



23rd World Gas Conference

UNDERGROUND GAS STORAGE IN AN UNDERSATURATED OIL FIELD IN ARGENTINA

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PRESENTATION SCOPE

PART 1

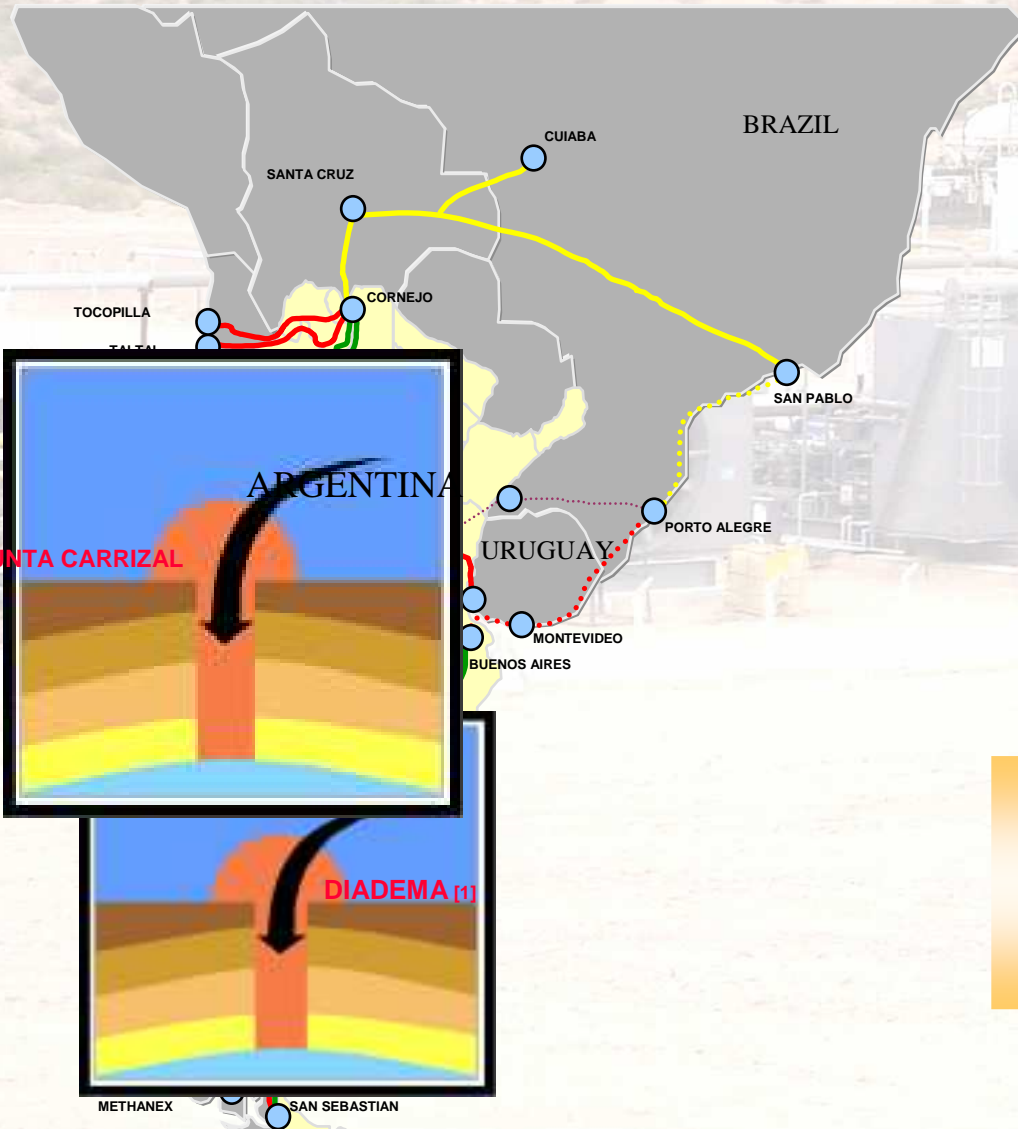
- LOCATION
- PURPOSES OF THE UGS PROJECT
- GEOLOGY & RESERVOIR
- SURFACE FACILITIES

PART 2


- PILOT PROJECT GOALS
- COMPRESSION SYSTEM
- GAS BUBBLE EVOLUTION
- PRELIMINARY RESULTS
- QUALITY, SAFETY & ENVIRONMENTAL PROTECTION

