

Reducing Risk in the Implementation of the CO₂ Pilot Test in the Hall-Gurney Field, Russell County, Kansas

G. Paul Willhite

Tertiary Oil Recovery Project

Department of Chemical and Petroleum
Engineering

University of Kansas

Oil Recovery Conference

March 13, 2003

Overview

- **Pilot Pattern-2003**
- **Projected Performance**
- **Risk**
- **Uncertainty**
- **Development Plan to Reduce Risk and Uncertainty**
- **Progress to Date**

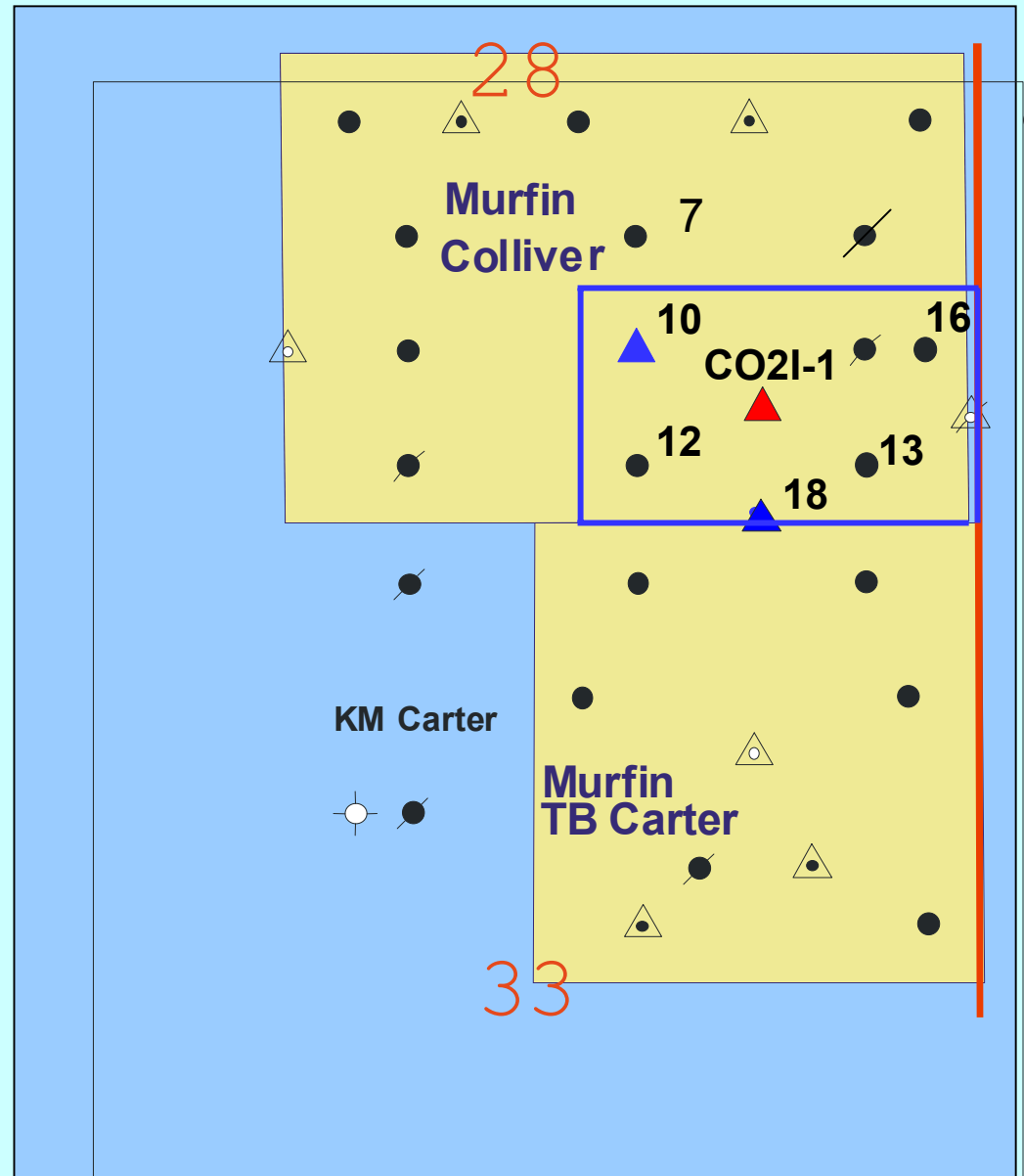
Pilot Project-2003

- Goal--conduct a pilot that minimized loss but provide sufficient information to expand to commercial scale if warranted.
- Oil in the tank
- Operating experience

14S-13W Russell Co., Kansas

Pattern #6

- ~15 acre half of five spot
- One CO2 injector
- Three Producers
- Two Containment Injectors
- 0.271 BCF CO2 injected
- 4.6 year operating life
- 27,784 BO estimated recovery



Flooding Plan

- **Pressure reservoir by injection of water with wells shut-in**
- **Must be able to reach pressure of ~1200-1300 psi (MMP) in significant portion of pattern volume**
- **Inject carbon dioxide in CO2 I-1 and begin pumping production wells-fluid levels controlled to obtain 500-600 psi BHP in production wells.**
- **Alternate water and carbon dioxide injection (WAG) to control rate that carbon dioxide moves through formation**

