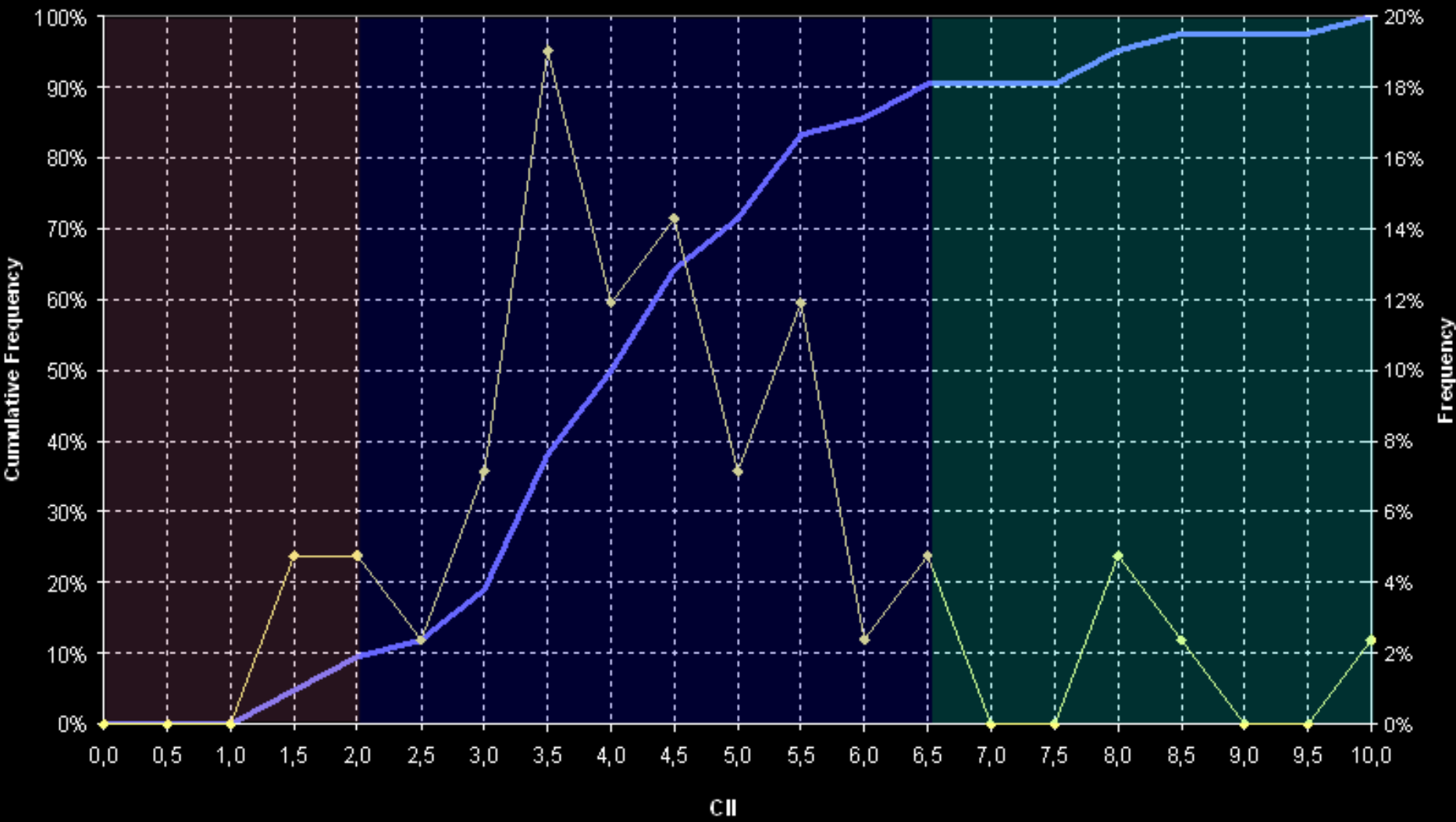




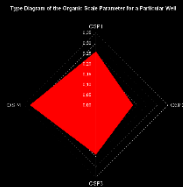
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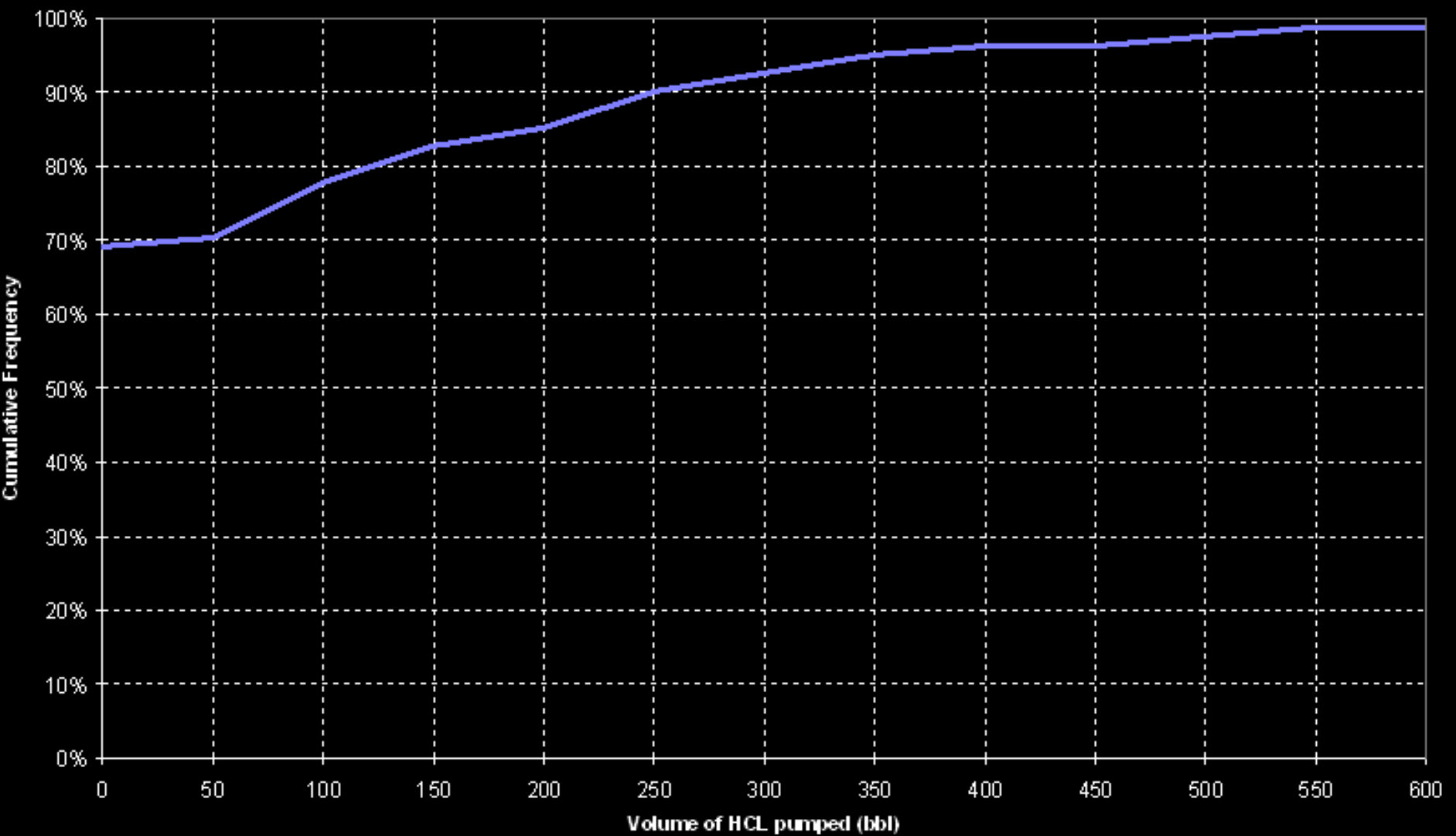
CII derived from SARA Analysis and API Correlation for all the Wells



