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# Re-designing EOR through Integration: Fast Track Approaches

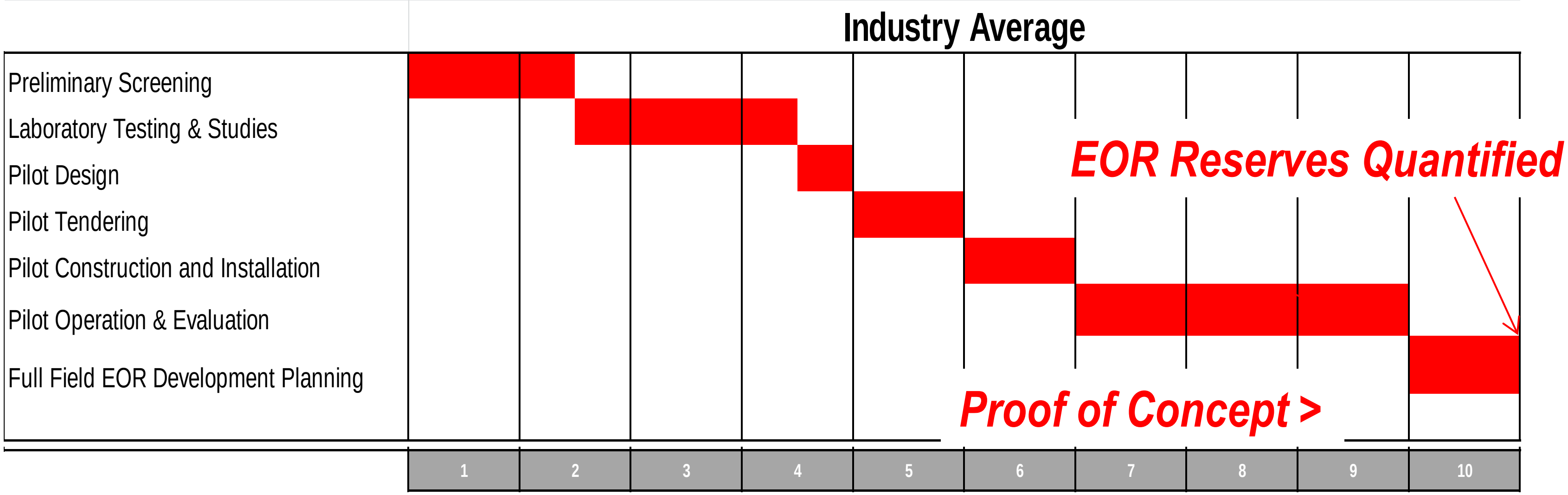
**Rick Penney**

**Global Development Planning & EOR Director**

**Schlumberger Production Management (SPM)**

**Presenter: Hassan Akram**

# Issues with Deployment of EOR

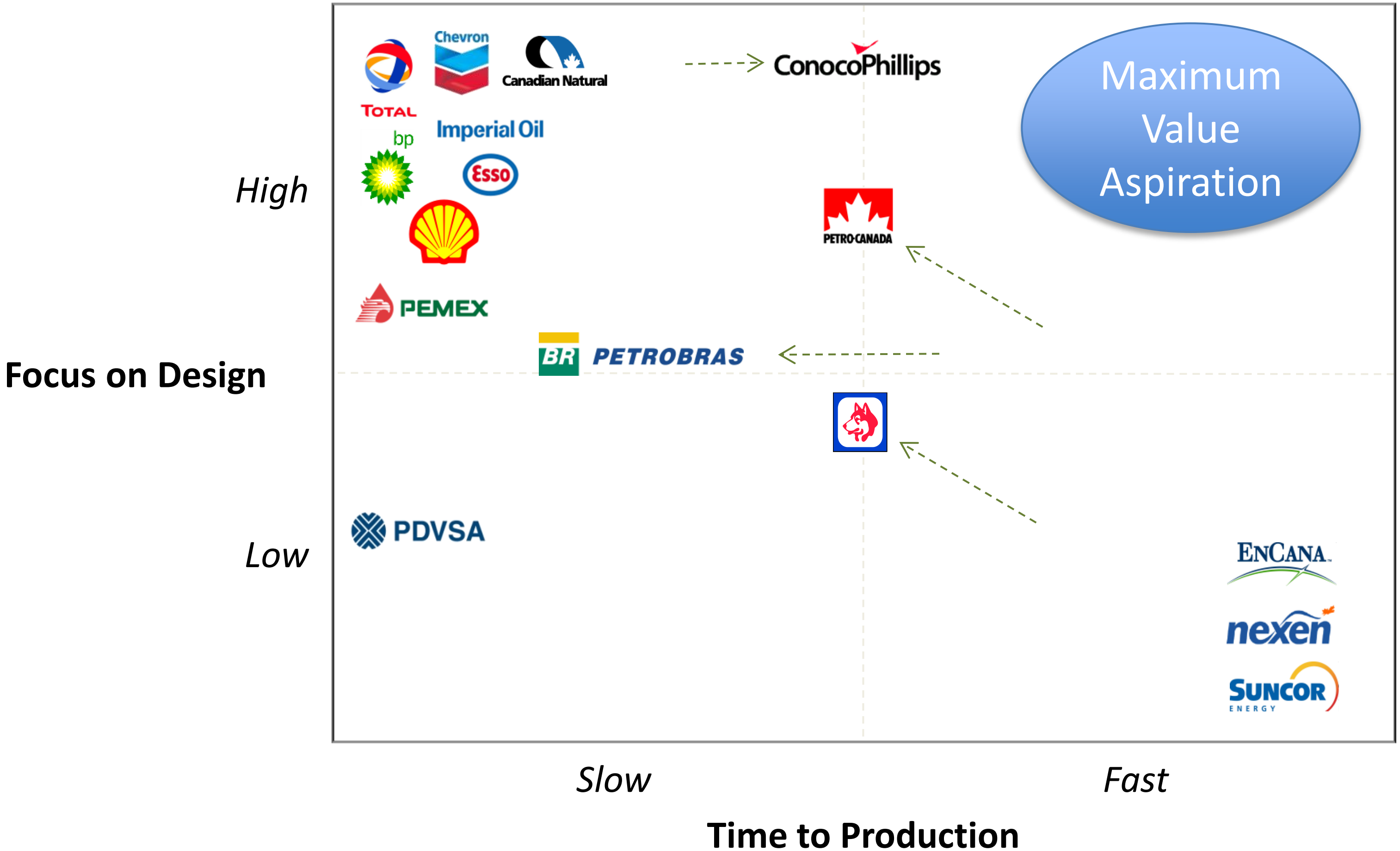



- <u>**Long lead times**</u> for pilot delivery and excessive time to full field FID
- <u>**Inconclusive Pilot results**</u> due to lack of data or design (cost cutting?)
- <u>**Success case economic drivers**</u> not properly understood (pilot objective?)
- <u>**Lack of implementation experience**</u> and <u>**lack of continuity**</u> of project team
- <u>**Lack of integration**</u>: facilities-subsurface-operations
- Internal service providers (drilling, facilities, production, surveillance) <u>**slow to adapt to EOR**</u> requirements

