Vertical Conformance, the Challenge at Rangely

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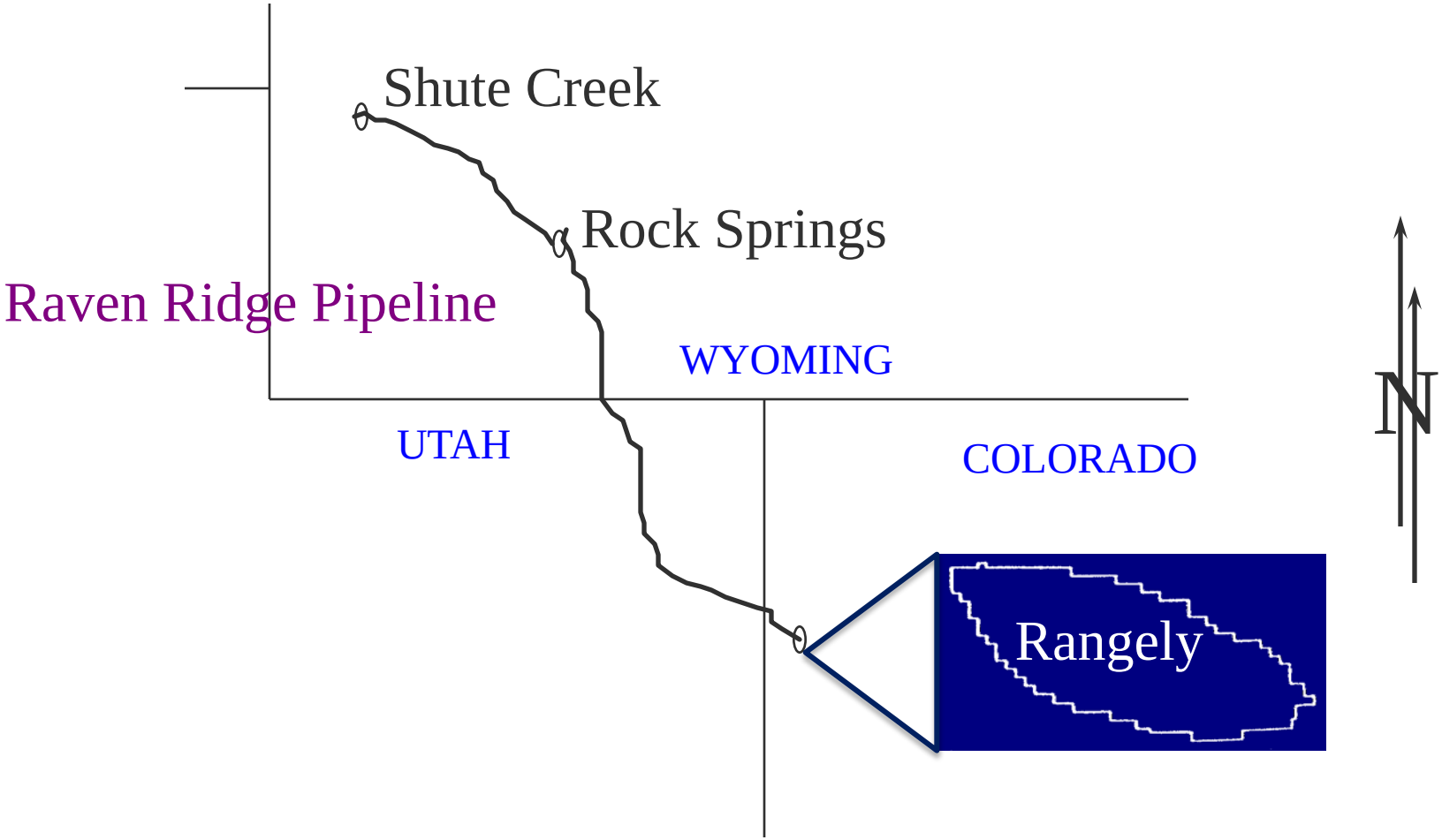
Midland, Texas

Agenda

- The Rangely Weber Sand Unit (RWSU).
- The geology of the Weber Sand.
- The pace of development and completion strategies.
- The Water Flood project development.
- Preparation for the CO_2 project.
- Conformance improvement.
- Lessons Learned / Summary.