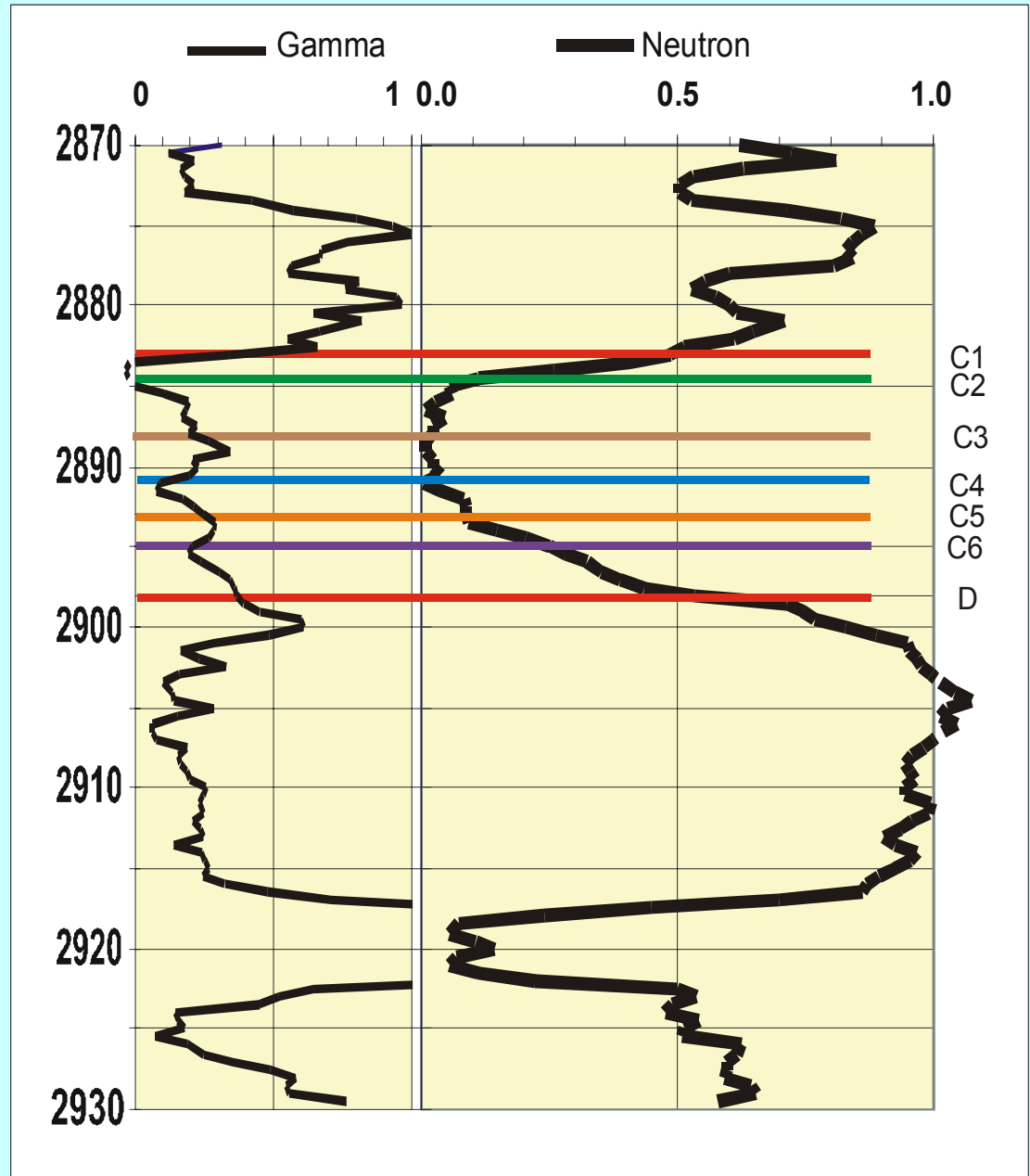
- **Colliver No.18
CO₂ Injector**

L-KC "C" divided into 6 Layers-three flooding cycles

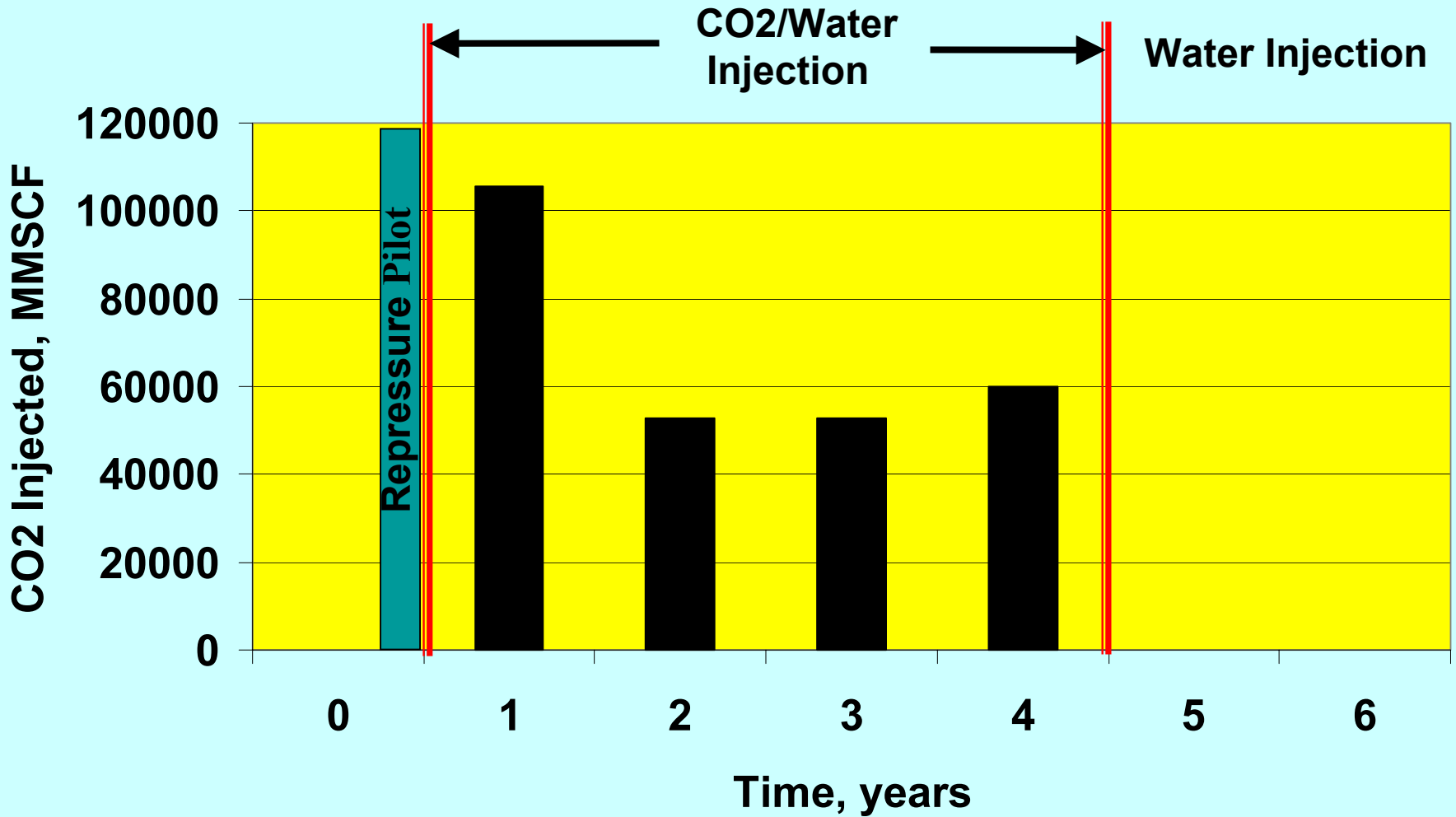
- **General Properties***

- C1: 8 md, 18.8%
- C2: 150 md, 25.8%
- C3: 40 md, 22.0%
- C4: 6 md, 19.4%
- C5: 2 md, 14.7%
- C6: 0.3 md, 12.0%

*.- Colliver No. 18 injector exhibits better properties than average for site

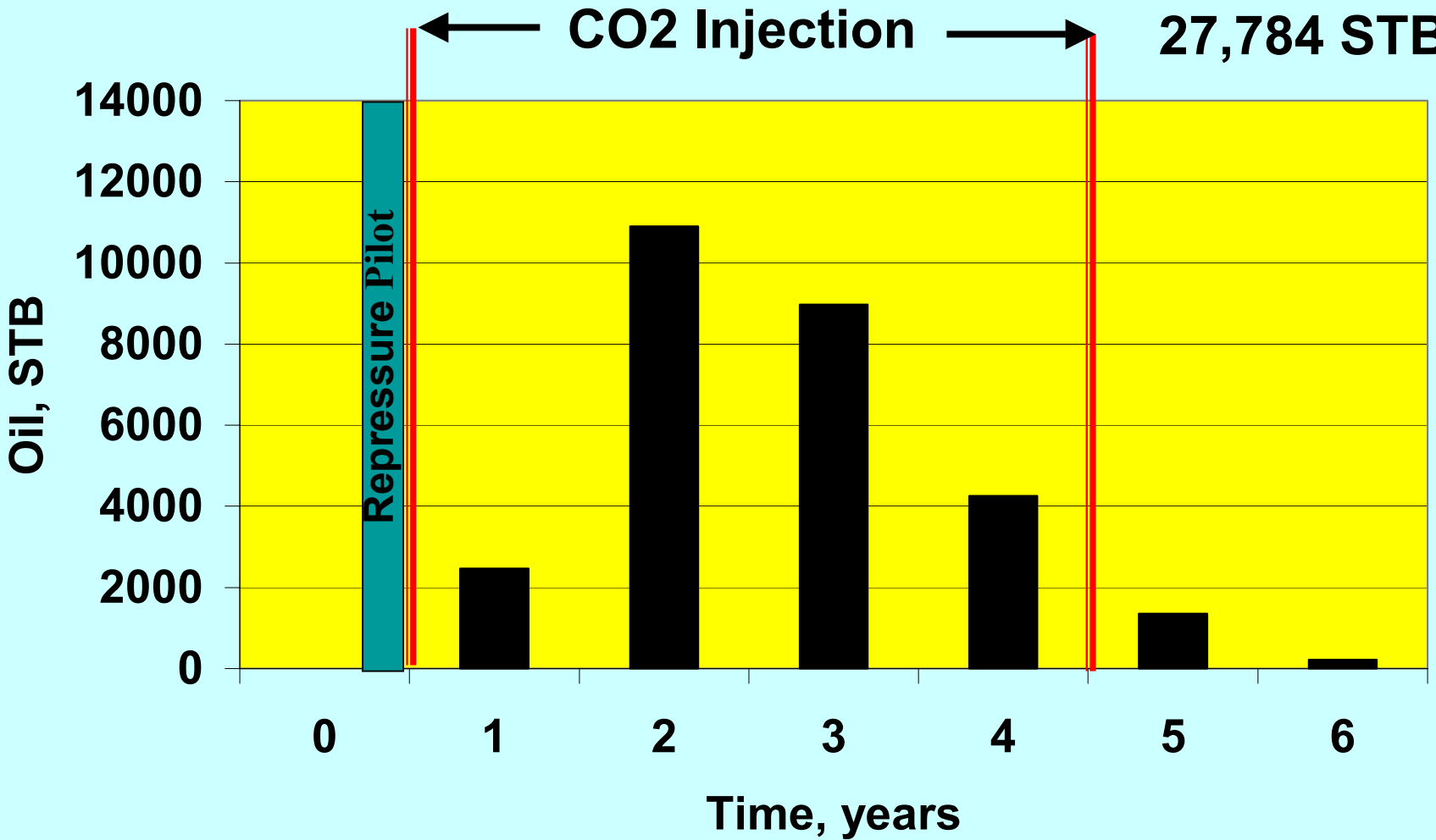


Carbon Dioxide/ Water Injection 271,360 MMSCF



Anticipated 15 Acre Pilot Response ~20%PPV

Cumulative Oil
27,784 STB



Summary of Costs- 2002 Design (15 Acre)

Facilities	\$918,215
Flood Operations	\$928,658
CO2 Supply	\$870,000
Research, Data, Tech Transfer, Administration	\$1,698,168
Total	\$4,415,041

Summary of Revenue Sources- 2002 Design(15 Acre)