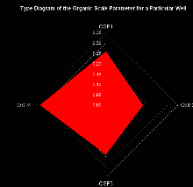
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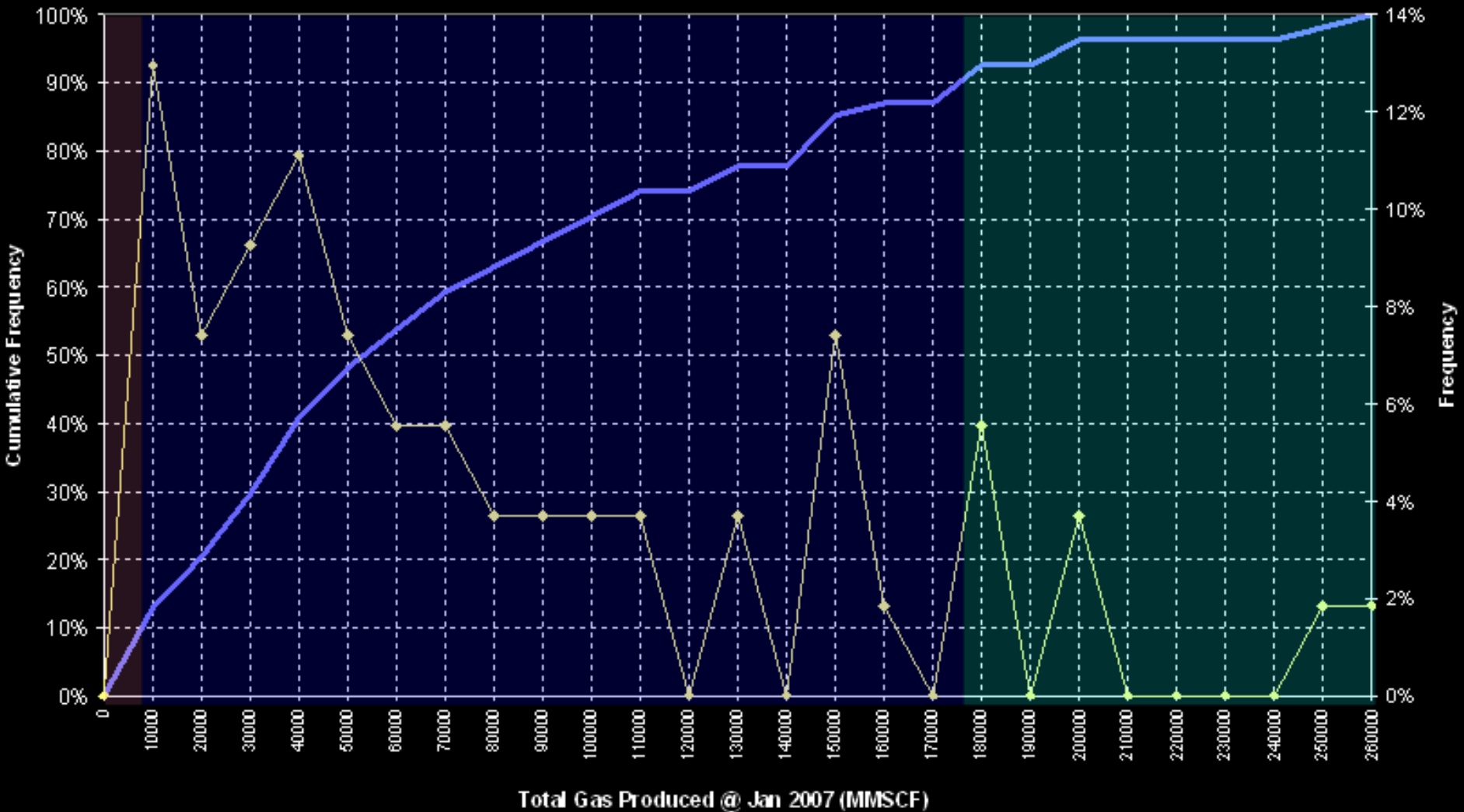
Volume of HCL Pumped - Cumulative Frequency