Rangely Weber Sand Unit, RWSU



Rangely Statistics, 2014

Daily Average 2014	
Oil Production	11,200 B/D
NGL Production	1,200 B/D
Water Production	250,000 B/D*
Gas Production	153 MMCF/D*
CO_2 Purchases	35 MMCF/D
*All produced gas and water is re-injected.	

Cumulative as of 2014	
Oil Production	897 MMB
NGL Production	12.9 MMB
Water Production	4.7 BB
CO_2 Purchase	573 BCF
Gas Production (since CO_2)	1.2 TCF
CO_2 Injection	1.8 TCF

Well Data, 2014

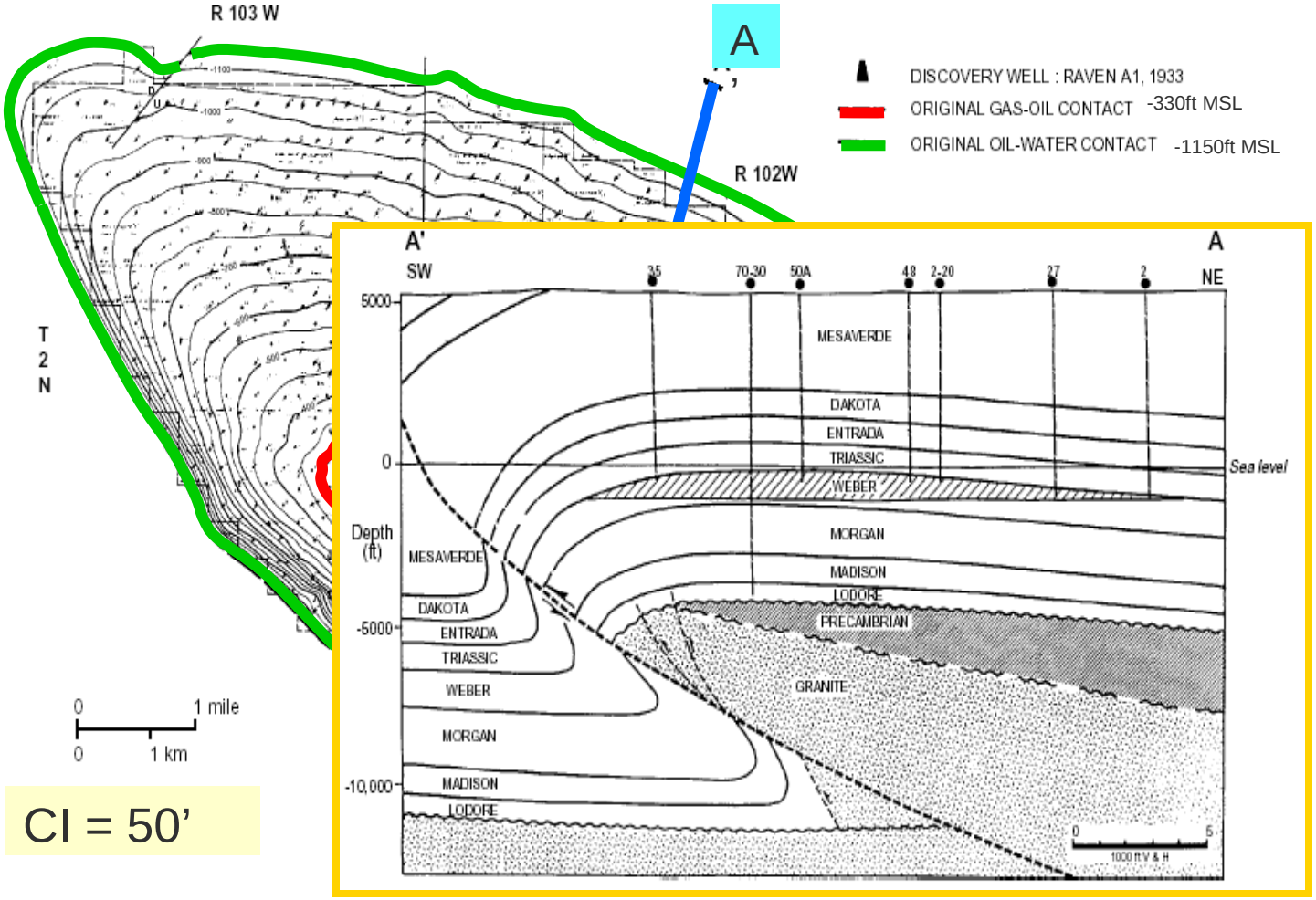
Average Elevation	5300 FT
Average Perf Depth	6000 FT
Active Producers	415
304 Electric Submersible Pumps	
46 Flowing Wells	
65 Rod Pumps	
Active Injectors	277
Total Wells, including P&A and SI	954