<u>***AS MANY AS 80% OF PILOTS FAIL TO LEAD TO FULL IMPLEMENTATION (YET)***</u>

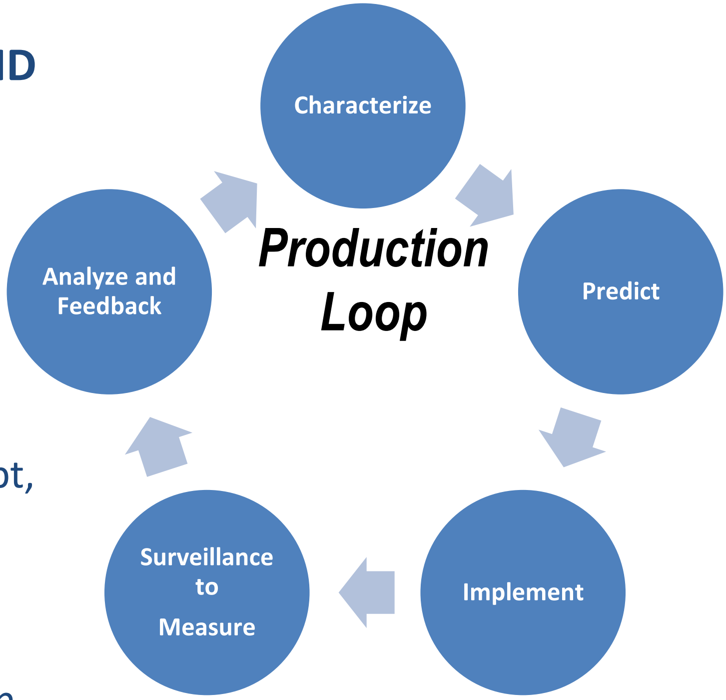
# Change Approaches: re-design EOR for fast track implementation

***Positioning of NAM/LAM Heavy Oil Operators, 2010***

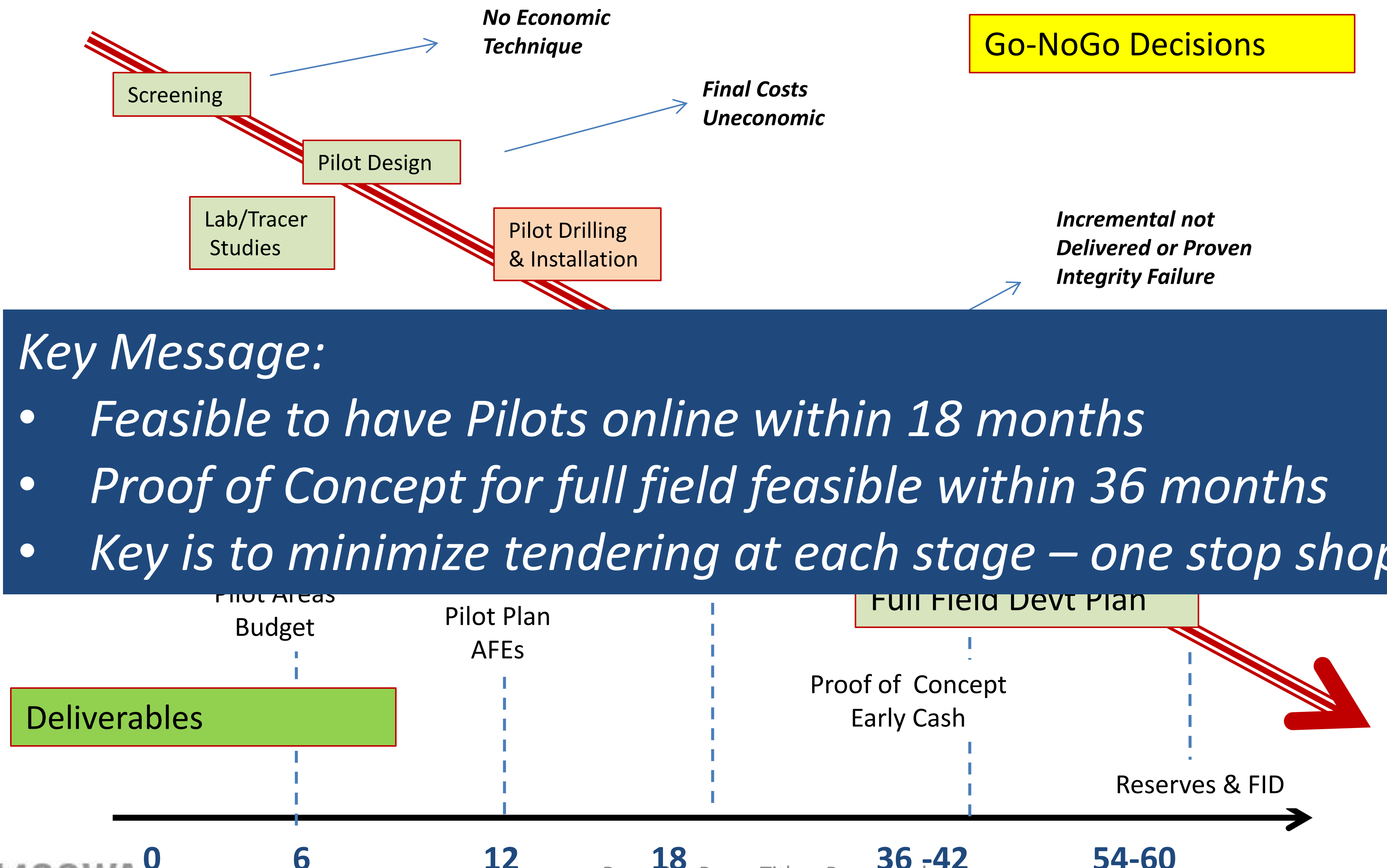


# Reducing EOR Cycle Time

- **Develop a common EOR Workflow**
- **Reduce EOR cycle time to proof of concept and EOR FID thru:**
  - **One stop shop:** Services and Project Management.
  - **Continuity**: Same team to stay with the project , maintaining knowledge and minimizing handover delays
  - **Contracting:** up front and not tendering at each stage
  - **Integrated approach:** for lab, studies, design, implementation, operation, surveillance, proof of concept, EOR FDP
  - **Phasing:** Lab and studies in parallel with design, not sequential
  - **Design for Proof of concept**: leads to full field EOR FDP in parallel with early pilot expansion
  - **Commoditizing pilot equipment:** standardize on modular steam boilers, chemical units, gas supply
  - **Confirmation:** Best in class surveillance technology to confirm benefits are achieved by **closing the production loop in the shortest time**