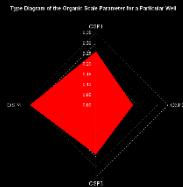
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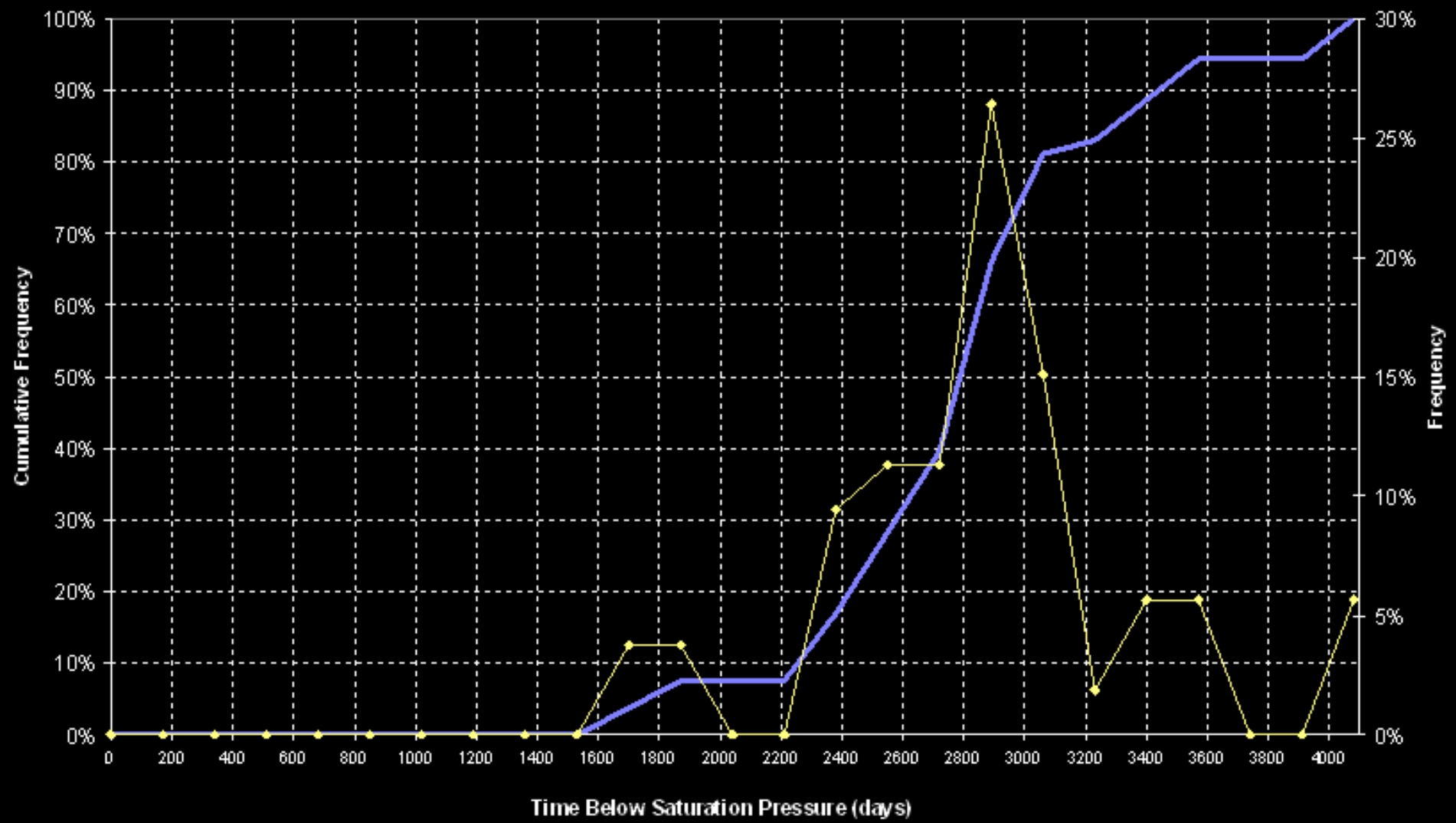
Total Gas Produced



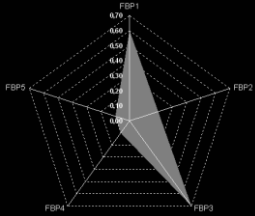
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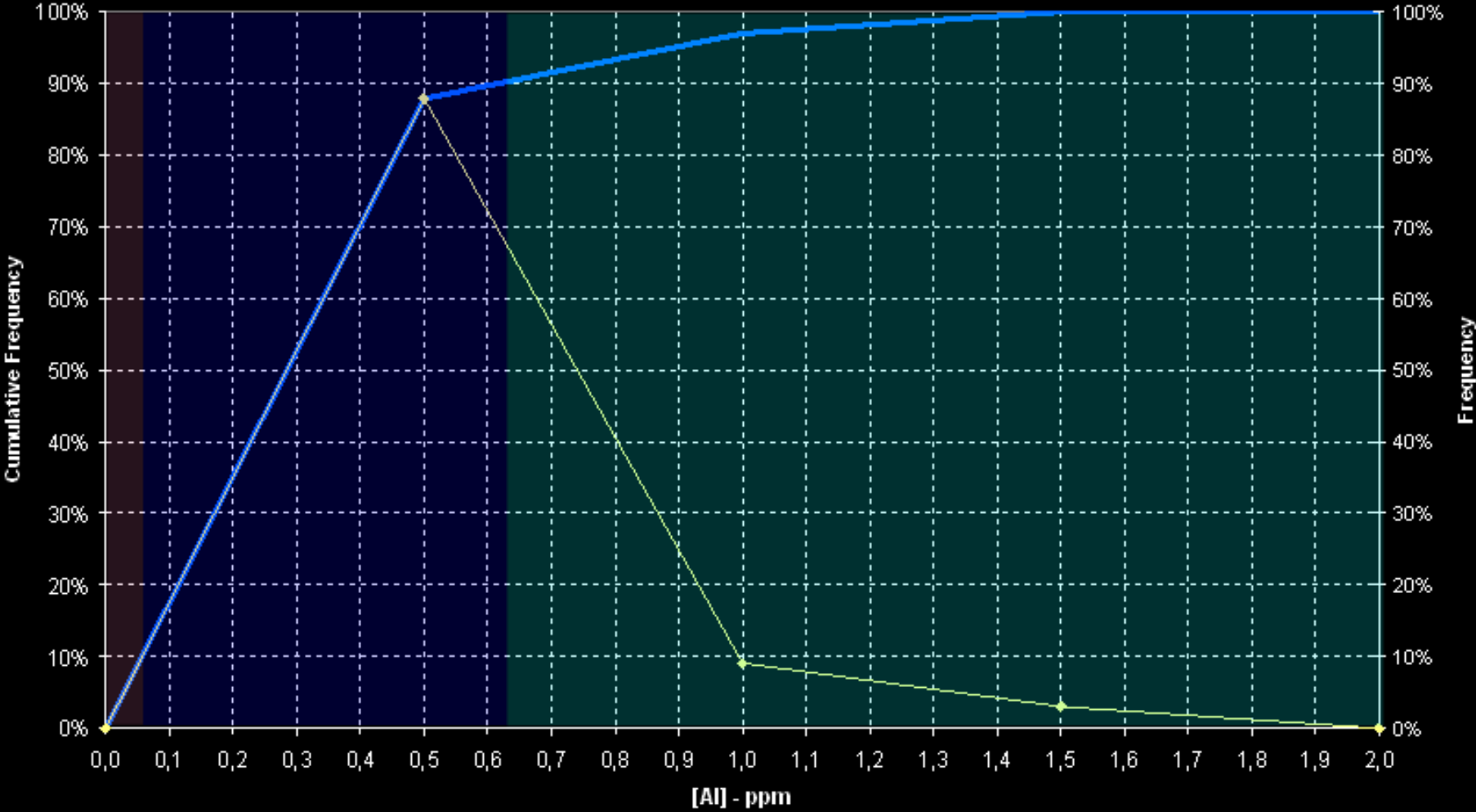
Days Below Saturation Pressure