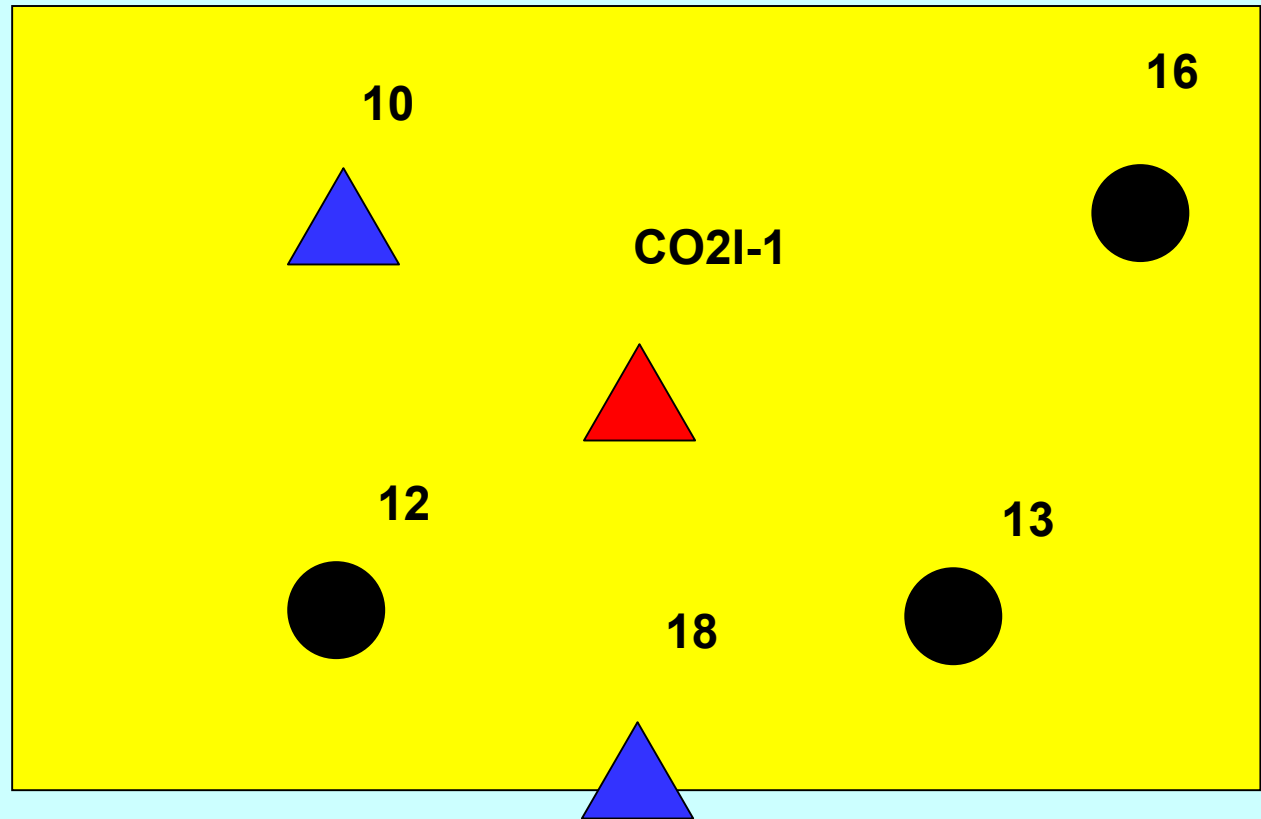
	In-Kind	Cash
DOE		\$1,702,242
Murfin and WI		\$903,124
Kinder-Morgan	\$188,500	\$54,716
U.S.Energy Partners	\$377,000	
KUCR(TORP,KGS)	\$1,001,458	
State of Kansas-DOC		\$188,000
Totals	\$1,566,958	\$2,848,082

Summary of Partner Contributions

	Contribution	Cost
Kinder-Morgan	CO2 in-kind	\$176,384
US Energy Partners	CO2 trucked to site(\$1.05/MCF from DOE funds)	\$284,928
USDOE	45% Startup Costs	\$284,928
USDOE	35% of LOE	\$125,867
State of Kansas	KDOC	\$88,000
Murfin and WI Partners	55% of Startup Costs	331,277
	65% of LOE except CO2 Costs	\$233,753
Total		\$1,525,162

Carbon Dioxide Pilot Flood

- Must be able to reach pressure of ~1200-1300 psi (MMP) in significant portion of pattern volume