CONCLUSIONS

LOCATION



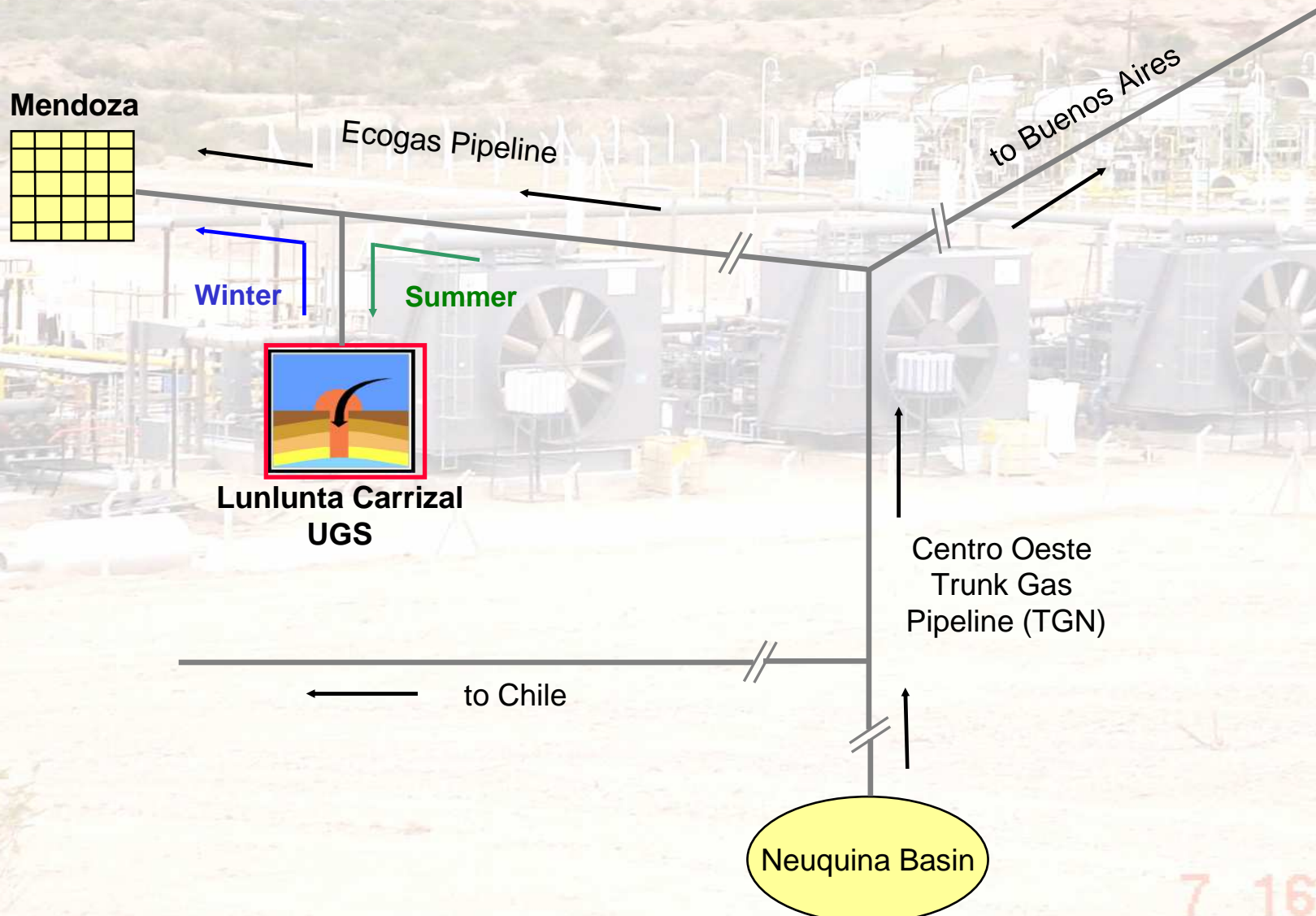
REFERENCES



UGS FACILITY

(1) Depleted gas field
(2) Depleted oil field

CONNECTION TO MAIN AND SECONDARY GAS PIPELINES





LUNLUNTA CARRIZAL UGS PURPOSES

- ✓ To comply with Repsol YPF obligations under the natural gas sale contracts in the region of Mendoza
- ✓ To improve the oil exploitation in Lunlunta Carrizal field (secondary recovery)
- ✓ To optimize natural gas and oil production in the fields located in Neuquina Basin