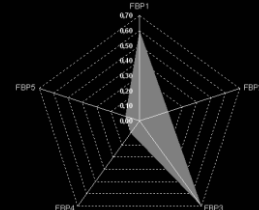
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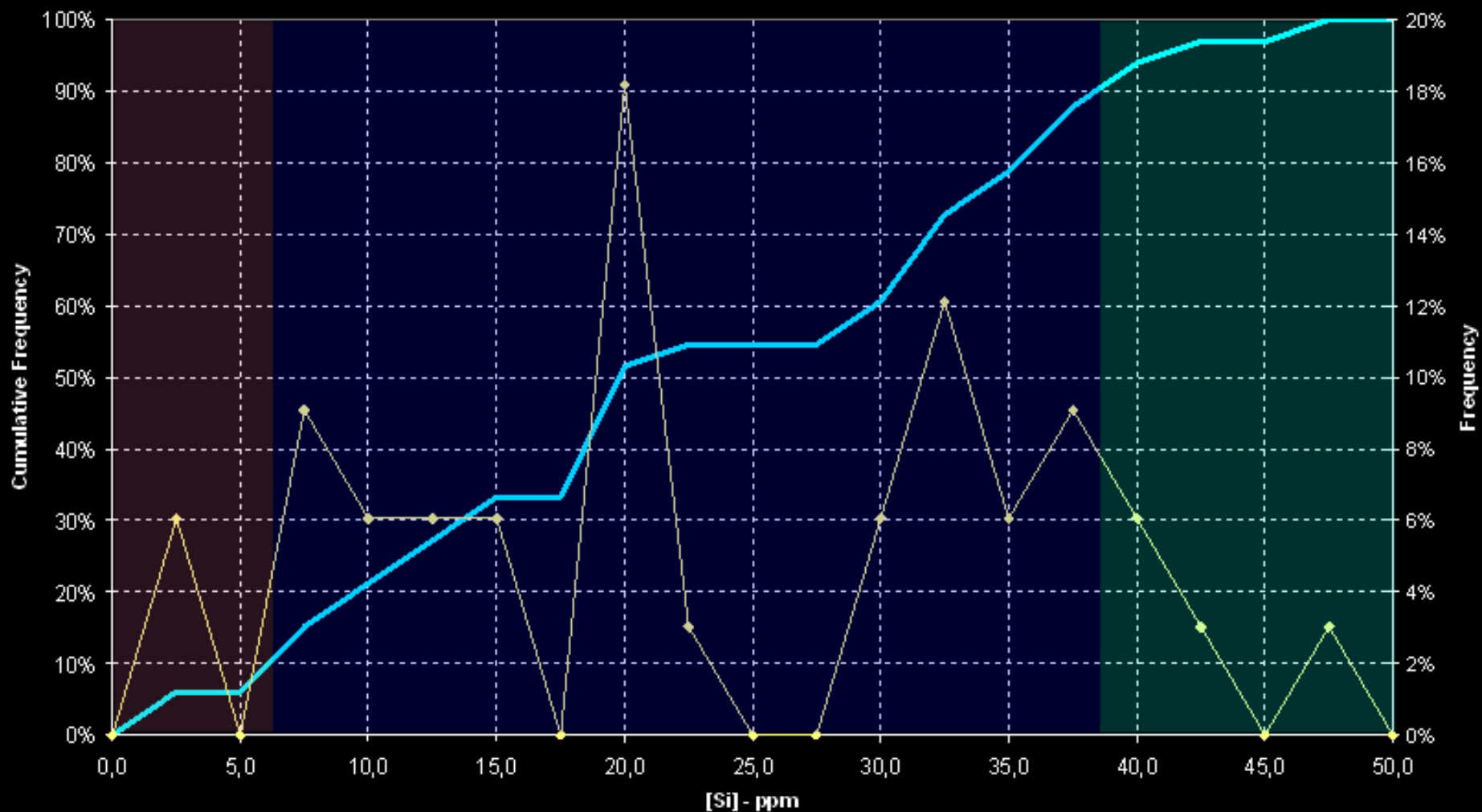
Aluminum concentration derived from produced water analysis