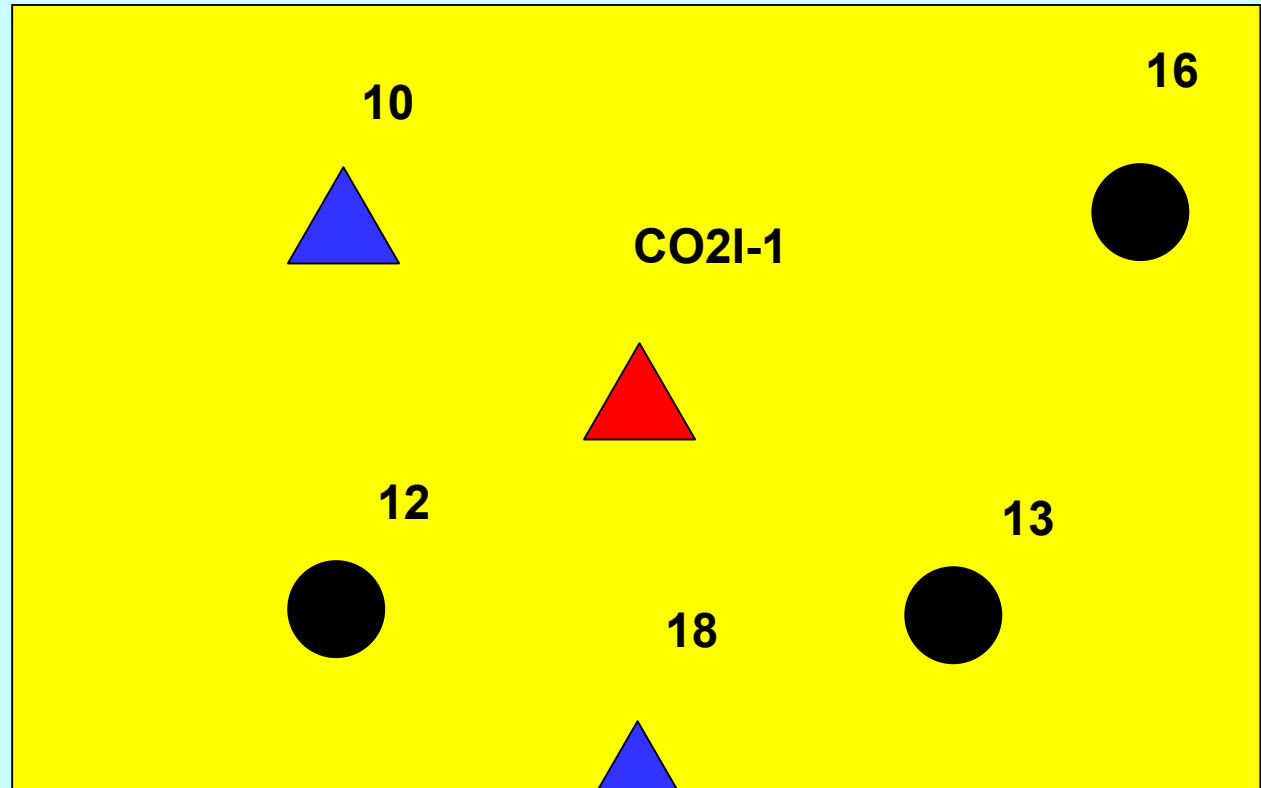
Carbon Dioxide Pilot Flood

Pressure Management

BHP in CO2 I-1
@ 2000 psi

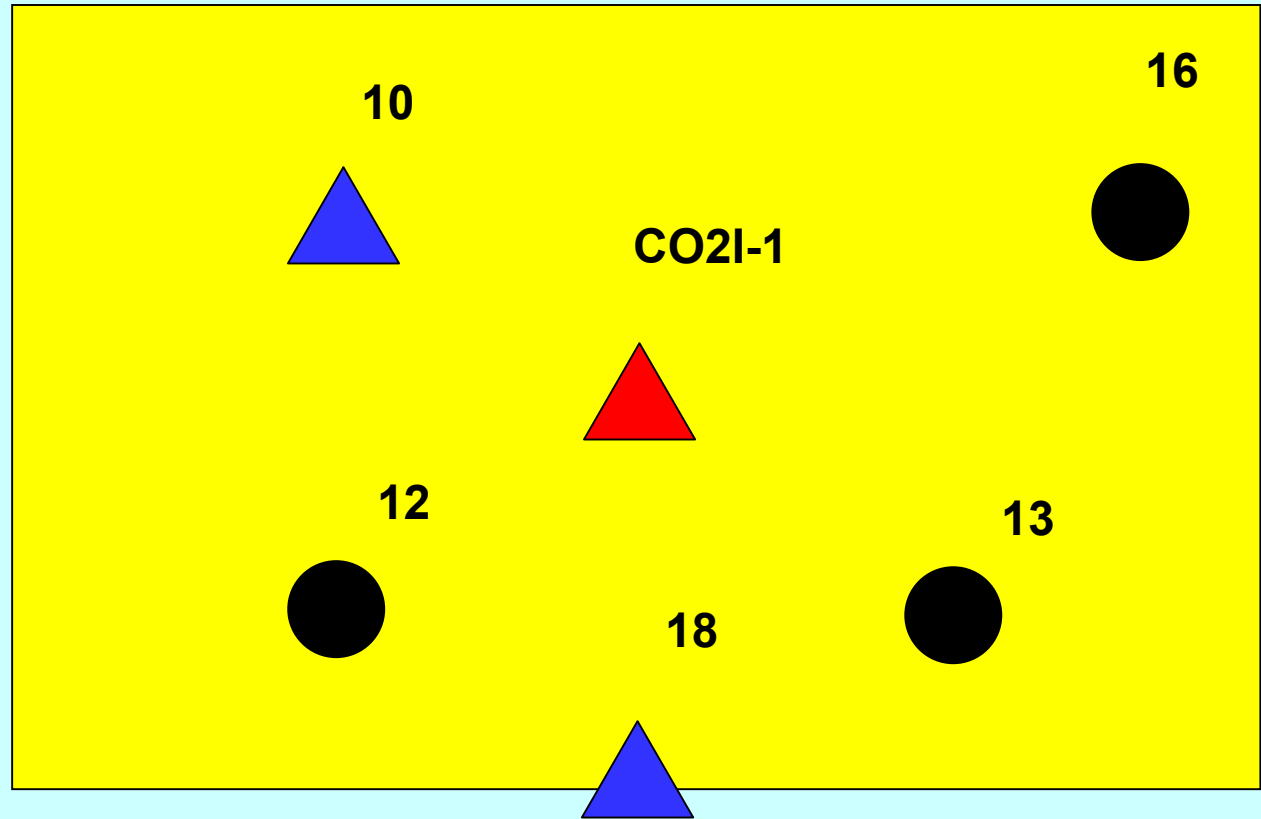
Injection into
C10 and C18

BHP in
production
wells
@500-600 psi



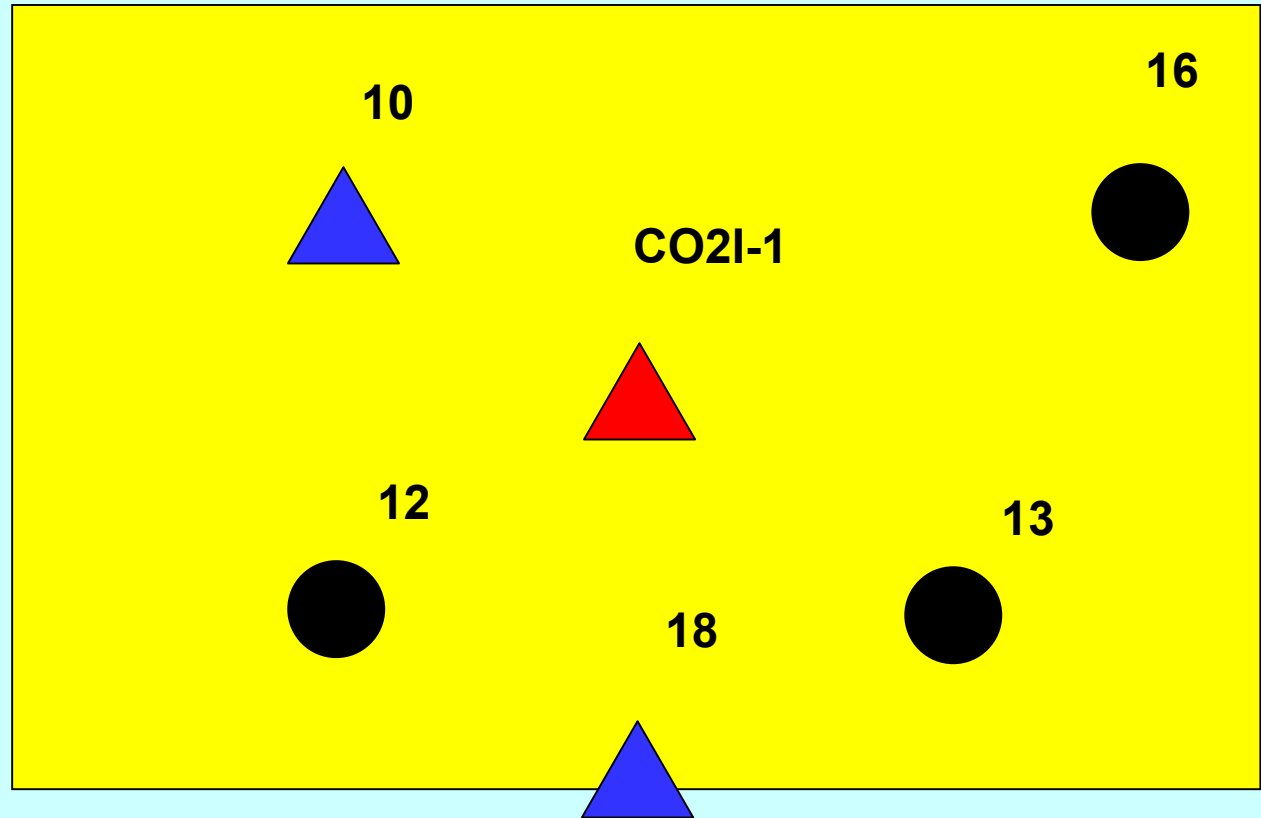
Carbon Dioxide Pilot Flood

Inject carbon dioxide and water in CO2 I-1 at rates to permit completion of the flood in the project time frame



Carbon Dioxide Pilot Flood

Simulations demonstrate that confinement is possible using C18 and C10 as confinement wells



Reservoir Risks

- Fluid injection rates in CO2I-1 adequate to complete pilot test in specified time limits?
- Good interwell continuity in **C** zone in pilot region?
- Development of adequate pressure bubble in pilot area?
- Isolation of **C** zone?
- Oil saturations less than estimated?

Financial Risks

- Capital investment in well recompletion and surface equipment would be lost if project did not move into implementation phase (there is some salvage value)
- Reduced income if projected oil recovery does not meet expectations
- Income delayed and operating expenses increase if fluid injection and production rates are less than anticipated

Working Interest Partnership- Startup Costs

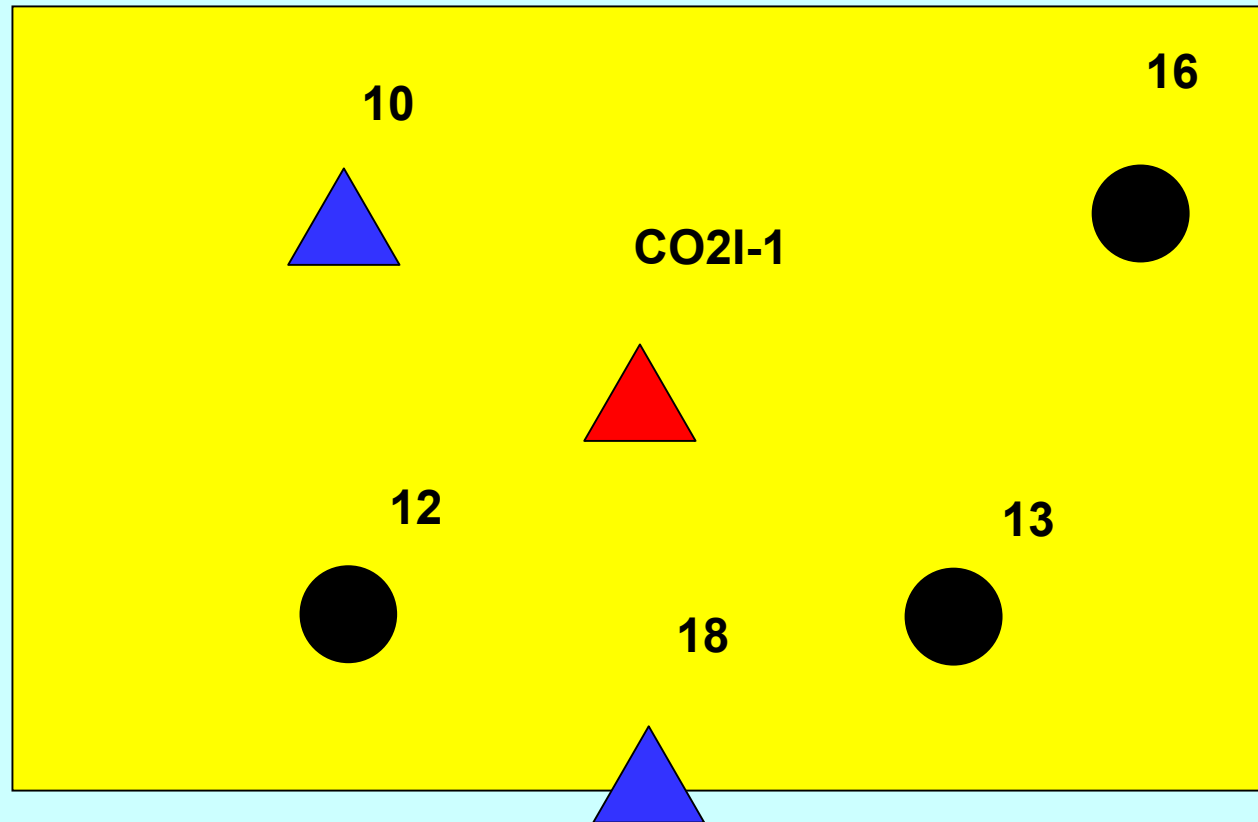
	Step WI Cost	Cum WI Cost
WI Cost to Date	49,686	49,686
Leasehold	71,000	120,686
KS Dept of Com	(88,000)	32,686
Water Supply	28,875	61,561
Colliver #12	29,071	90,632
Colliver #16	49,289	139,921
Surface Facilities	148,260	288,181
Colliver #10	43,096	331,277