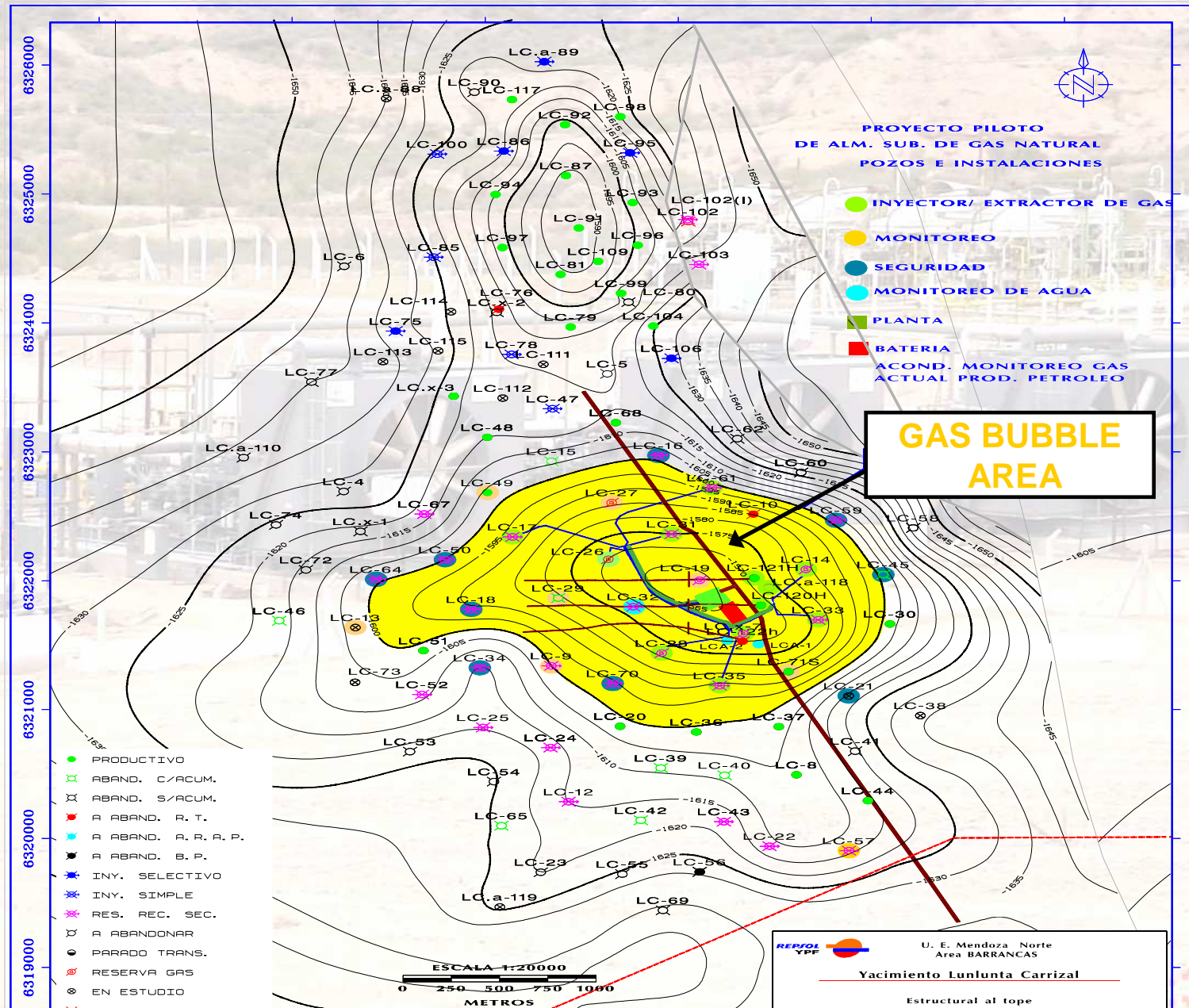


GEOLOGY & RESERVOIR

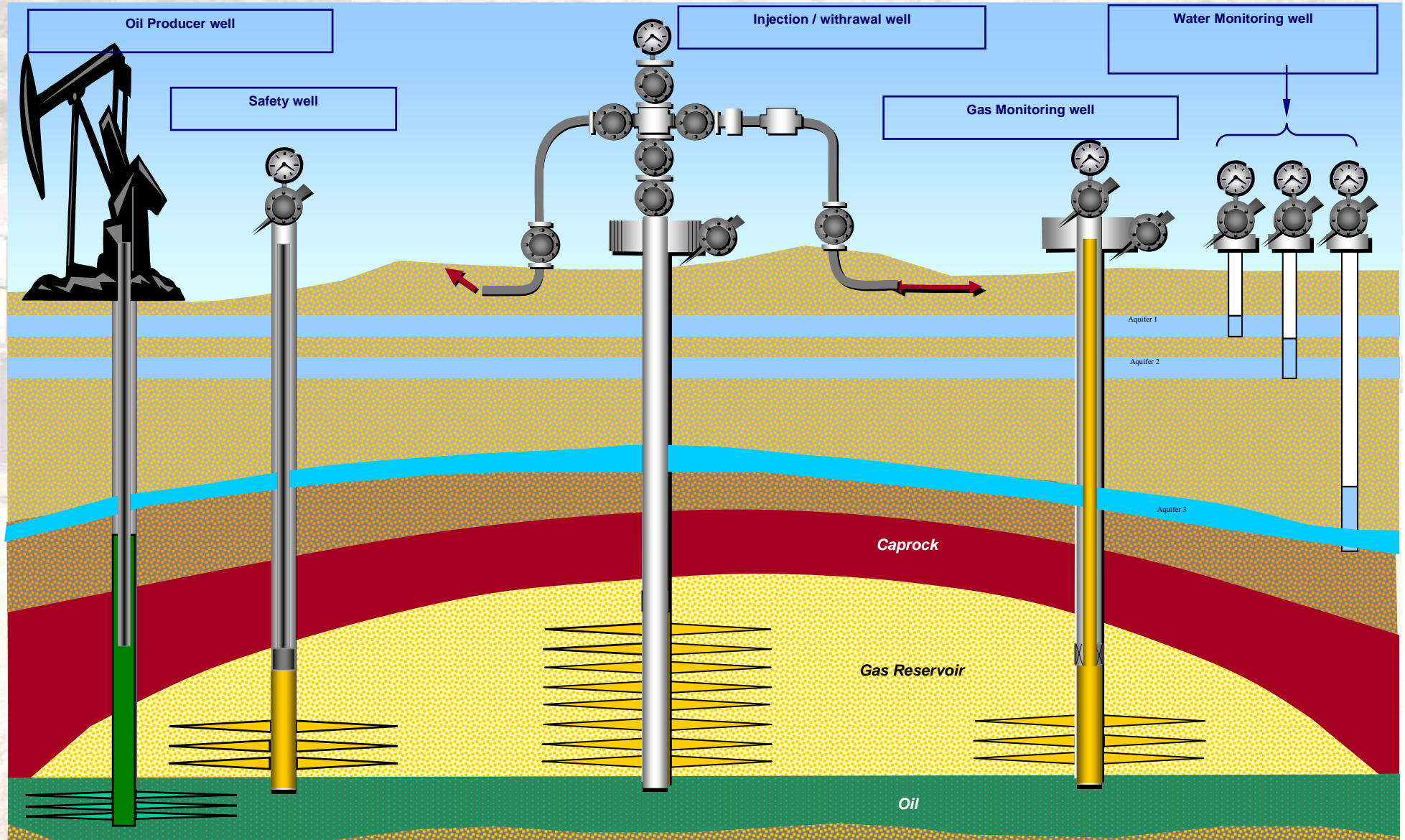
- ✓ **STRUCTURE:** Lunlunta Carrizal structure is an anticline with two apexes separated by a structural low
- ✓ **CAPROCK:** Claystones and volcanic rocks from Punta de las Bardas formation
- ✓ **RESERVOIR:** includes sandstones and conglomerate (Fluvial deposit)