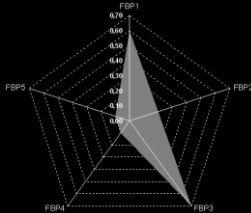


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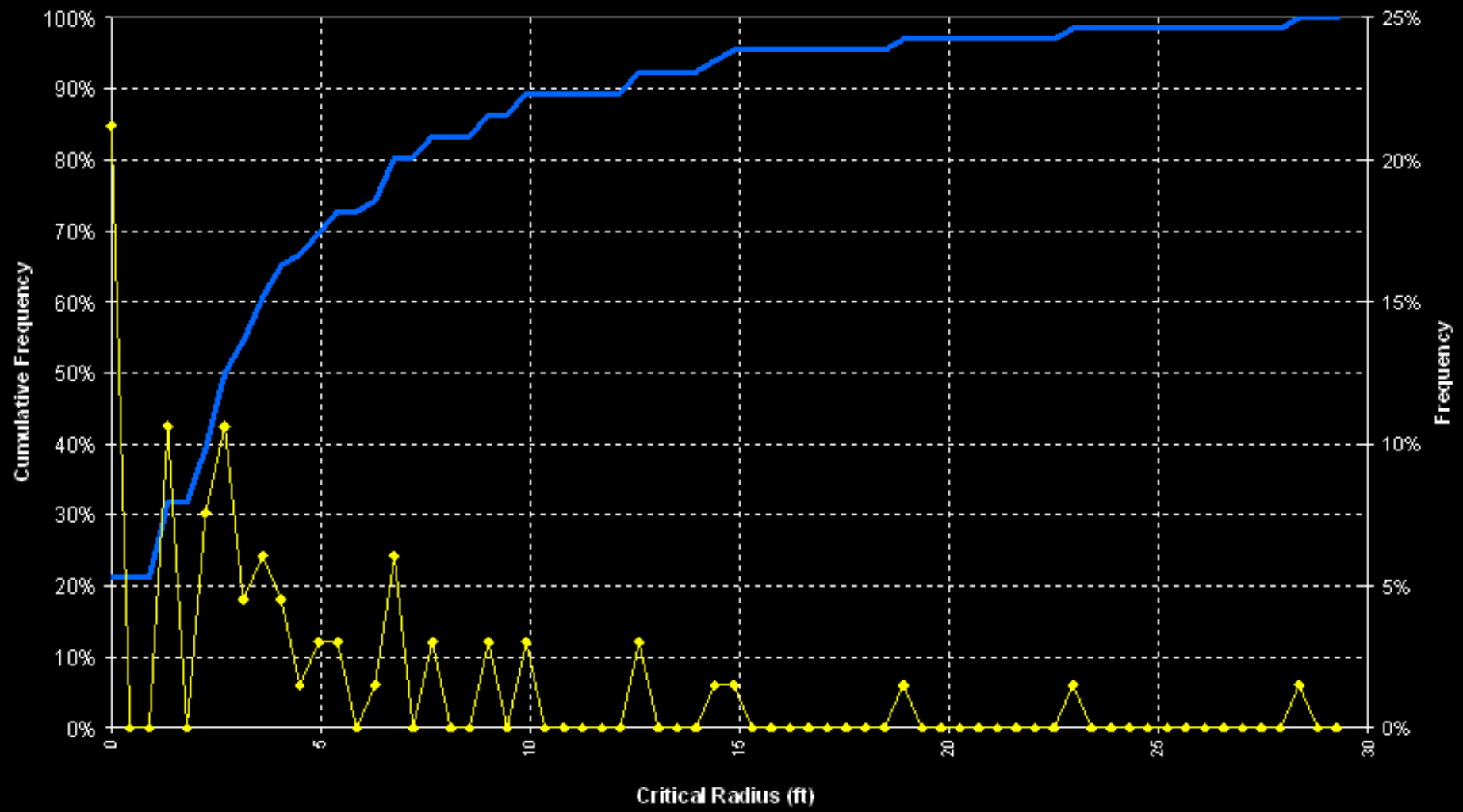


Silicium concentration measured on produced water - all the wells

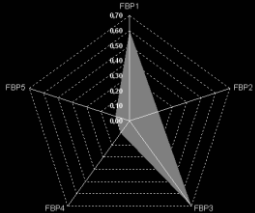




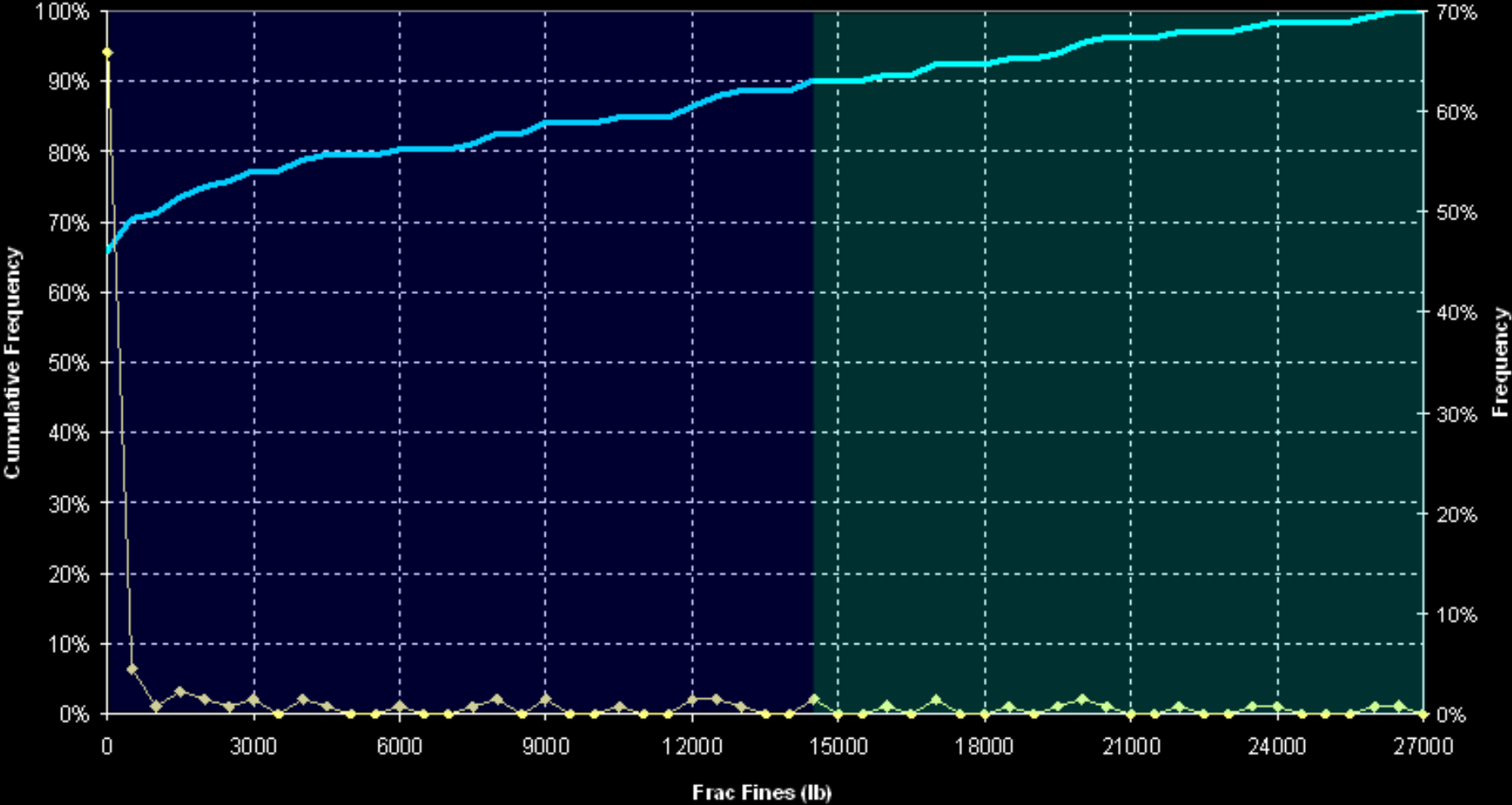
Calculated Critical Radiuses for all the wells