Reducing Risk Through Project Management

- Identification of GO/NO GO points in the project
 - Recompletion of wells-multiple zones open
 - Injection rate into CO2I-1
 - Water supply
 - Interwell continuity
 - Pressurization of pilot area
 - Installation of carbon dioxide injection facilities

Project Planning

How should field work be managed to minimize risk due to uncertainties in the reservoir characterization and wellbore costs?



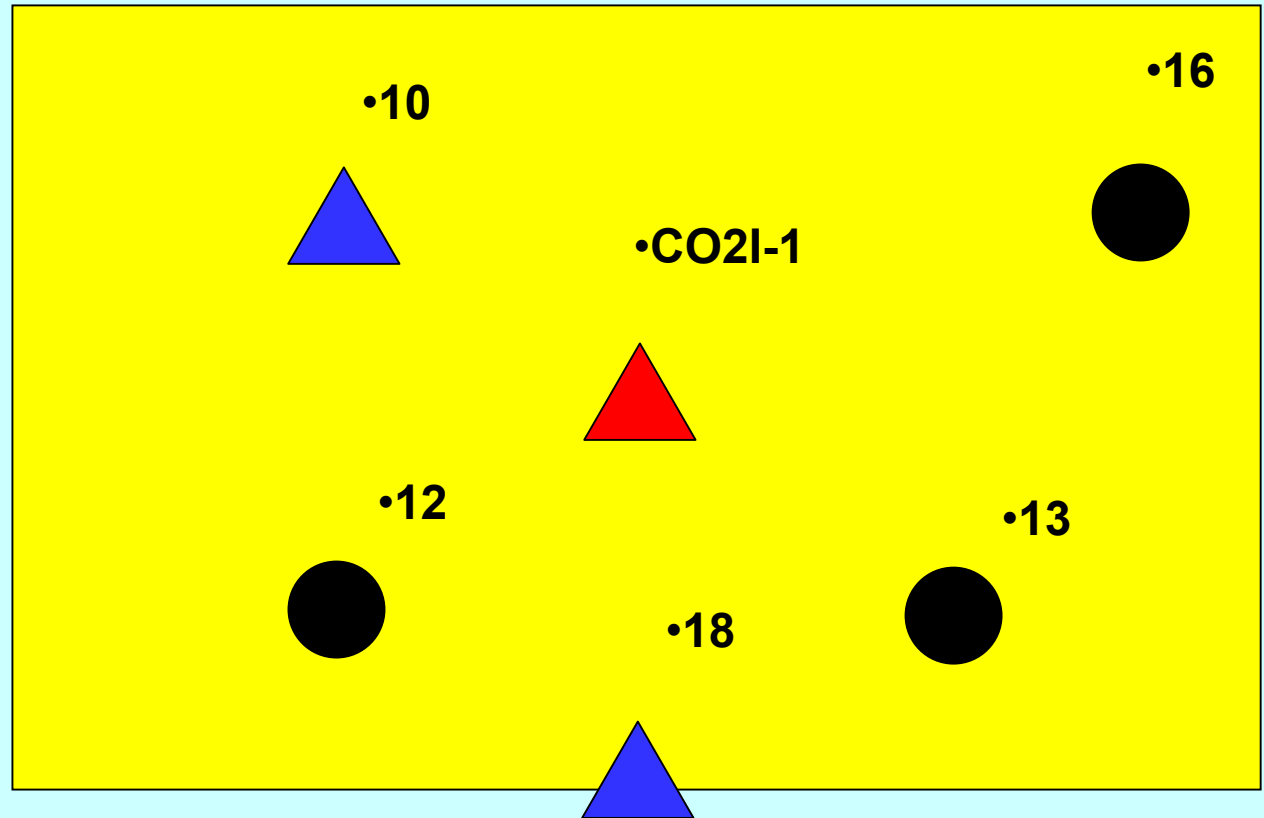
Ranking Uncertainties by Risk (Highest to Lowest)

1. Pulling liner from Colliver 16(completed in shallow zones)
2. ***Injectivity of CO2I-1***
3. Recompletion of Colliver 12-**C zone** only
4. Recompletion of Colliver 10-**C zone** only
5. ***Interwell continuity between CO2I-1 and pattern wells***
6. ***Re-pressurization of pilot area***
7. Recompletion of Colliver 16 into LKC **C zone**
8. Recompletion of Colliver 13 into LKC **C zone**

Field Work-Progress

Colliver 16

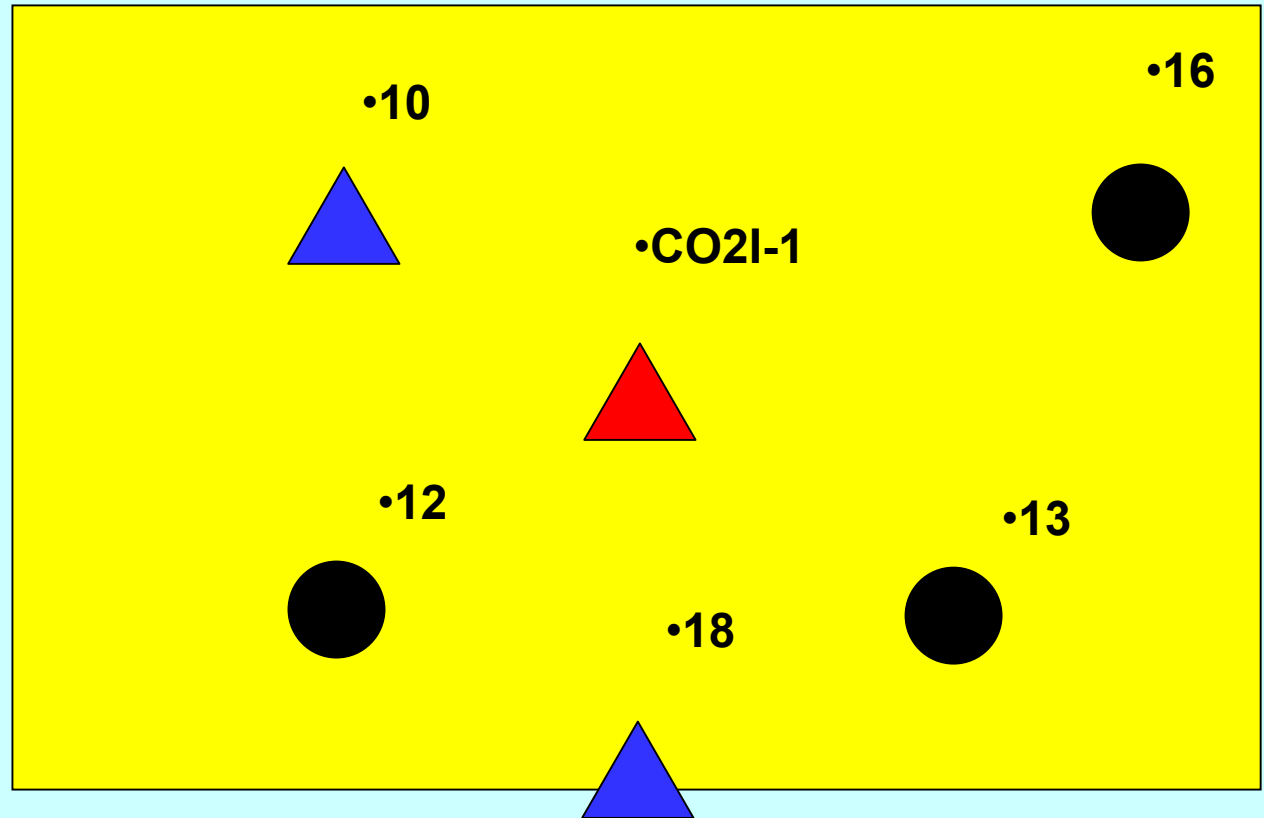
- Completed in shallow zone with liner
- Liner pulled-12/02
- Deepening to C zone and recompletion appears possible with no additional risk