Depth:	2,400 meters below g.l.
Porosity :	18 %
Permeability :	70 mD
Original Pressure :	230 Bar
Current Pressure :	100 Bar

STRUCTURAL MAP



UGS CROSS SECTION



UGS WELLS



Injection / Withdrawal well

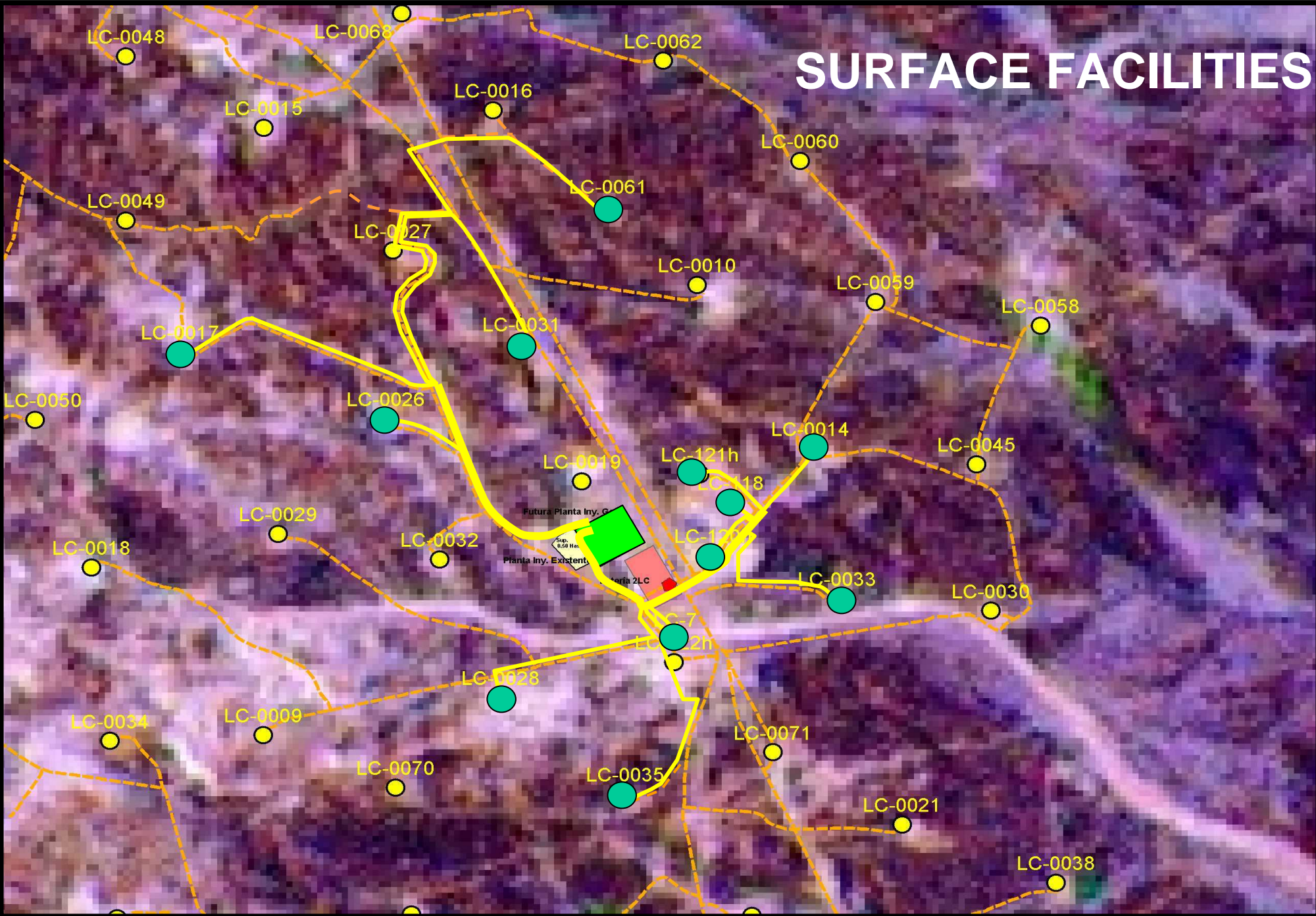


Gas monitoring well



Aquifer monitoring well

SURFACE FACILITIES





PART 2

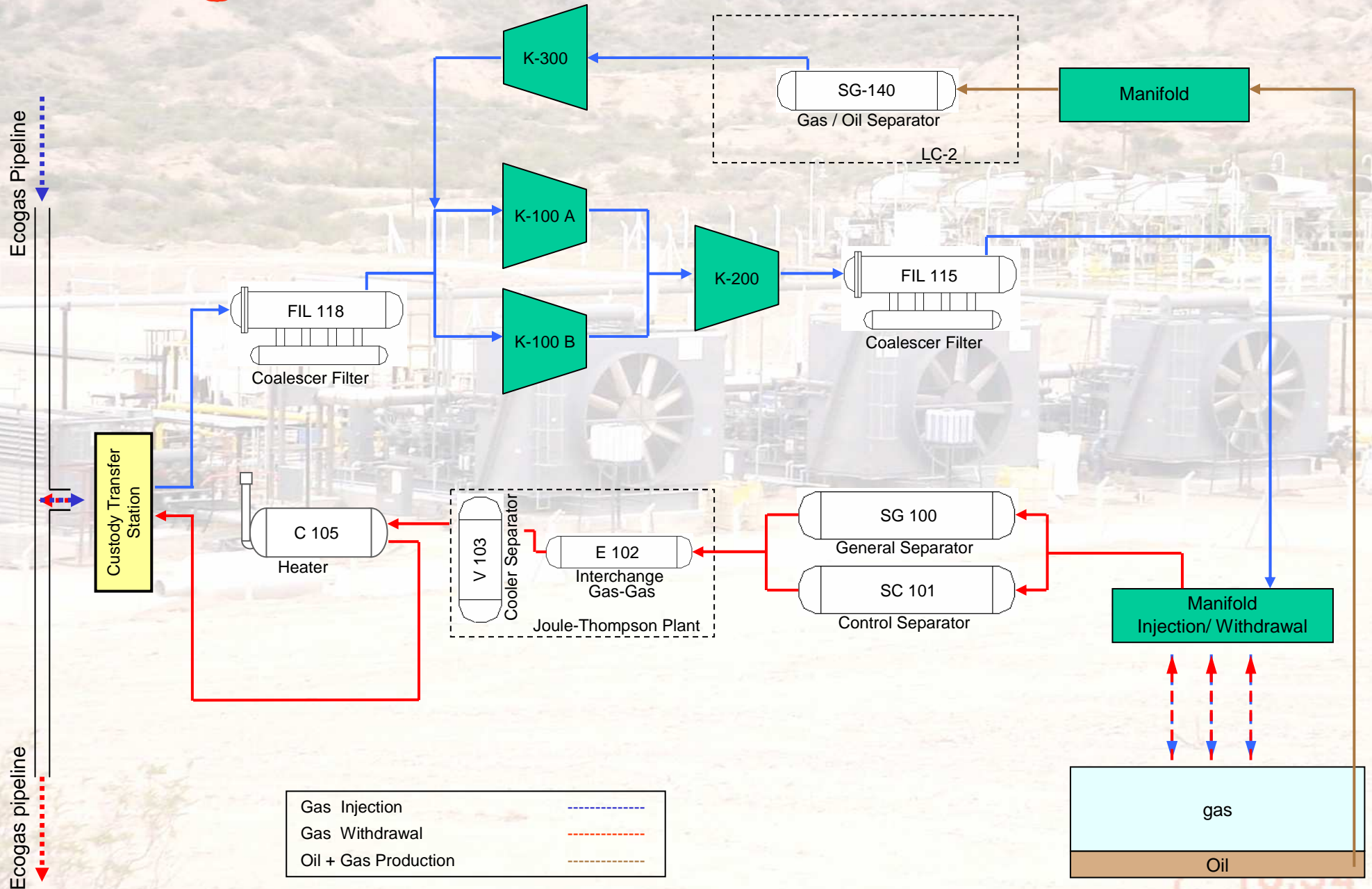
- **PILOT PROJECT GOALS**
- **COMPRESSION SYSTEM**
- **GAS BUBBLE EVOLUTION**
- **PRELIMINARY RESULTS**
- **QUALITY, SAFETY & ENVIRONMENTAL PROTECTION**



PILOT PROJECT GOALS

- ✓ Working gas: 120 M Std. m³
- ✓ Cushion gas: 150 M Std. m³
- ✓ Maximum pressure: 210 Bar
- ✓ Gas injection flow rate: 0,30 / 0,90 M Std. m³/d
- ✓ Maximum gas withdrawal: 1,0 M Std. m³/d
- ✓ Gas Injection wells (available) : 12
- ✓ Gas Monitoring wells: 12