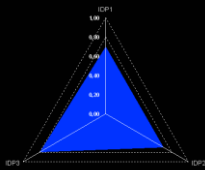
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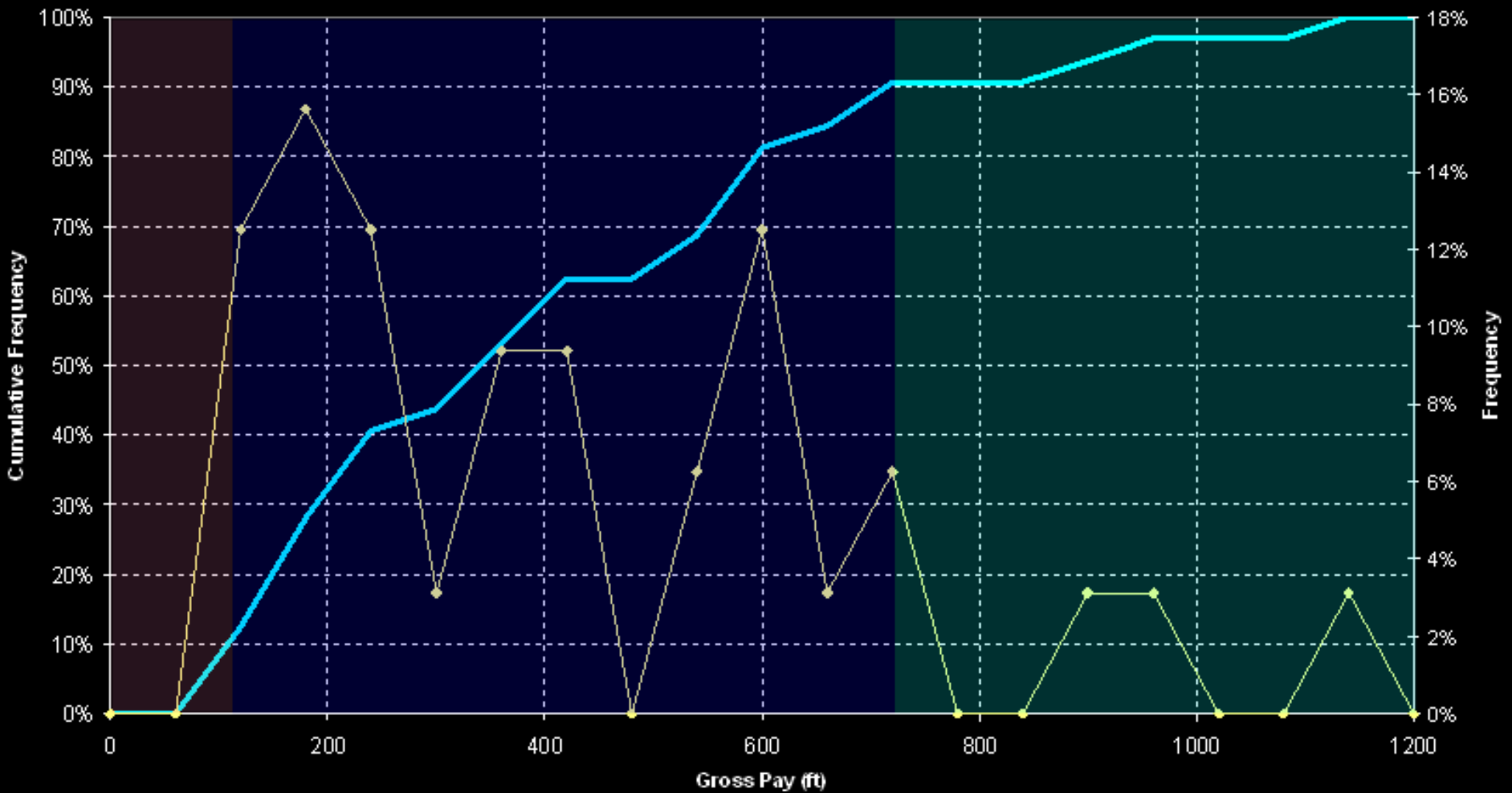
Frac Fines for all the Wells