Field Work-Progress

CO2I-1

- Short term injectivity test completed 2/7/03
- Projected stable injection rate ~140 B/D at 2000 psi BHP



Field Work-Progress

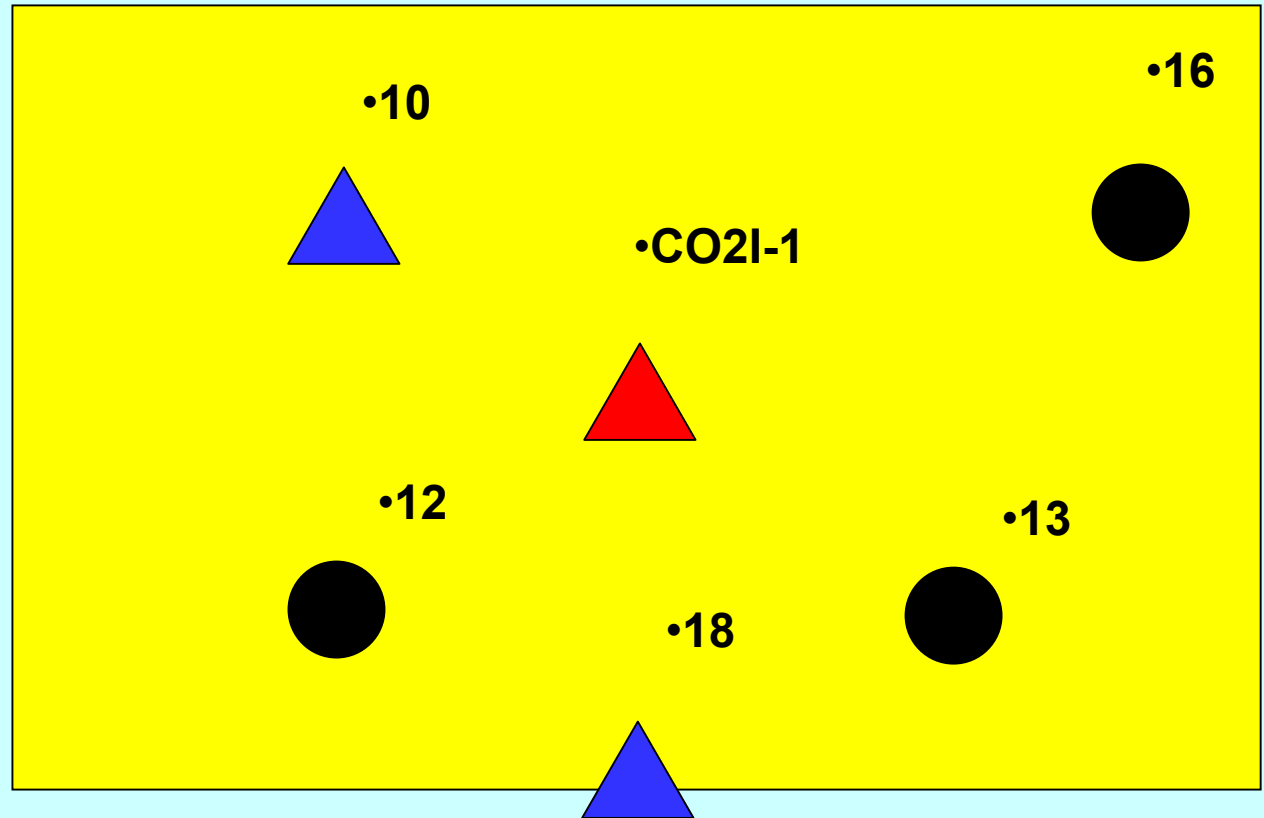
Colliver 12

Open in C, G and several shallow zones

•G plugged 2/18/03

•Shallow zones isolated with liner

• C zone recompletion 3/7/03



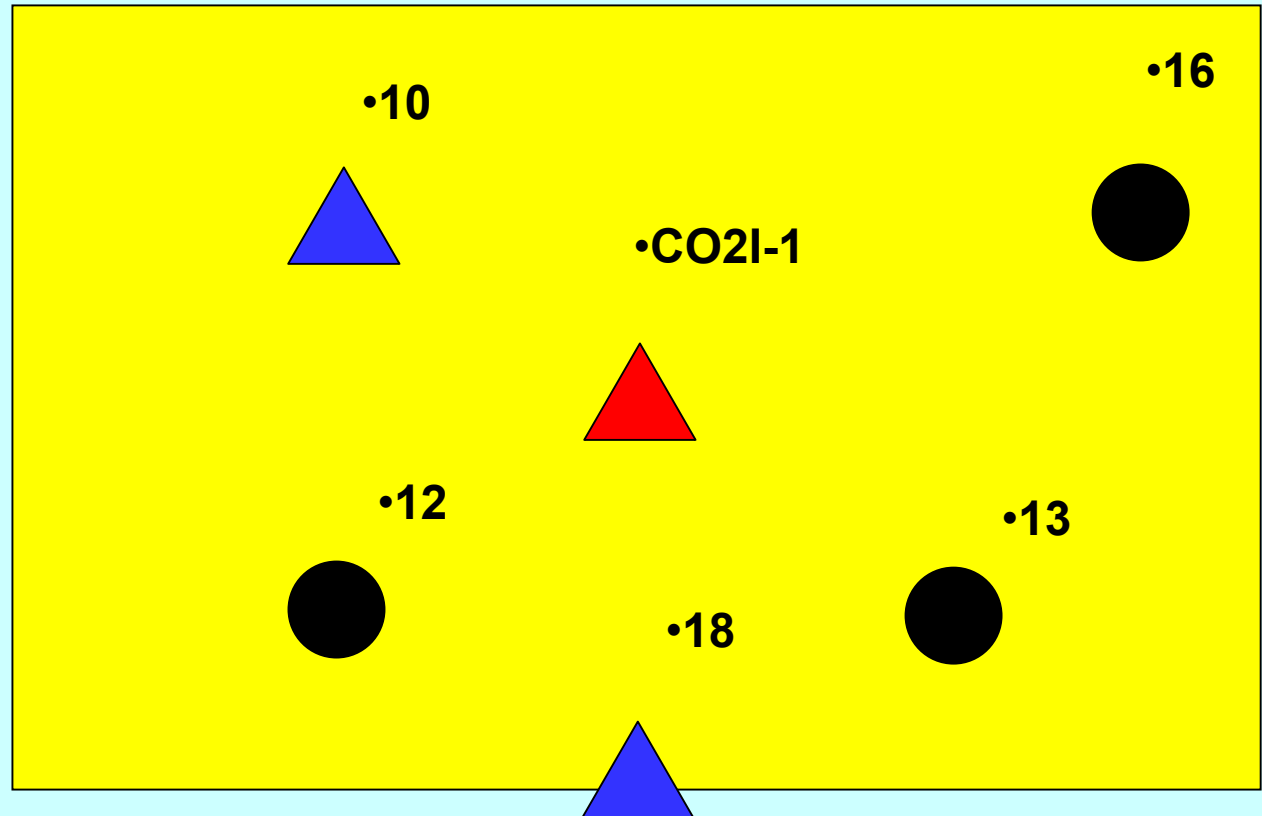
Field Work-Progress

Colliver 10

Open in several shallow zones

•C, G plugged 10/01

•Recomplete C with tubing on packer to isolate C from shallow zones-in progress

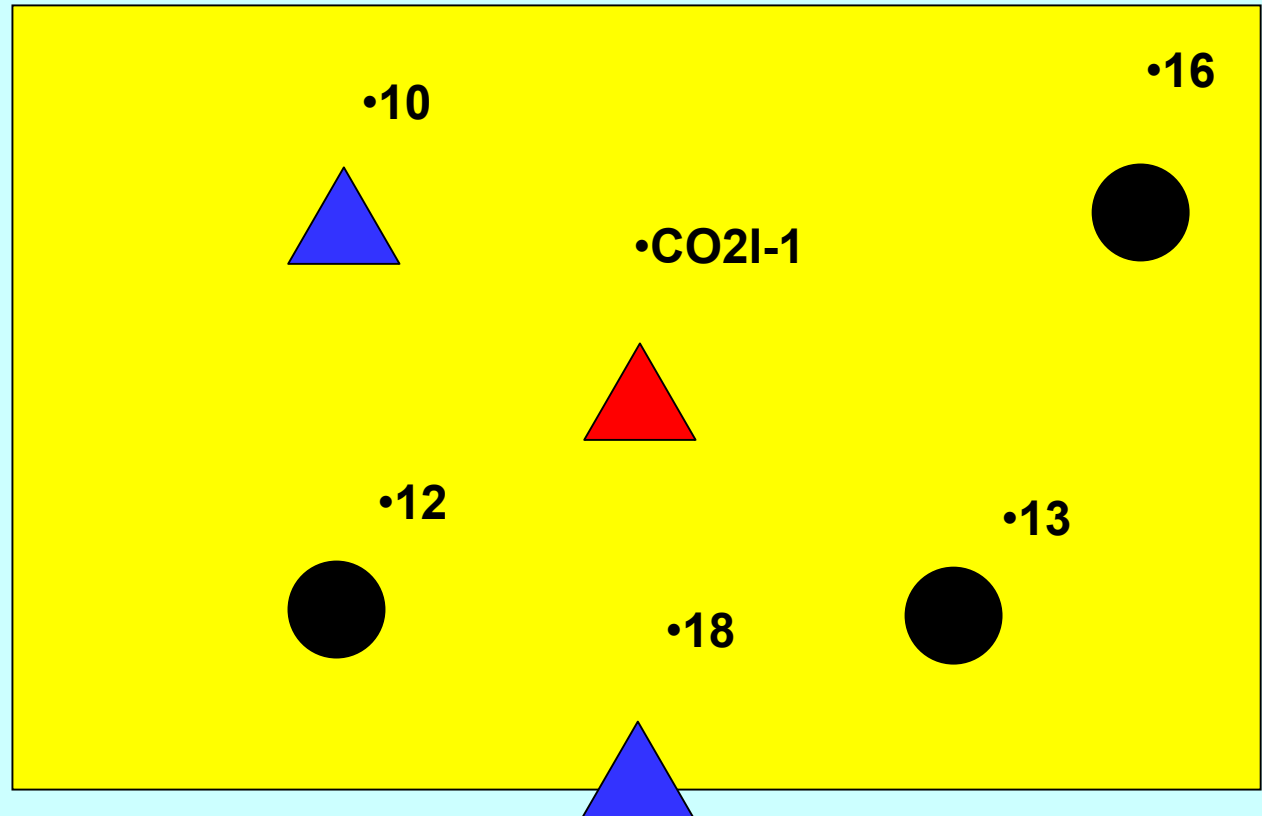


Field Work-Progress

Colliver 18