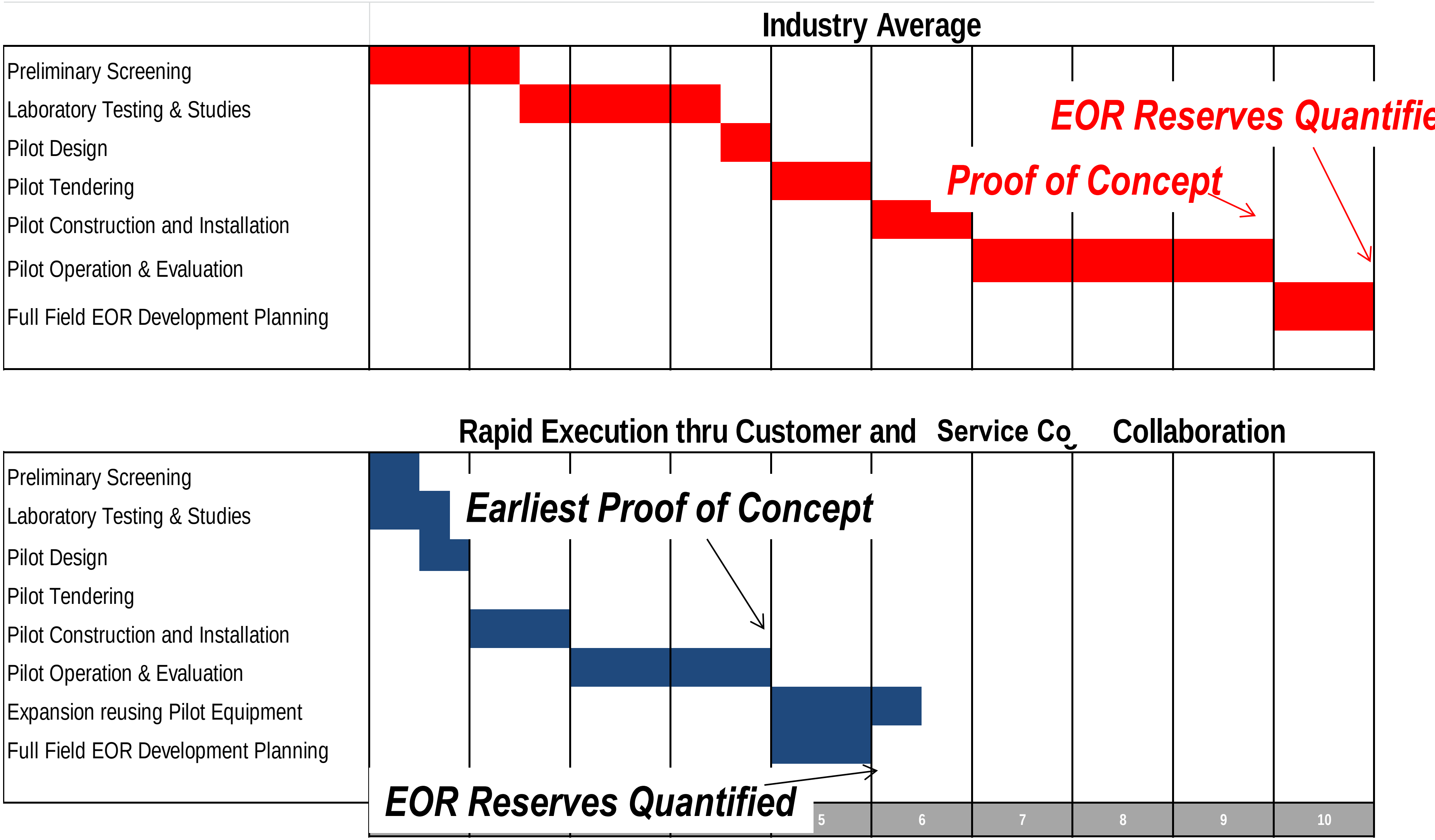
# EOR Project Roadmap (excl Decision Delays)