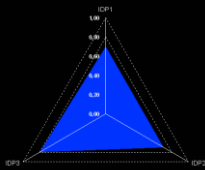
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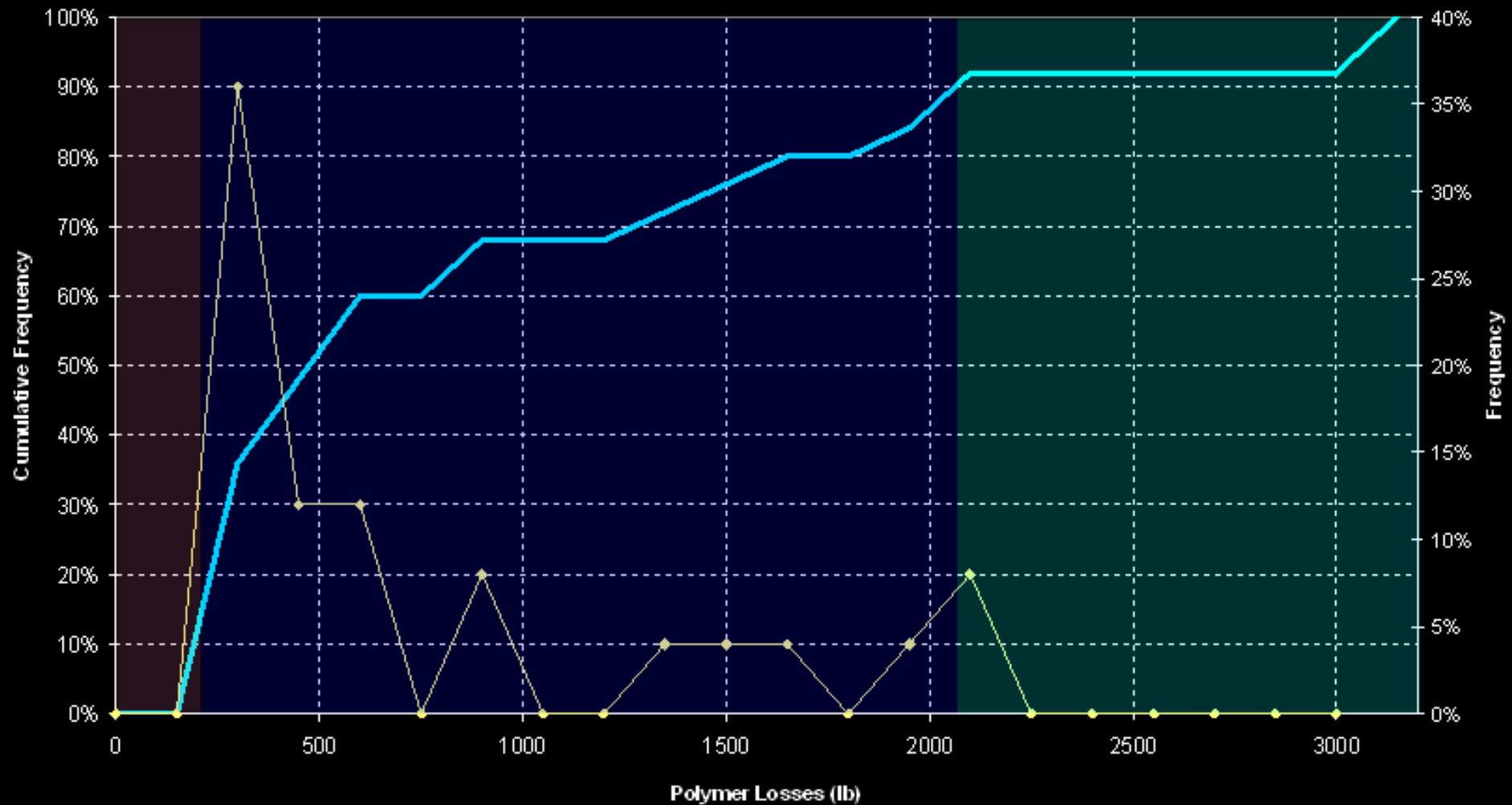
Mud damage factor (associated to gross pay) - all the wells

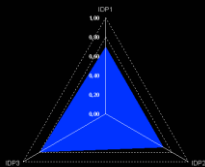


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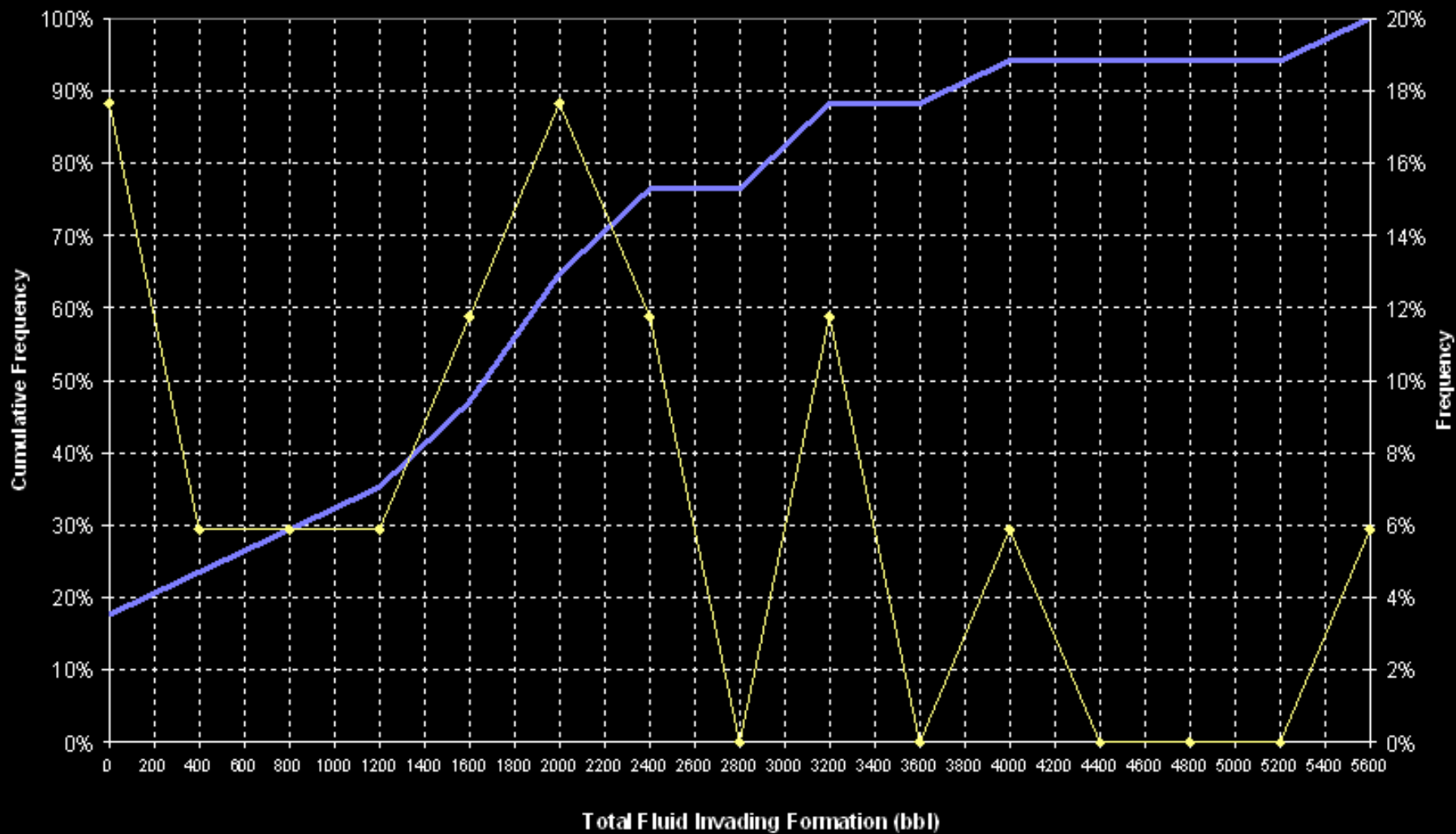