Reservoir Properties

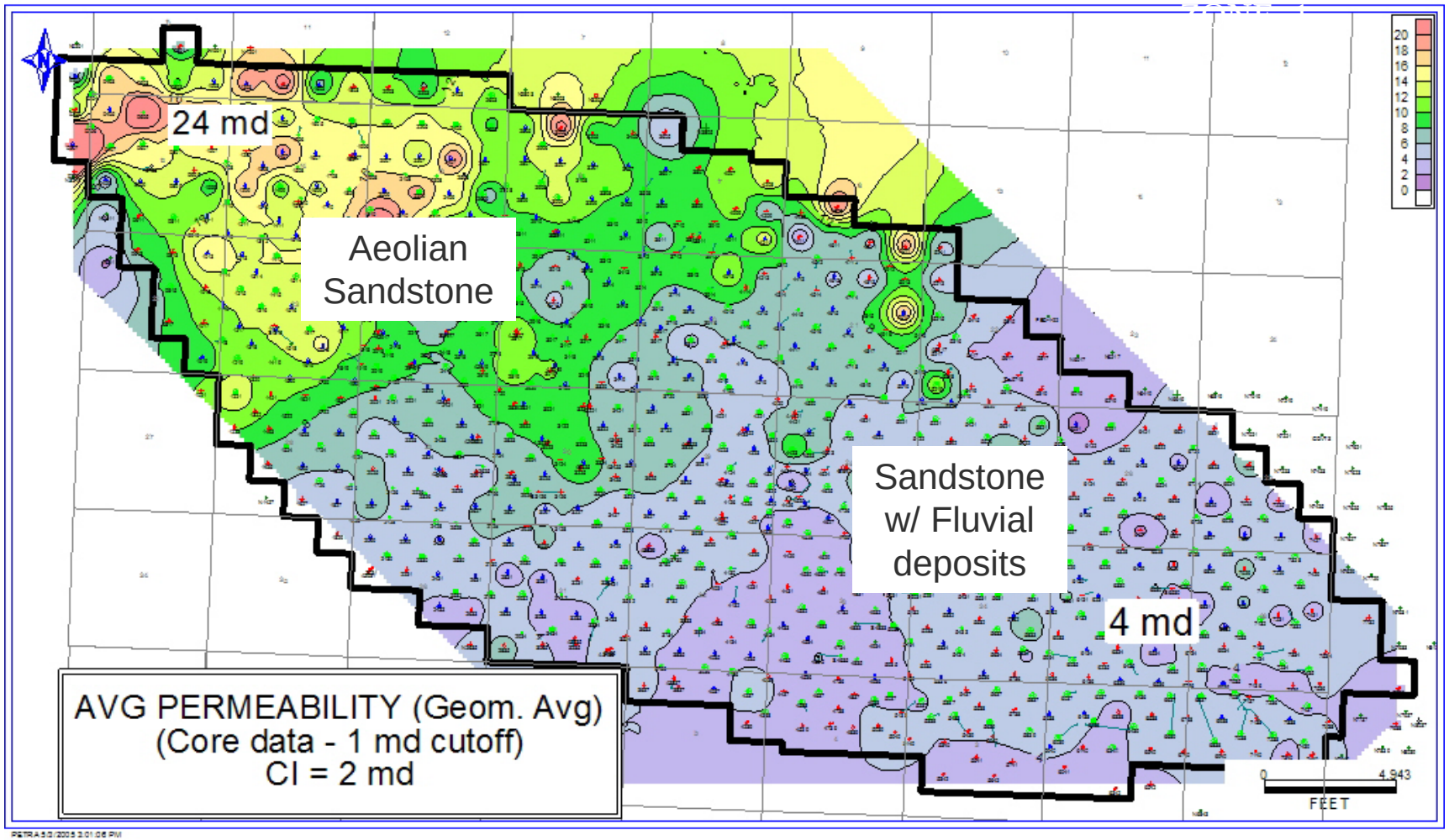
Producing Horizon	Weber
Lithology	Aeolian SS w/fluvial stringers
Unit Area	19,153 Acres
Average Gross Thickness	526 FT
Average Effective Thickness	189 FT
Average Effective Porosity	12%
Average Effective Perm.	8 md
Average Initial Swi	35.8%
Reservoir Temperature	160 deg. F
Initial Reservoir Pressure	2750 psi
Fractures	Some faulting & natural fractures