COMPRESSION SYSTEM

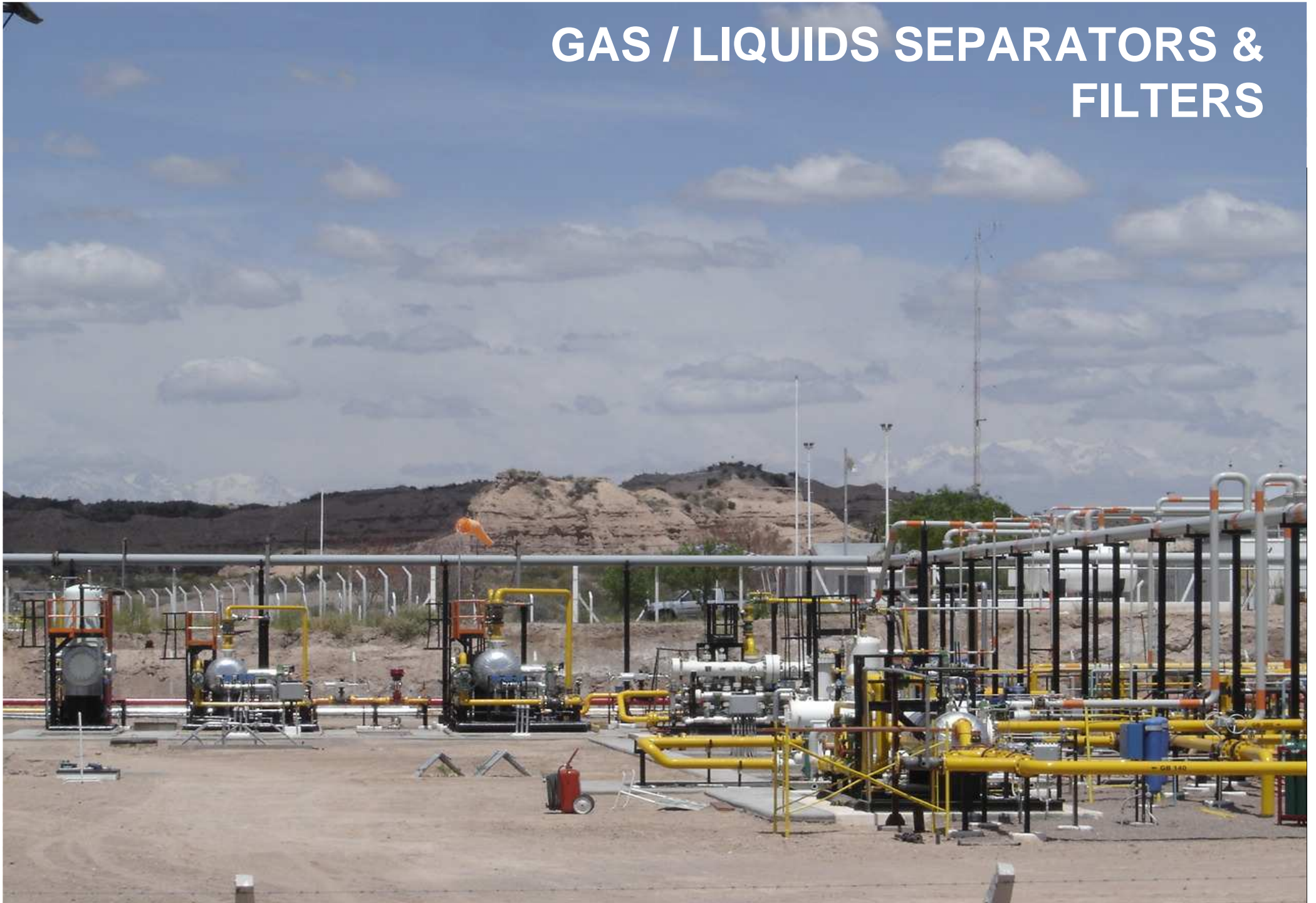


Gas Injection	-----
Gas Withdrawal	-----
Oil + Gas Production	-----

LUNLUNTA CARRIZAL GAS PLANT



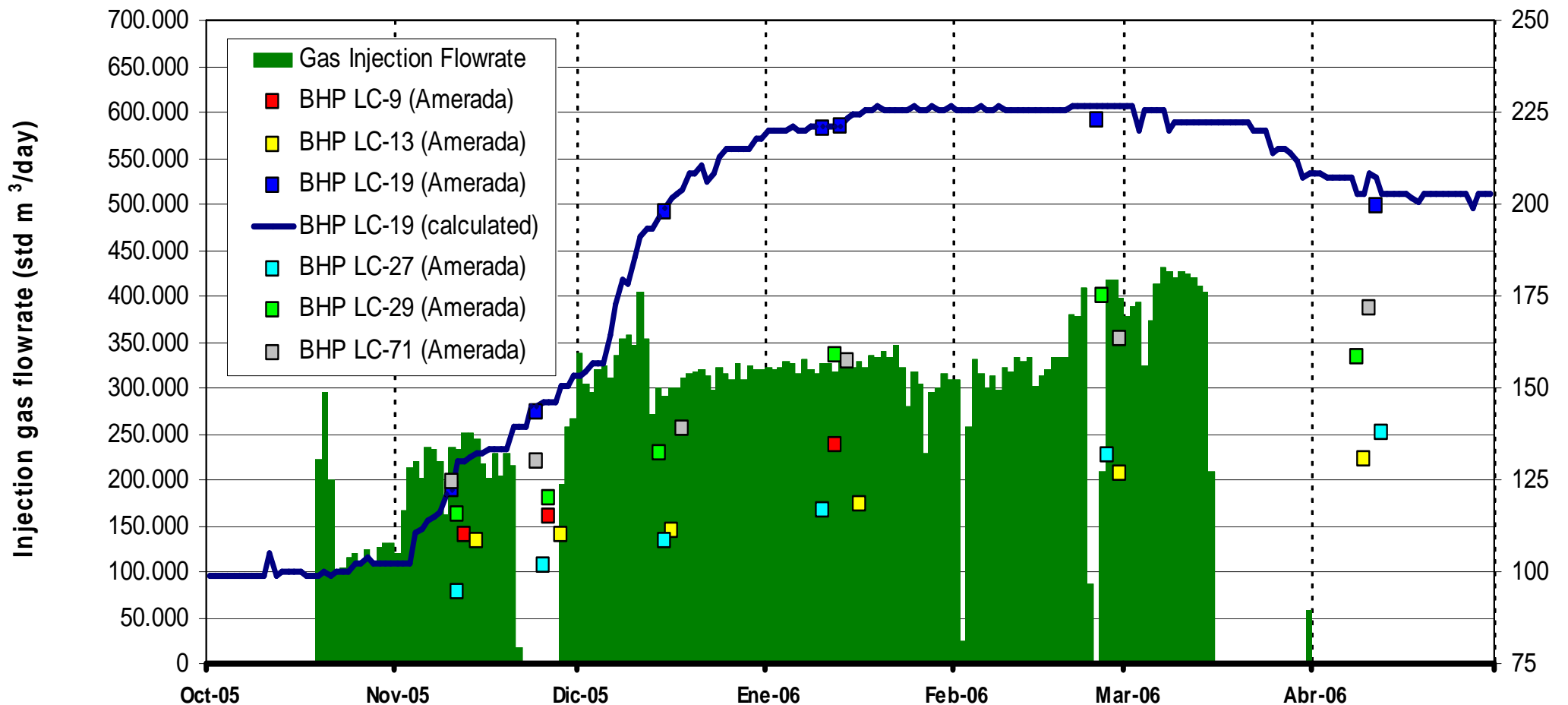
GAS / LIQUIDS SEPARATORS & FILTERS