Polymer Losses for all the Wells

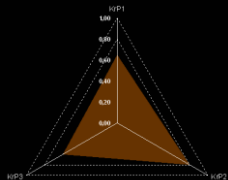




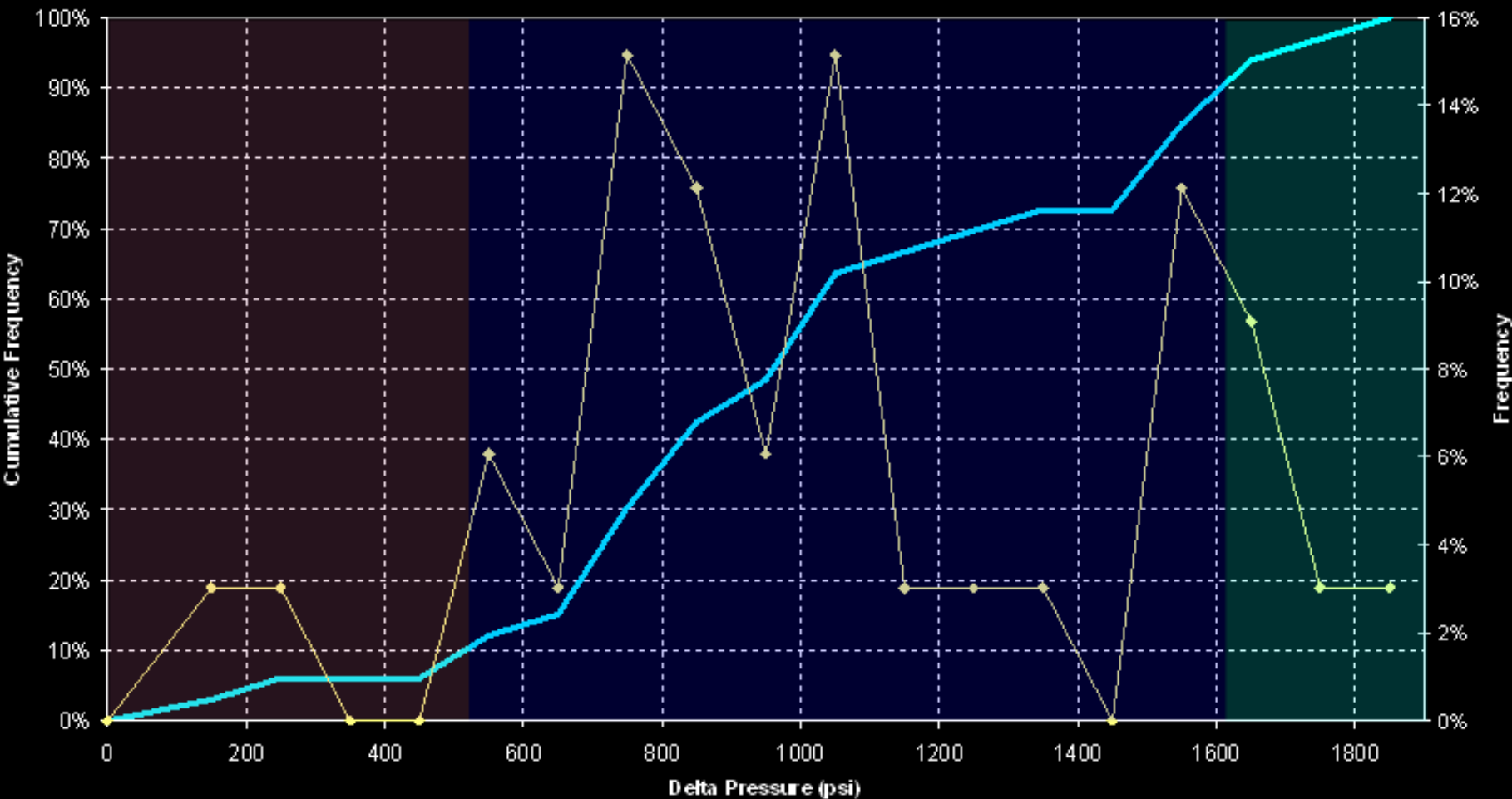
Total Fluid pumped during Fracs and Kill Well Ops



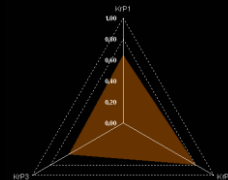
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Delta Pressure Below Saturation Pressure for all the Wells



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QW for all the Wells