Rangely Field Top Weber Structural Contour Map

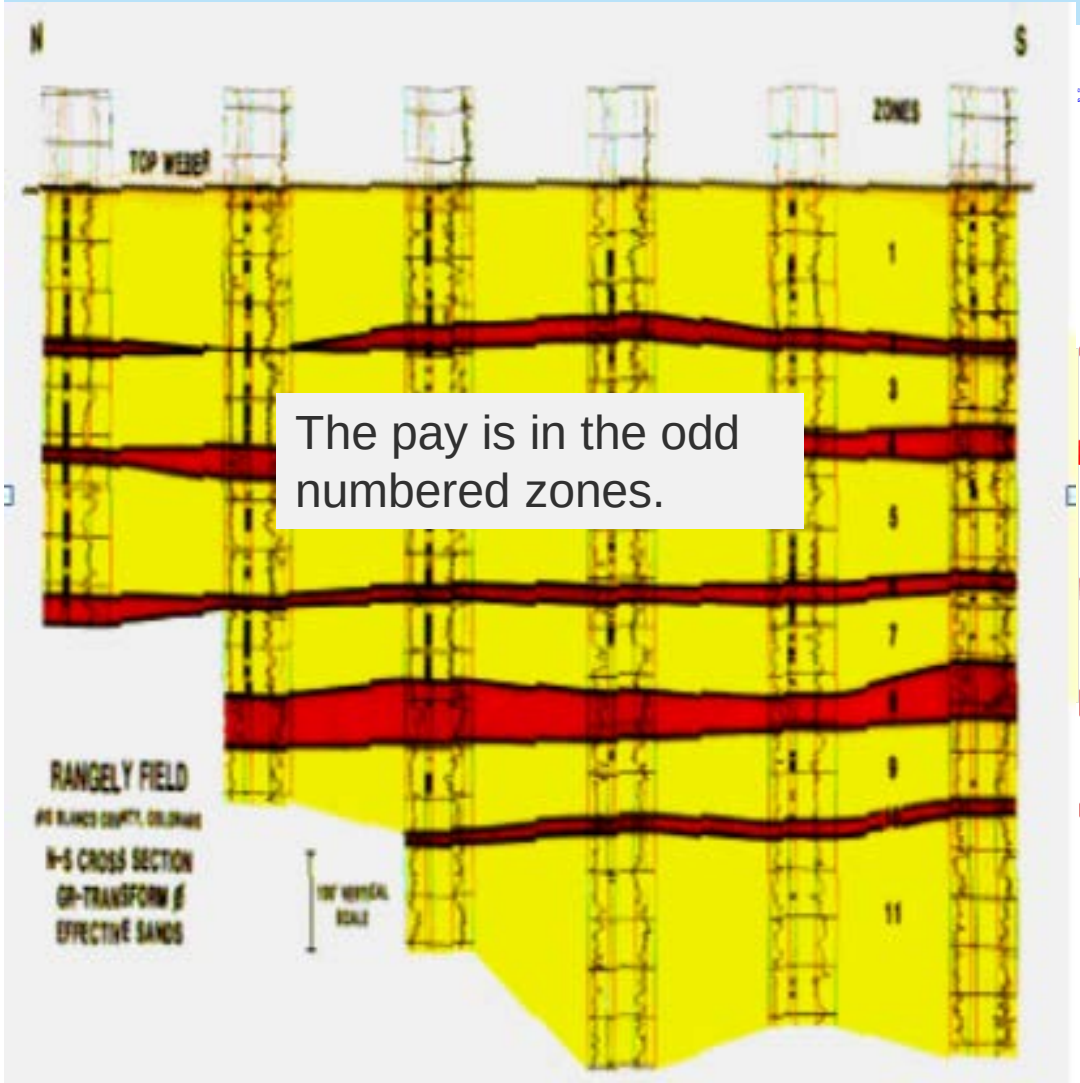
Top Weber Ss structure map of the Rangely Field (Mendeck,1986)