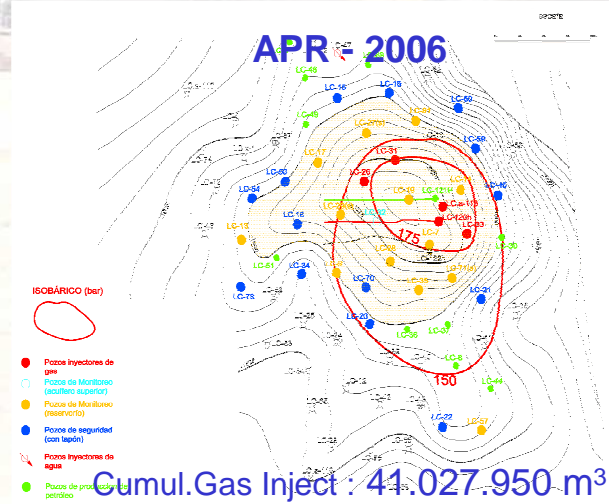
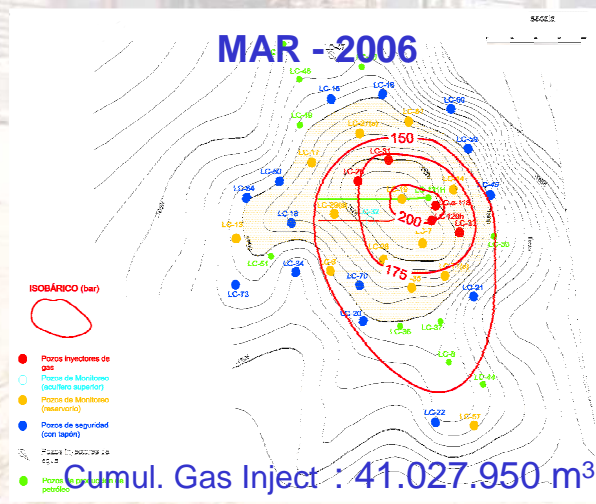
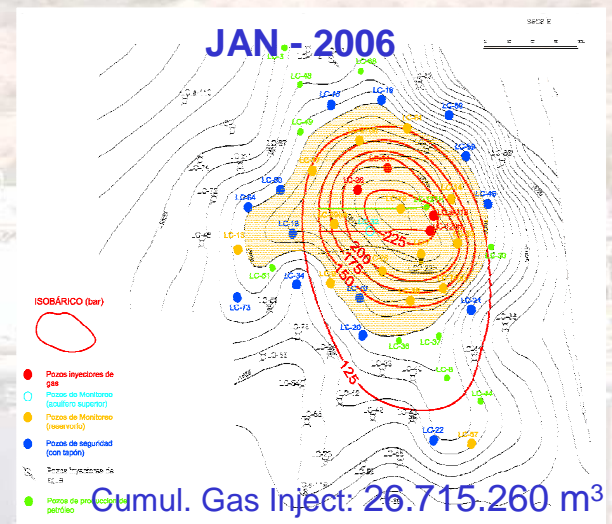
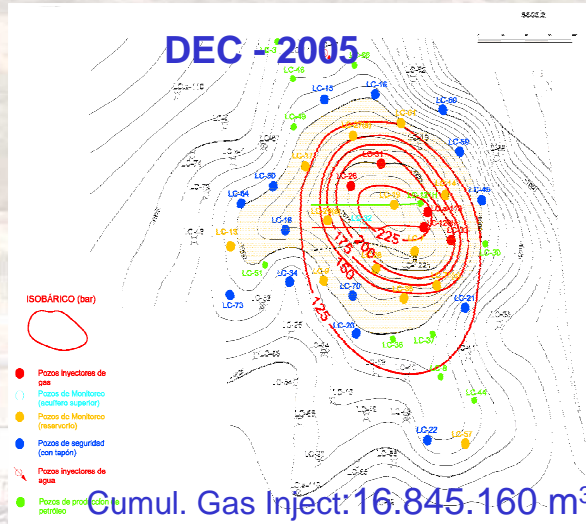
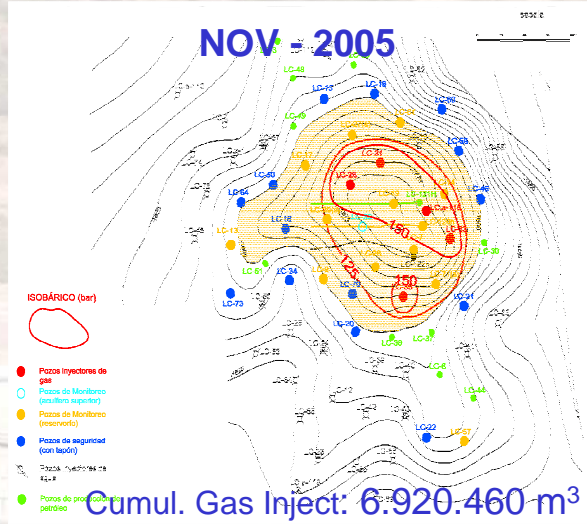
PRESSURE VARIATIONS IN THE MONITORING WELLS