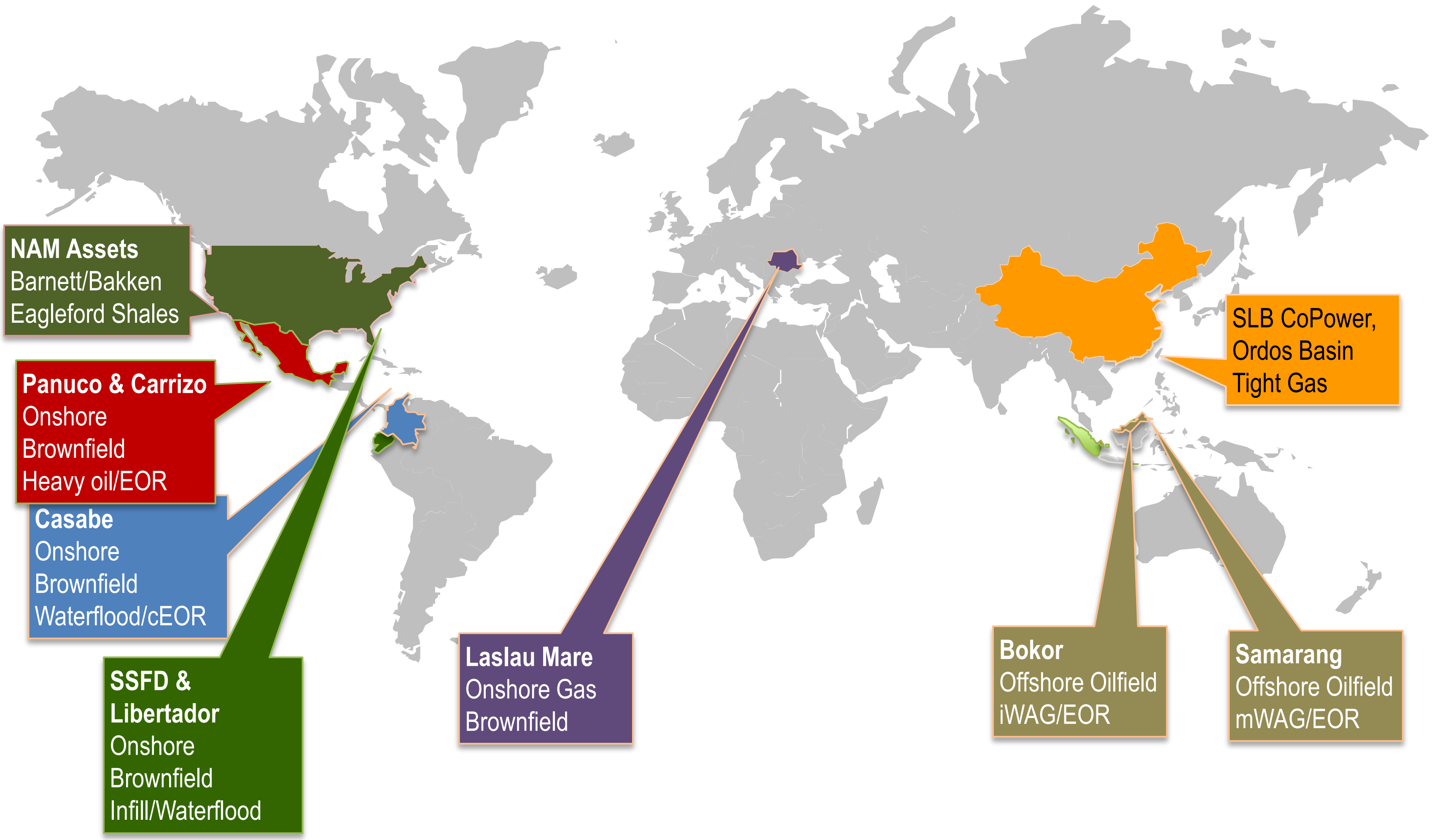

*Key Message:*

- *Feasible to have Pilots online within 18 months*
- *Proof of Concept for full field feasible within 36 months*
- *Key is to minimize tendering at each stage – one stop shop*

# RIDER: Rapid Integrated Deployment of Enhanced Recovery



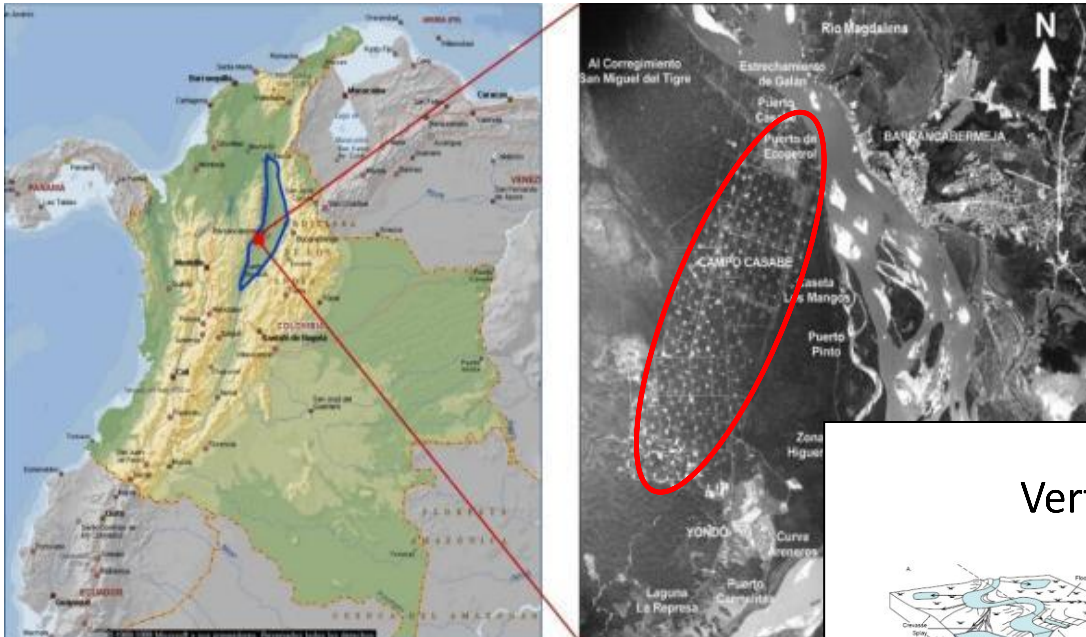
# Fast Track in SPM
# Portfolio by Recovery Themes



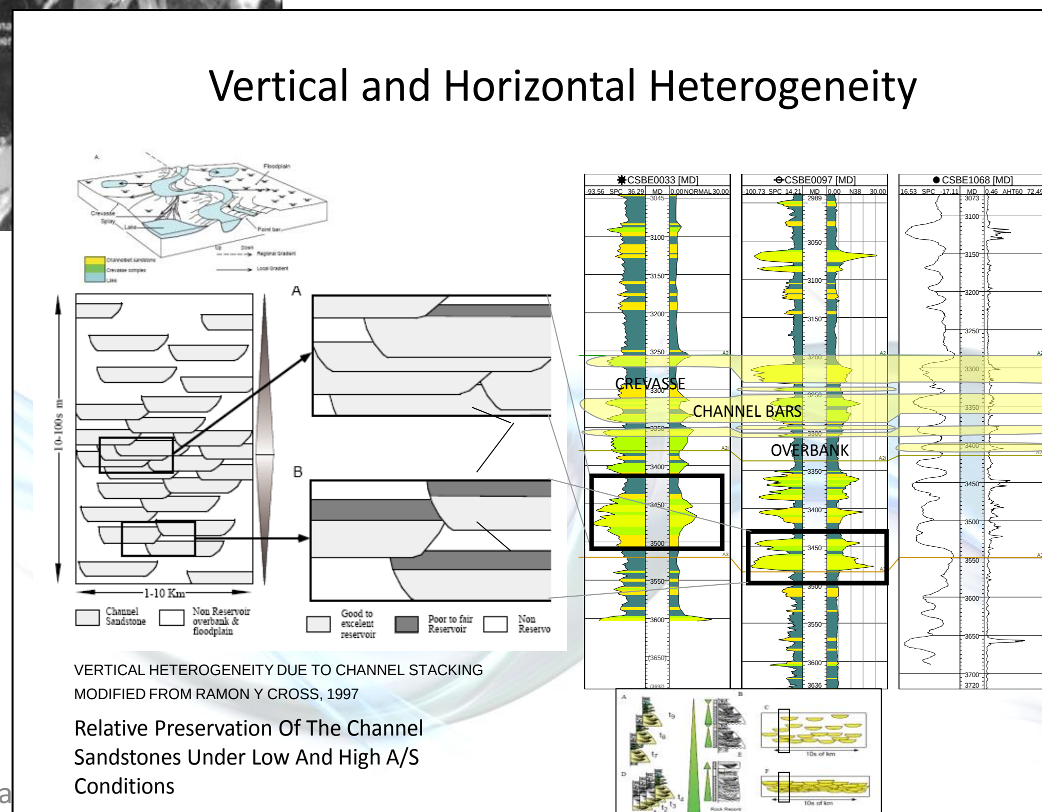
# *Is the Fast Track EOR Roadmap Achievable in Practice?*