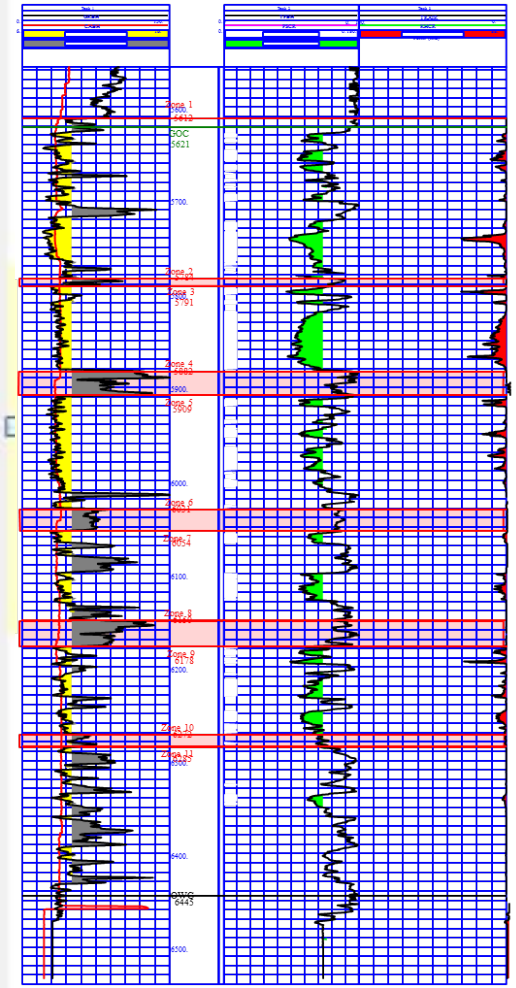
Rangely Weber Sand Unit



Rangely Type Log

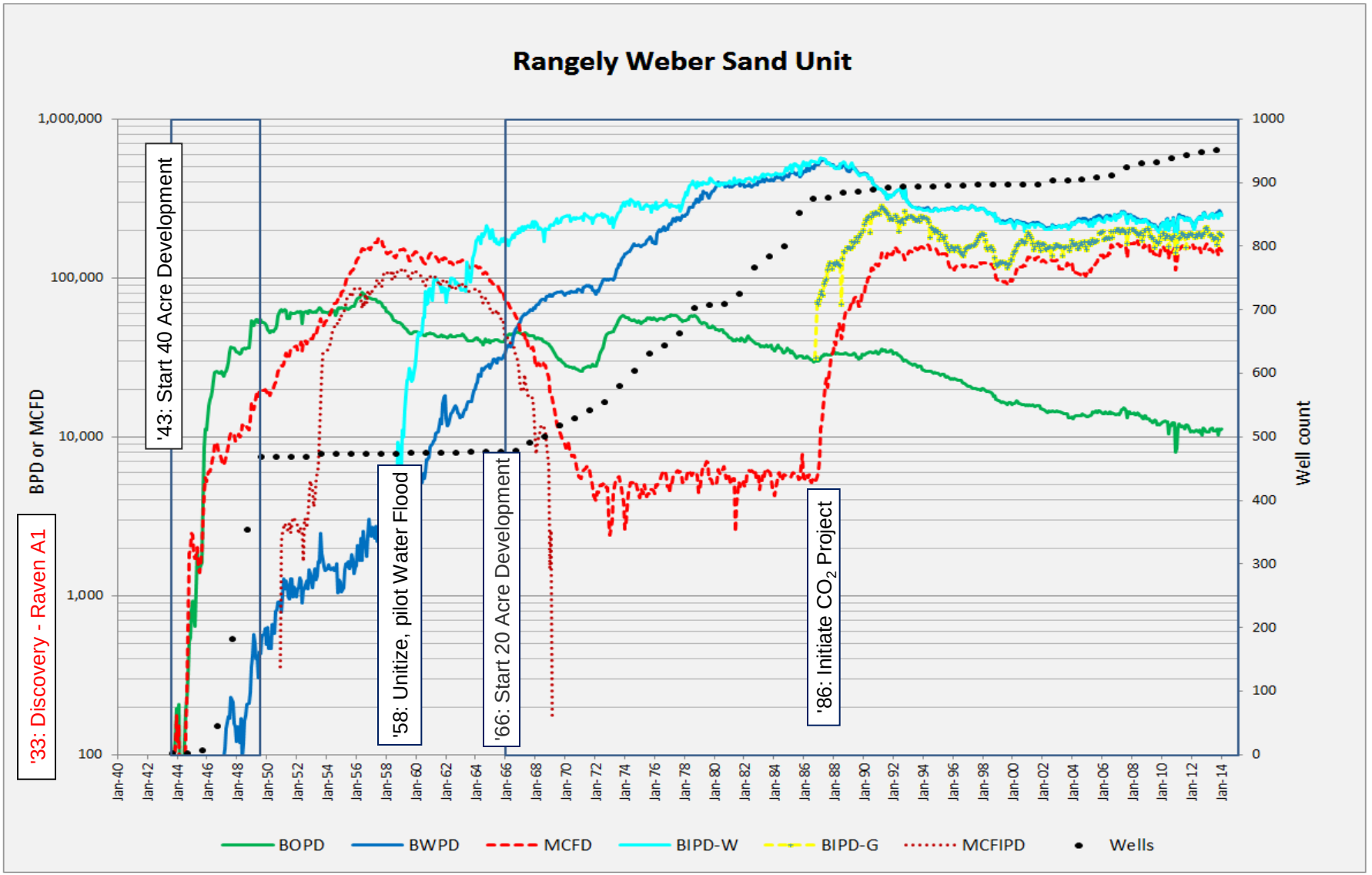


The pay is in the odd numbered zones.



TOP WEBER
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
ZONE 8
ZONE 9
ZONE 10
ZONE 11