UNDERGROUND GAS STORAGE IN LUNLUNTA CARRIZAL OIL FIELD

PRESSURE VARIATIONS IN THE MONITORING WELLS vs GAS INJECTION FLOWRATE



GAS BUBBLE EVOLUTION



Gas Injection wells used: 5

Gas Monitoring wells: 12

Gas inj. flow rate (avge) : 318.000 m³/d



PRELIMINARY RESULTS

- ✓ The gas injectivity of the wells matches previous estimates
 - ✓ Vertical wells: 50,000 std. m³/d per well
 - ✓ Horizontal well: 150,000 std. m³/d
- ✓ As expected, gas injection was not found to impact the aquifers located above the cap rock, which is clearly positive given the large number of wells drilled in the area.
- ✓ The major mobility of the gas injected is registered in zones with high permeability of the reservoir, which are at the same time, areas of high water saturation.
- ✓ The minimum gas saturation (S_g), necessary for a continuous gas bubble is about 7% of the porous volume.
- ✓ Considering a reservoir thickness of 10 meters and porosity of 18%, the gas volume necessary (S_g: 7%) is about 40 Mm³ (std), at pressure of 100 Bar .
- ✓ We estimate that 15 m on the top of the reservoir, is enough for developing a gas bubble of about 100 M Std m³ (S_g: 15%).



QUALITY, SAFETY & ENVIRONMENTAL PROTECTION

Repsol YPF successfully completed (2004) the certification of an Integrated Management System (IMS), including the following standards:

Quality (ISO 9001:2000)

Environmental Protection (ISO 14000:1996)

Safety and Work Health (OHSAS 18001:1999)

The aspects controlled by the IMS are:

- ✓ Water quality control in higher aquifers, every 6 months.
- ✓ Casing integrity in oil production Wells located in the area of gas bubble influence.
- ✓ Casing protection in Gas Injection Wells, against high pressure.
- ✓ Gas bubble control at spill points
- ✓ Escape gases composition control at the Compression Plant, Waste Disposal, etc
- ✓ On-line gas control (Scada): Auditable measurement system



CONCLUSIONS

- ✓ The Lunlunta Carrizal Project presents a major challenge for Repsol YPF as it involves developing a gas bubble in an undersaturated oil reservoir composed of low-permeability sandstones.
- ✓ After injecting more than 40 Million Std. m³ of gas into the reservoir, the gas bubble is in progress on top of the structure.
- ✓ The IMS in place at Lunlunta Carrizal Storage facility has provided us with effective control tools: no accidents since 2003, accurate gas balancing and a precise monitoring System of the gas bubble and upper aquifers.
- ✓ Gas production tests will be performed during Jun/Aug-2006, in order to assess recoverable gas volumes and productivity indexes,