Water disposal well
for lease

- Open in B and C
- Fill above C
- Shut-in 3/03 to observe effect on surrounding wells.



Water Injection System

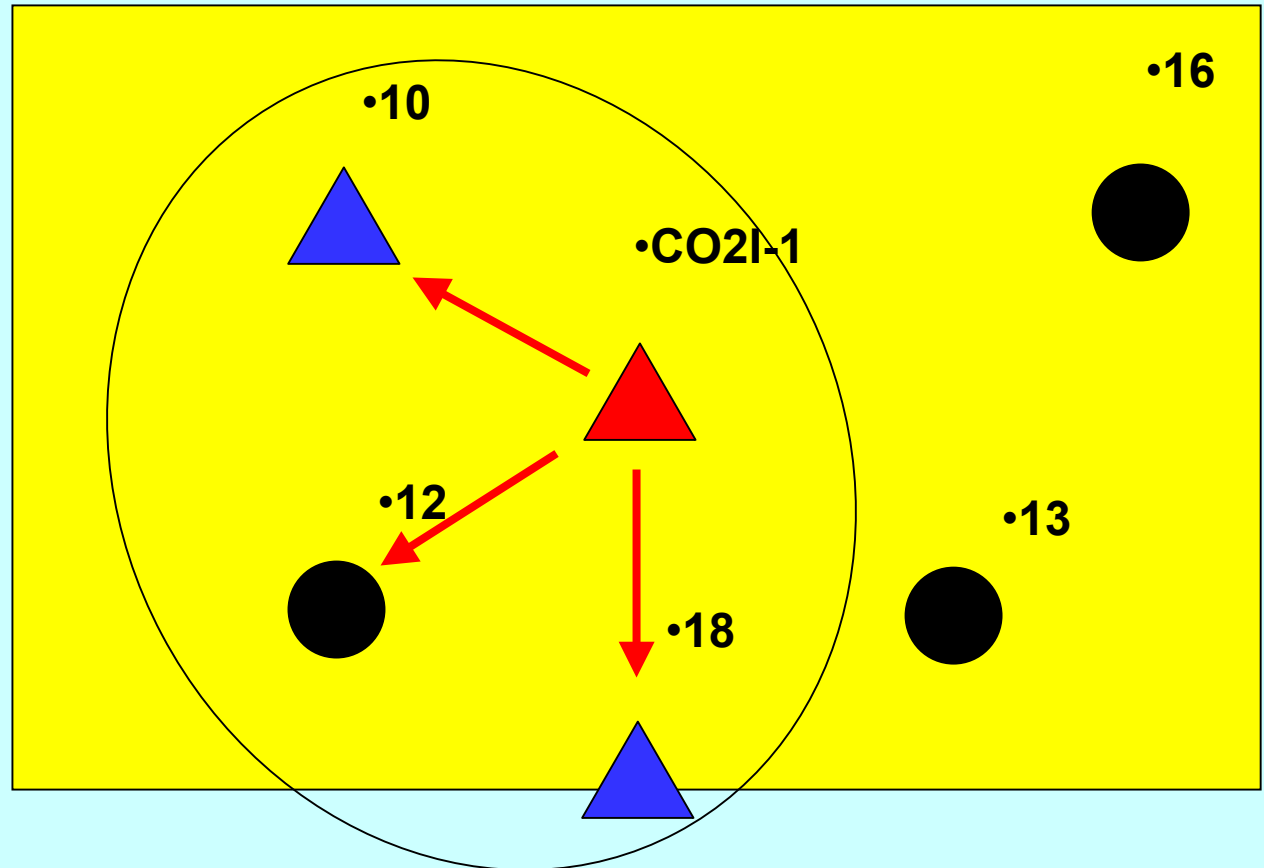
- Water source identified and tested
 - Water supply to be drilled on the lease
- Injection system designed
 - 200 BBL storage tank
 - Triplex pump
 - Pressure control valve
 - Filter through 5 micron filter system

Field Work-Planned

CO2I-1

Long Term Injectivity Test

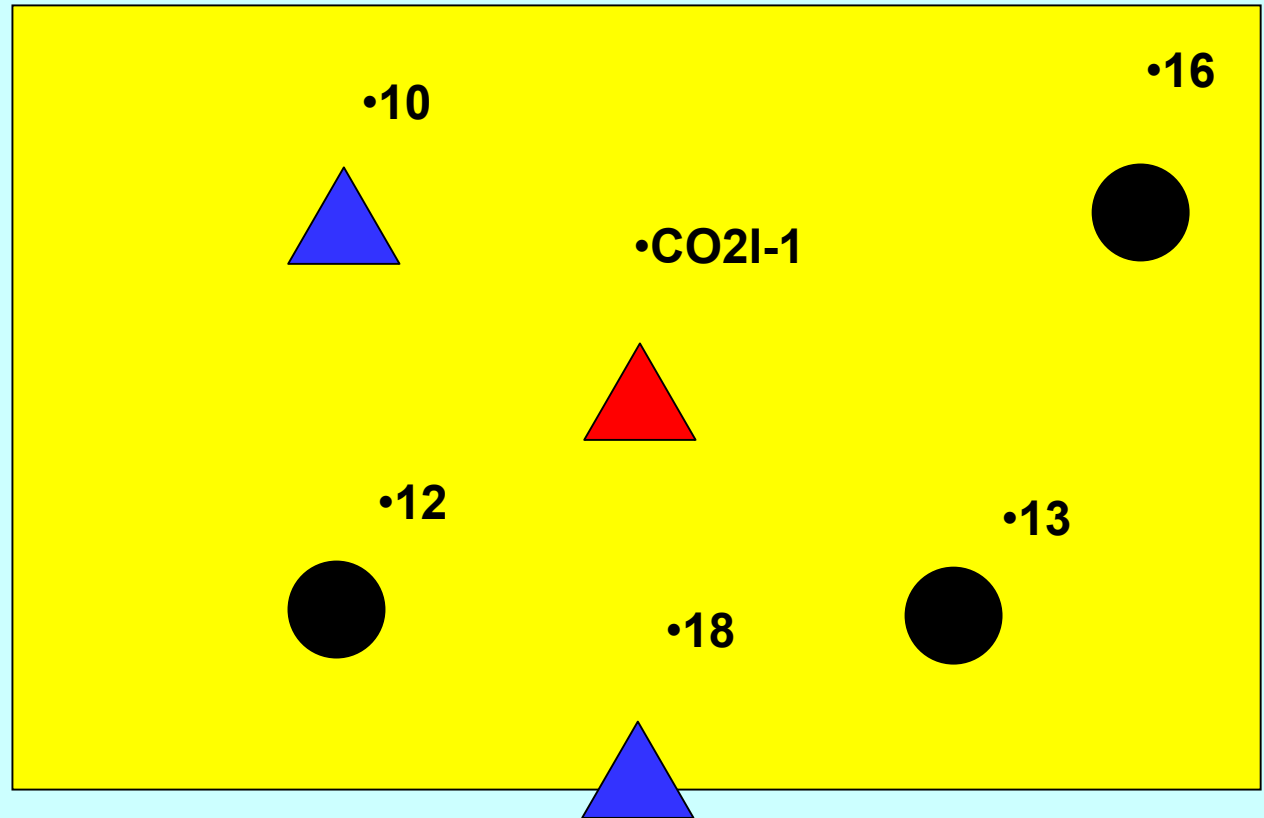
- Verify continuity between CO2I-1, C12, C10 and C18
- Assess capability to increase pressure in pilot region to MMP