Rangely Weber Sand Unit Development History



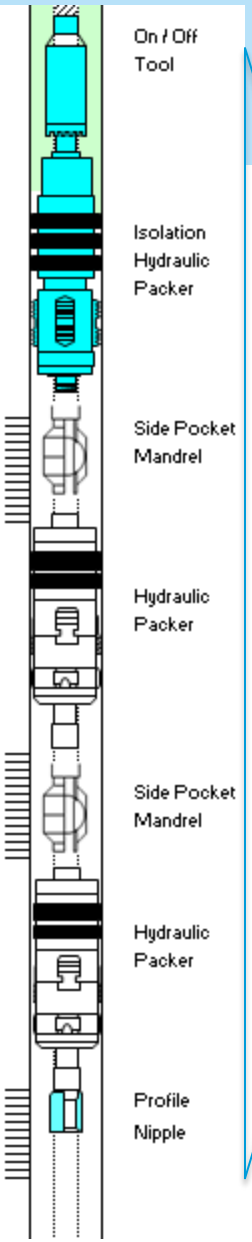
RWSU- Field Development History

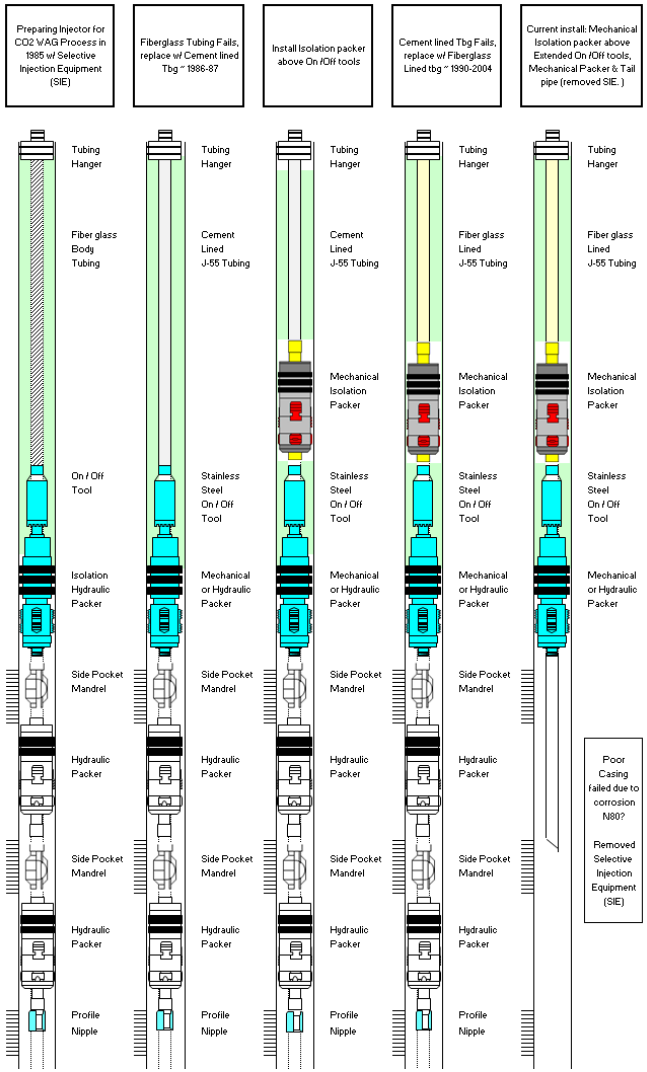
- **Discovered the Raven A1 well in 1933, idle for ten years.**
- **40-acre development 1943 – 1948, in five years.**
  - 470 - wells completed as open hole producers in the Weber sand.
    - 51% shot with Nitro Glycerin (East End).
    - 49% braden head sand oil squeezes (West End).
    - Many 40-Acre producers were fracture prior to conversion to injection.
- **Unitized in 1957 and initiated the Water Flood in 1958.**
  - 37% of 40-acre open hole producers were converted to water injection.
  - Installed 5” and 5-1/2” liners across the Weber Sand in 53% of these open hole producers.

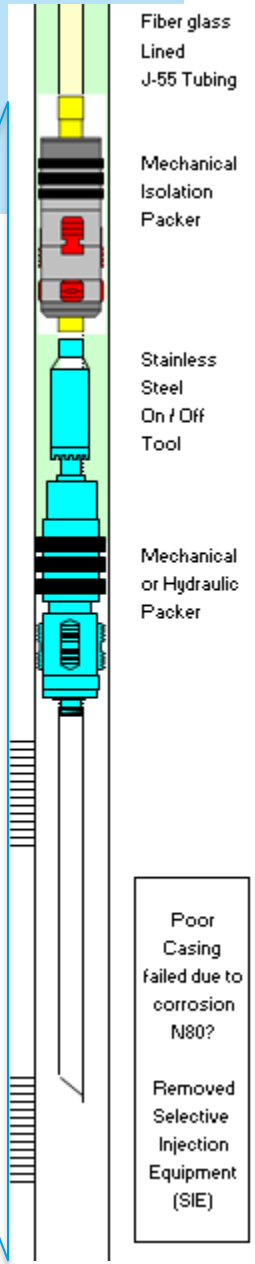
RWSU- Field Development History

- **20-acre development, 1966 – 1992 ~**
  - 400 wells, typically cased to Total Depth.
  - 40% were drilled and completed as injectors.
- **Selective Injection Equipment (SIE) installed from 1977 – 1986.**
  - A single string of tubing with multiple packers and side pocket mandrels with an orifice to control the rate of injection into each zone.
  - SIE installed in 260 injectors, plugging and corrosion has reduced the effectiveness.
  - Removing SIE is very difficult and costly in old wellbores.
- **RWSU has 343 Injection wells**
  - 38% of all RWSU wells are designated as an injector with 277 active.