- Casabe (Colombia) Polymer Pilot
- Panuco Fractured Carbonate (Mexico) Thermal Pilot

# Colombia: Casabe Polymer Pilot




- Layered sand/shale sequence
– as many as 17 zones/producers
- 50-300mD
- 30-80cP oil
- RF<30% pattern WF



# Polymer Injection for Mobility Control

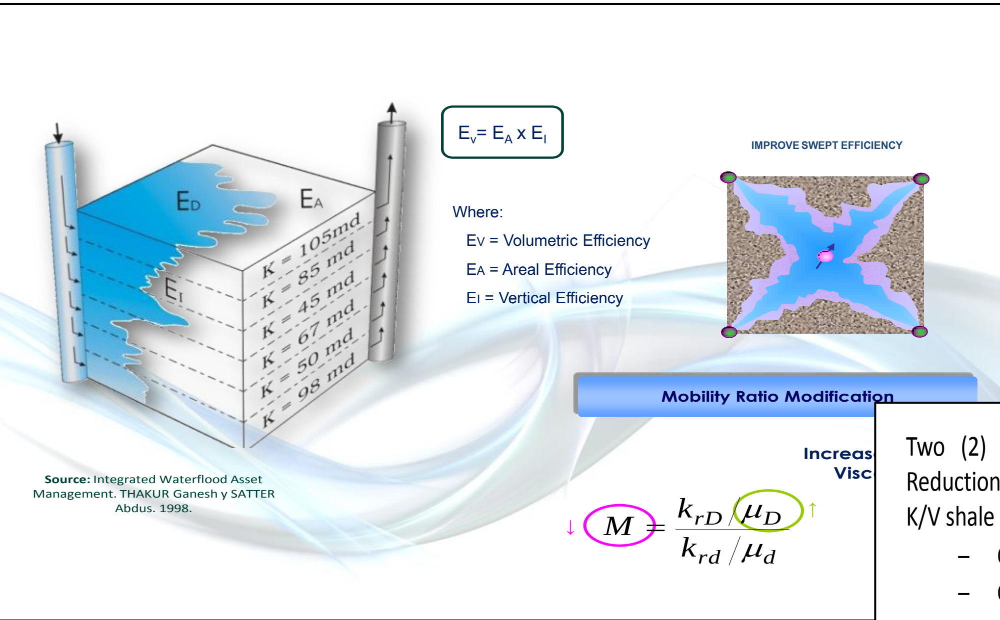
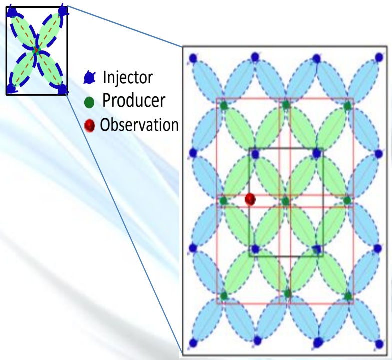


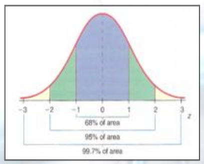

FIGURE 2. MOBILITY RATIO

- Two pilot patterns selected
- Better ResQ and below average ResQ
- Covers range of effectiveness
- Two layers comprising >40% of OIP
- Two suppliers – SNF and MI/BH

Two (2) SP Flooding Pilots for mobility control and $S_{or}$ Reduction EOR; variation in chemical make up for different K/V shale

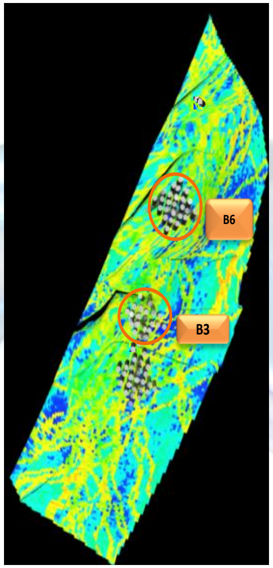
- One in Average Rock Quality, swept.
- One in Best Rock Quality, swept