Field Work-Planned

Colliver 16

- Deepen to C zone and obtain core
- Install liner and recomplete in C zone
- Evaluate interwell continuity with CO2I-1



Field Work-Planned

Colliver 13

Open in several shallow zones

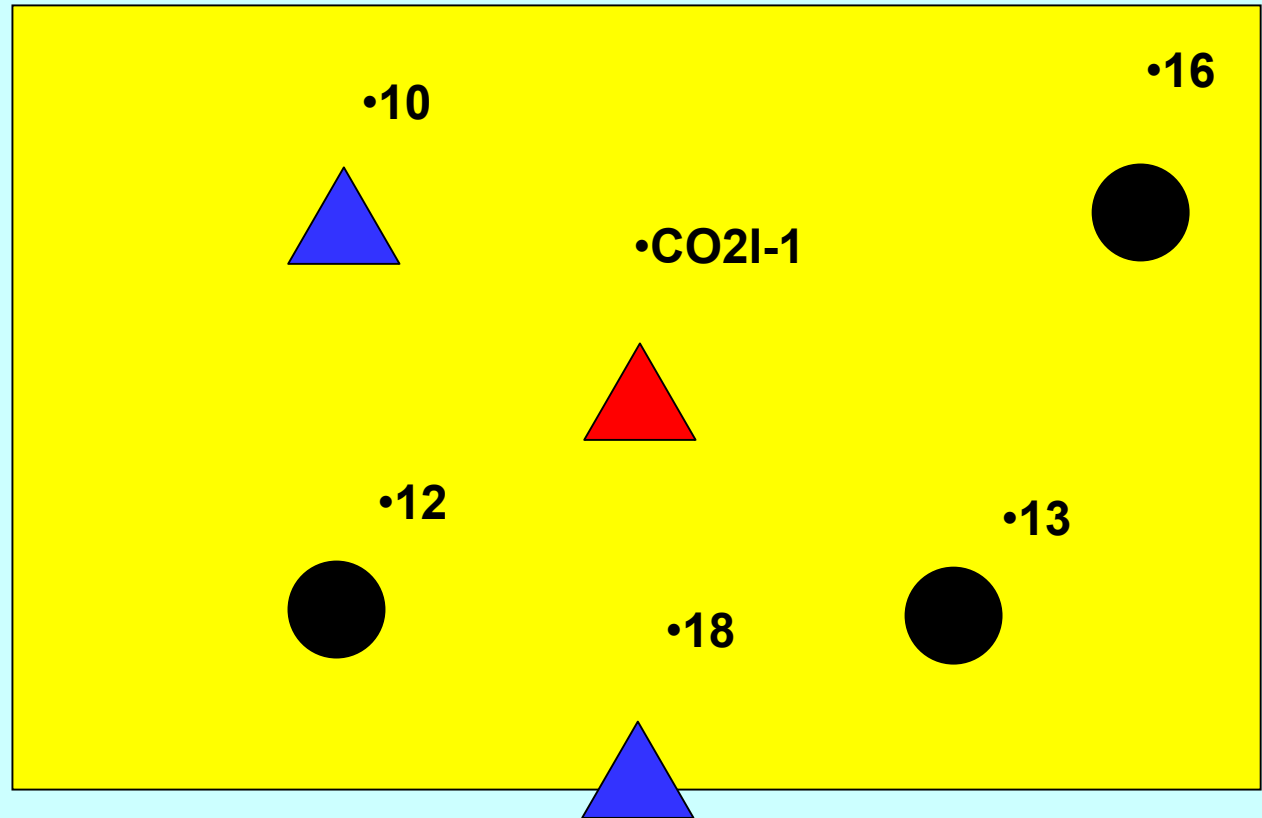
- Bridge plug above C

- C, G comingled

- Plug G

- Install liner to isolate shallow zones

- Recomplete C with tubing on packer to isolate C from shallow zones

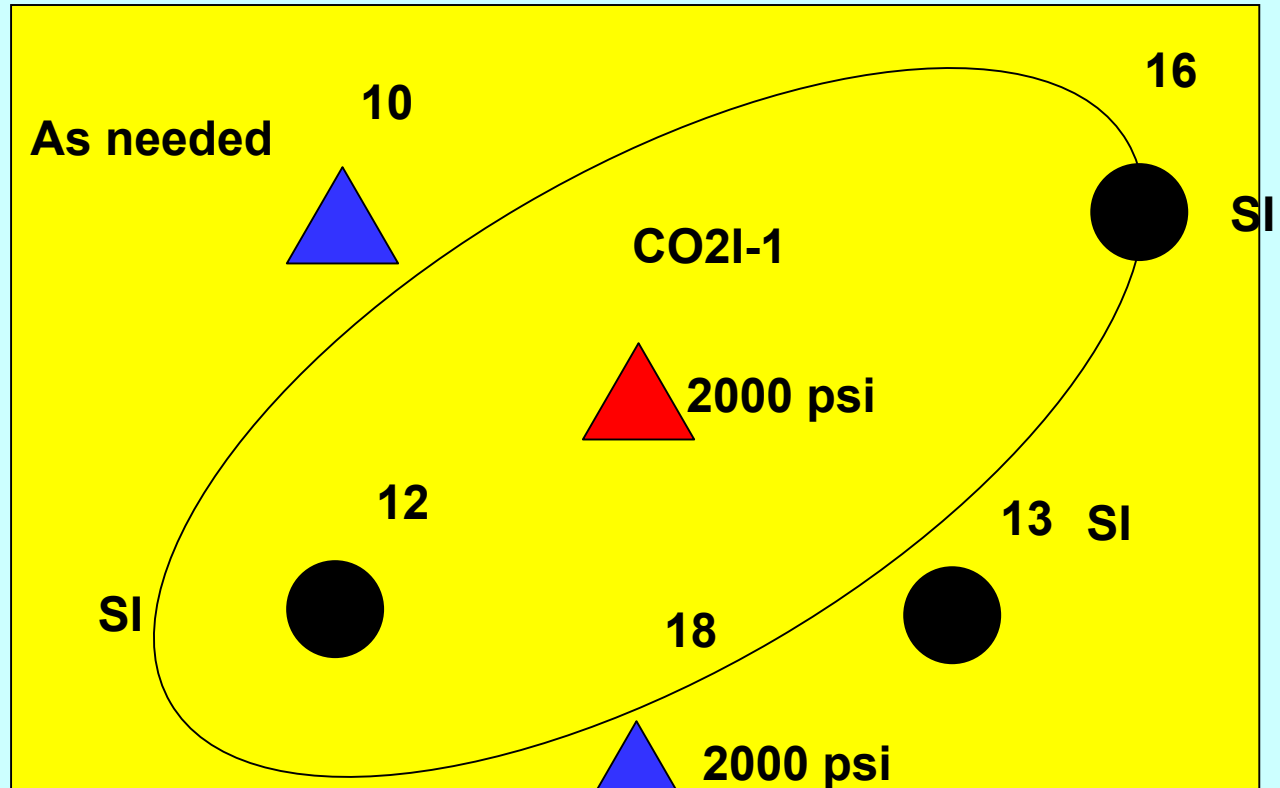


Field Work-Planned

Re-pressure Reservoir

CO2I-1

- Inject at BHP=2000 psi
- C18-inject at BHP=2000 psi
- Inject at BHP=2000 in C10 as needed
- Shut-in C12, C16, C13 and monitor pressure



Projected Timeline

- **Water supply system developed and tested-March 24**
- **Long Term Injectivity Tests-CO2I-1 begin by March 24**
- **Initial evaluation interwell continuity -March 31**
- **Reservoir simulation/history match-April-May**
- **Decision to re-pressure reservoir
-June 1(Add Colliver 10,18)**
- **Decision to implement carbon dioxide injection-
July 1**
- **Reservoir re-pressurization completed by August 24**
- **CO2 Injection begins August 24**

Project Funding-DOE Class Revisited Program

- **Budget Period 1: Reservoir Characterization and Advanced Recovery Analysis**
March 2000-March 2003
(DOE Cost Share 45%)
- **Budget Period 2: Field Demonstration and Analysis:**
April 2003- March 2008
(DOE Cost Share 35%)
- **Budget Period 3:Monitoring and Post Flood Analysis:**
March 2008-March 2009
(DOE Cost Share 10%)