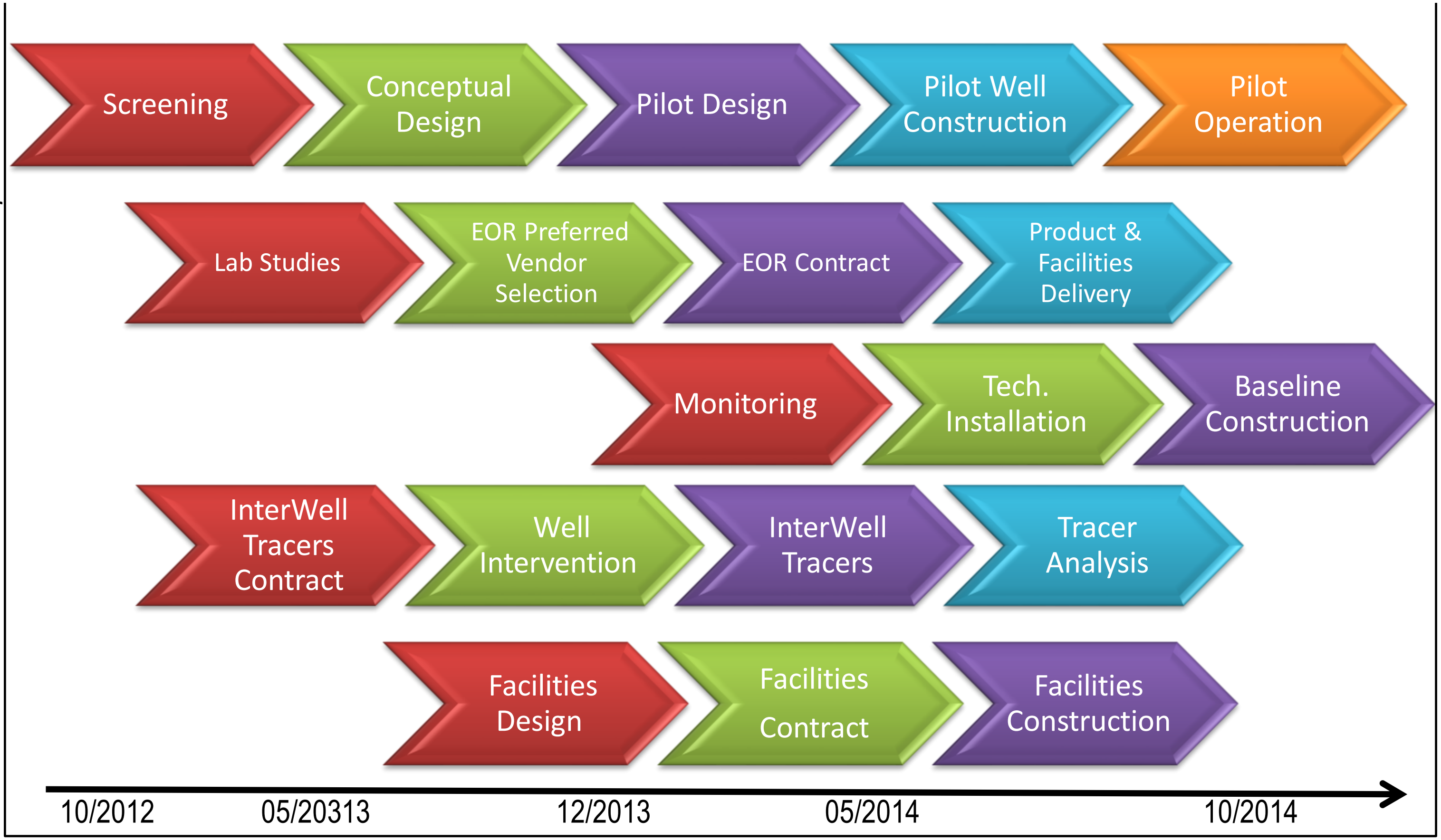
Reservoir Quality

EOR Pilot Areas



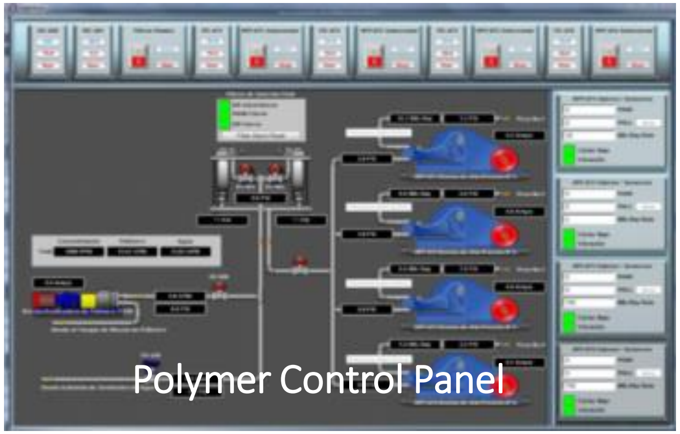
# Casabe Fast Track Timeline: Parallel Activities + Focus Team

- Project Manager
- Reservoir Engineer
- G&G
- Production Technologist
- Well Construction Engineer
- Facilities Engineer
- Production Optimization
- Economic Analyst
- Supply Chain Support




**** Facilities = Contracted Equipment, Installation & Connection***

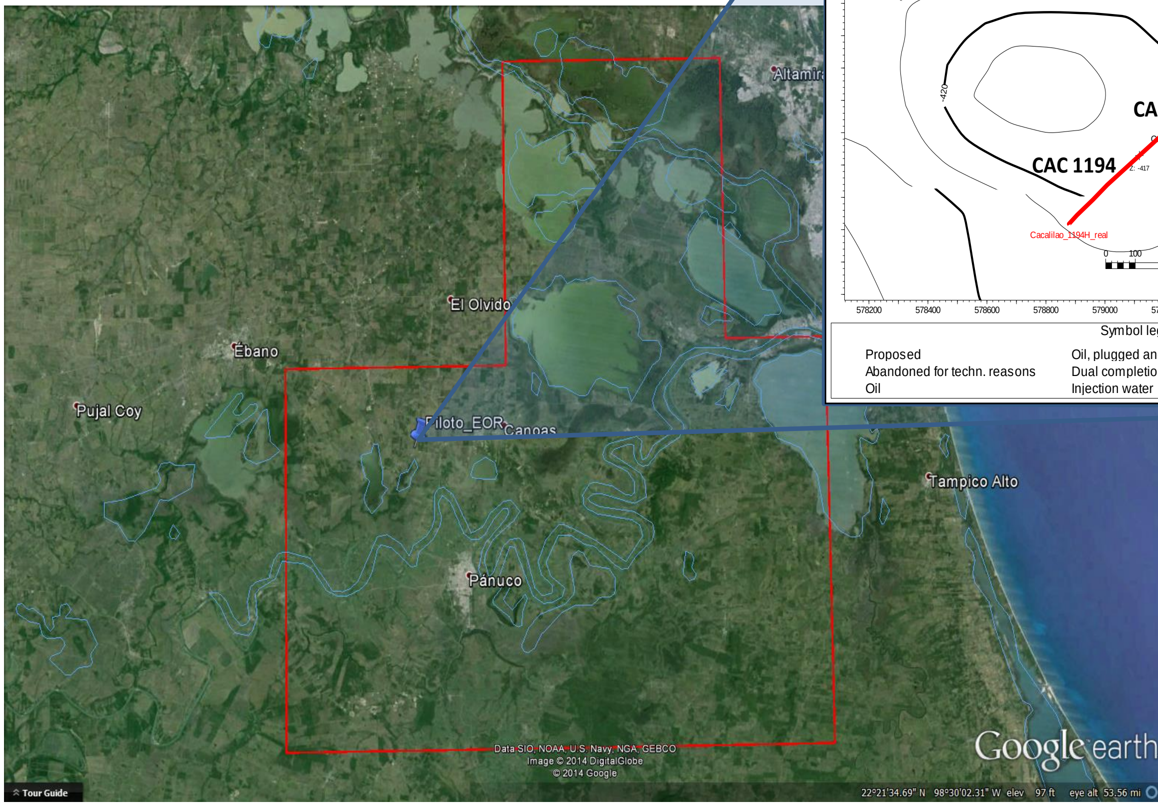
# Casabe Polymer

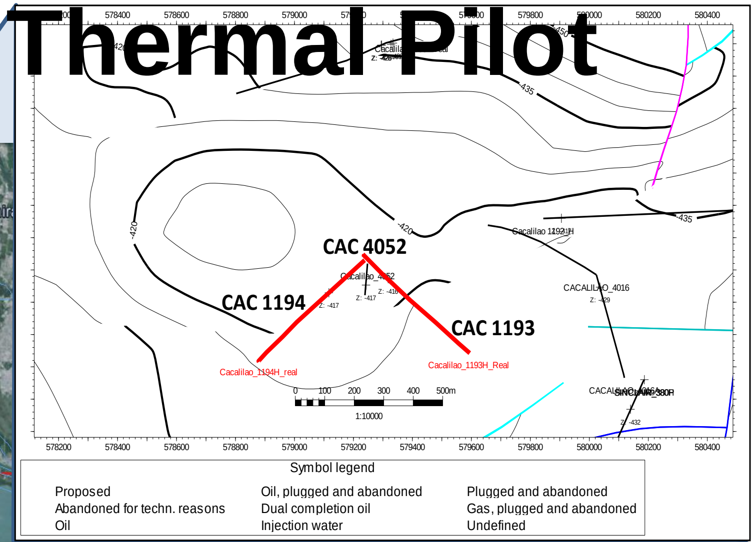




- Polymer injection commenced in first pilot pattern on October 28 2014
- 21 Months from kick off (due to equipment delay)
- Four polymer injector wells.
- Total injection capacity is 3.000 B/D of 500 ppm polymer solution at 2.000 psi
- Short term response shows decrease in water cut across all wells and central producer has increased oil rate.
- Second pilot pattern on hold due to ECP cash constraints. However, pilot expansion to multiple layers is under design for second stage pilot. .

# Mexico: Panuco Thermal Pilot




- Cyclic steam stimulation (CSS) pilot
- Fractured carbonate with heavy oil >300cP
- Two horizontal I/P wells penetrating the fracture corridors
- One deviated well for monitoring microseismic events

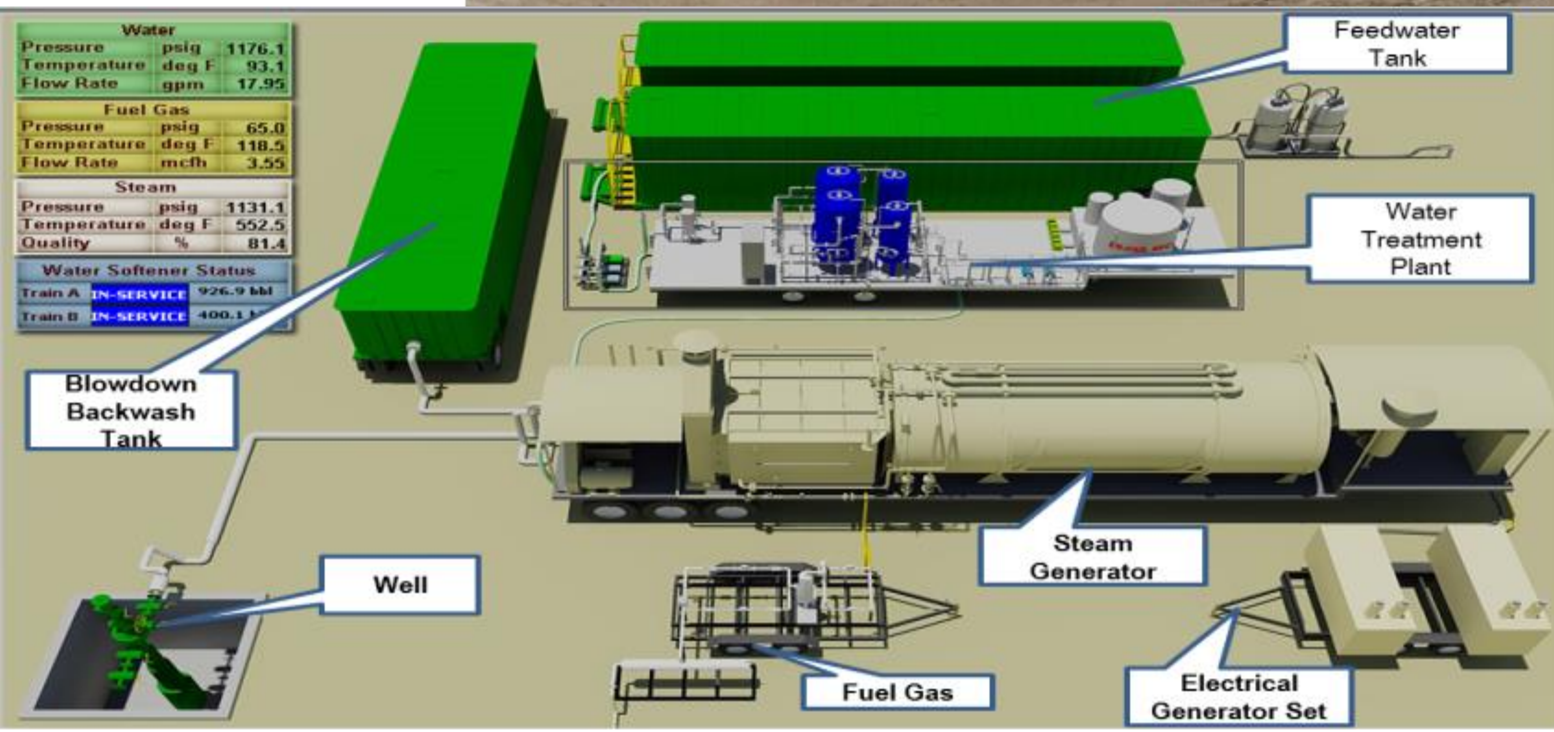
# Panuco Thermal Pilot Objectives & Risks

- Introduce thermal operations without HSE or social incidents.
- Designing the Pilot to give a conclusive proof of concept, proving :
  - Sufficient steam injectivity.
  - Sufficient incremental production associated to the thermal process.
  - Technical and economic feasibility of full-field implementation (if possible).
- Collecting sufficient data and measurements to confirm proof of concept.
- Delivering the project on time and within budget, and with a proper management of risks.
- Demonstrating SPM capability in EOR implementation for future collaborations

| Risk Category | Hazard or worst consequence | Initial Risk | Control Measure | Residual Risk |
|---|---|---|---|---|
| Seal rock integrity | Steam leaks or breakthrough at surface, with environmental consequences | High | Geomechanical study, injection pressure control, monitoring system (microseismic) | Low |
| Permitting | Delays in Project start | High | Pemex, PetroSPM support<br>Expedite thorough support | Mid |
| Social | Delinquency, robbery | High | Support from External Affairs. Explain risks of project. | Mid |
| | Manifestations and protests | High | Avoid areas close to towns, reduce use of noisy trucks, logistics for transportation, support from External Affairs to inform about the project, what is and what it is not. | Mid |
| Operational | Steam generation failure, procedures for measuring and handling hot fluids at Surface | High | Hired experienced contractors, apply PSIM, train operators | High |
| Water supply | No supply source found<br>Poor quality water, generator explosion | High | Local providers<br>Softeners, water treatment plant, water quality monitoring plan | Mid |
| Hot fluid production | H2S, difficult separation and measurement of fluids. | High | Operations plan | Mid |
| Poor cement job, poor well design | Casing growth with temperature, heat losses, steam leaks, well loss, casing collapse | Mid | Cement to surface, test quality and repair if necessary, proper casing and wellhead design program | Low |
| Integrity of old wells | Old neighboring wells affected by steam injection, steam flow to Surface with environmental consequences | Mid | Area selection. Wells shut in at bottom. Monitoring during injection. | Low |

# Panuco Pilot

*panoramic view of the surface facilities installed in the pilot pad*




*plan view of the steam generation equipment*

# Panuco: Surveillance Intensive

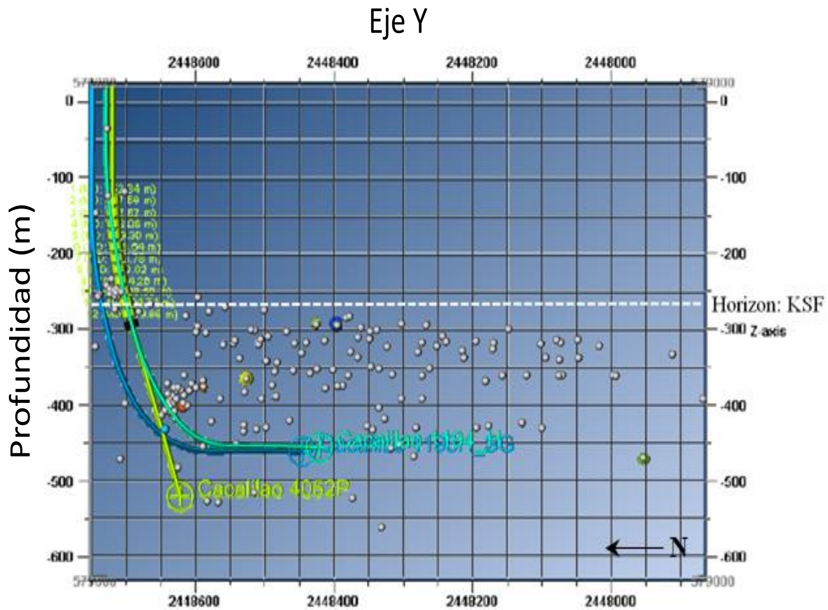
**Pilot construction and installation**
- Fluid analysis
- Core analysis – mechanic and thermal properties
- Basic petrophysical properties
- Logs (images, electrical properties, etc.)

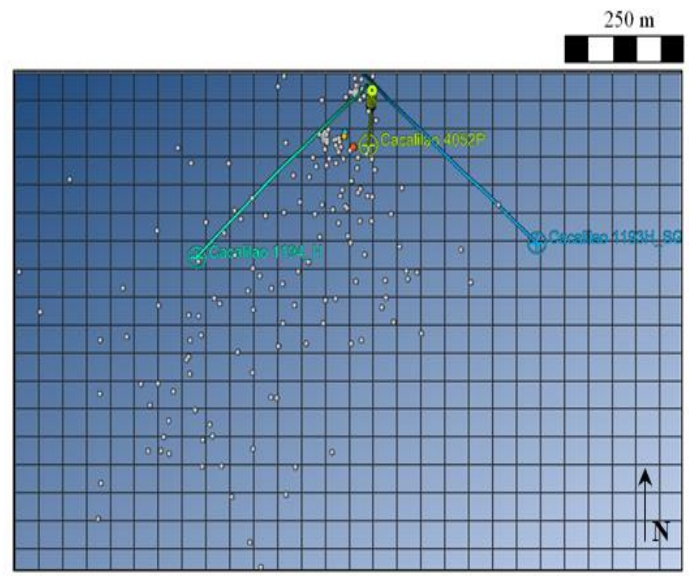
**Cold production**
- Flow rates (oil and water)
- Temperature profiles
- Bottom hole pressures
- Produced water salinity
- Oil viscosity

**Steam injection period**
- Daily steam injection rate and pressure
- Steam quality
- Bottom hole pressures
- Injection temperature
- Temperature profile
- Microseismic events
- Surface conditions and parameters of neighboring wells
- Casing thermal expansion

**Soaking period**
- Bottom hole pressure
- Temperature profiles
- Microseismic events

**Hot production**
- Flow rates (oil and water)
- Temperature profiles
- Bottom hole pressures
- Produced water salinity
- Oil viscosity
- Microseismic events




*Microseismic events during the injection, soaking and hot production periods*

# Panuco Pilot Outcomes

**Came on line some ten months after SLB took over the asset**, demonstrating:

- Delivery according to the scope, in record time and within budget.
- Most risks were managed successfully.
- Proved injecting steam is feasible **without social or HSE incidents.**
- Sufficient measurements were collected to confirm concept applicability.
- Injecting steam at 1,600 psi gave **no compromise cap rock integrity** over the pilot area. Geomechanics vital to minimize the risk of failure of the layer.
- Steam injectivity was low, yet cumulative injection achieved expected volume.
- **Productivity increased three to five times after steam stimulation**.
- A mechanical restriction near the top of one well did not allow installation of the artificial lift and production of stimulated intervals (620-630 m, 700-710 m) .
- Two nearby wells were influenced by steam injection: Pemex_1127 in which the fluid production rate increased by 50%, and Cacalilao_1192, in which the water cut was increased to 100% and after injection stopped, the water cut fell back to 5%.

# Integration has confirmed Fast Track EOR

- Successful Implementation by Casabe and Panuco Pilot Teams
- Fast Track EOR is not only feasible but achievable
  - With the right integration of Operator and Service Provider(s):
    - 18 months to pilot online
    - 36 months to proof of concept
- Critical success factors are:
  - Standard equipment – Boilers/Wtu; Polymer Skids; N2 Gas/Compressors
  - One Stop Shop to minimized tender, decision and handovers delays
  - Design, Operation & Surveillance must still be best in class and focus on earliest proof of concept
  - Close the production loop: Tie lab work to simulation to surveillance to predictions
- Over-riding Objective:

***Prove full field follow up is economically viable in shortest time***

# Thank You