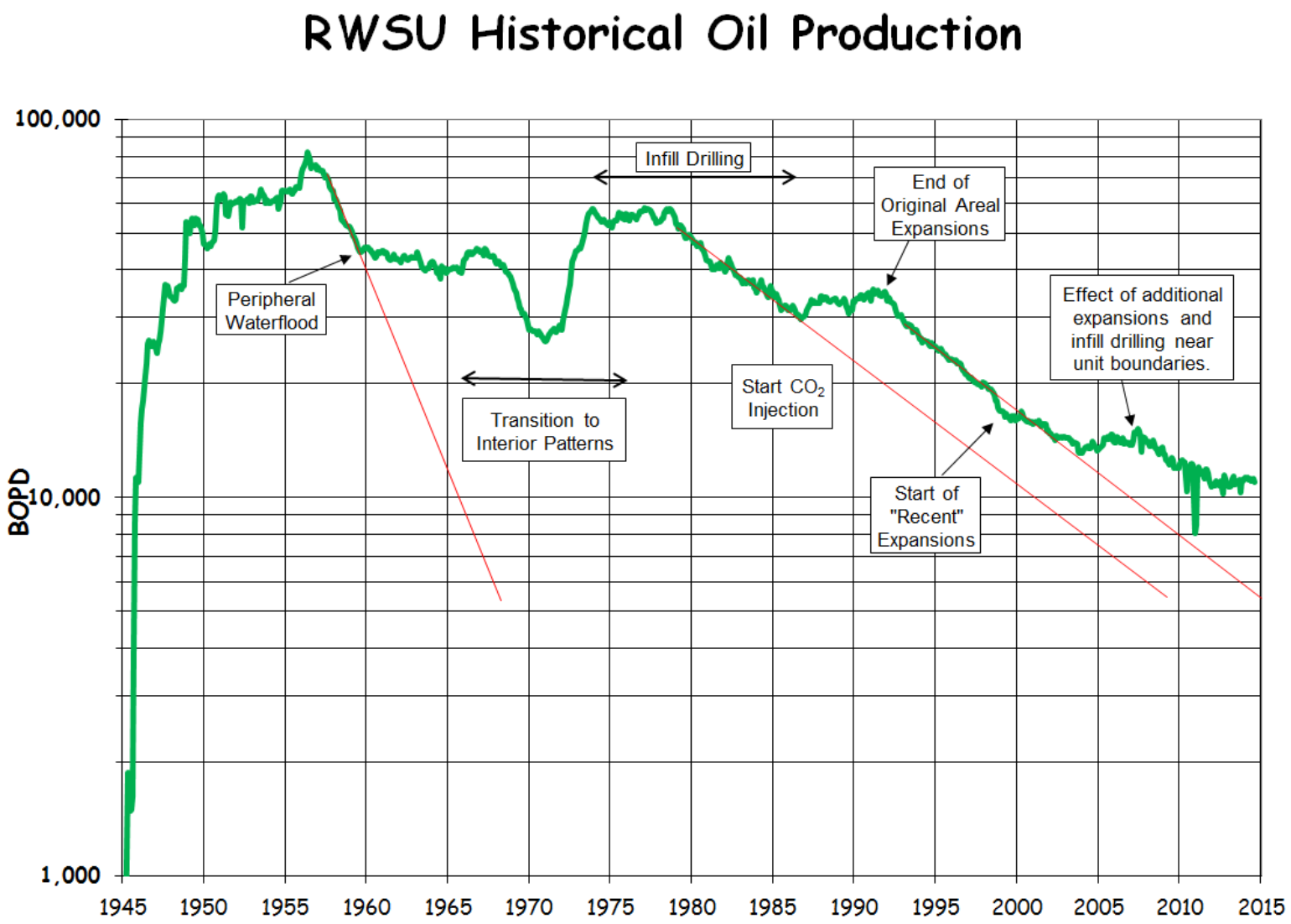
Selective Injection Equipment (SIE)







RWSU Oil Production History



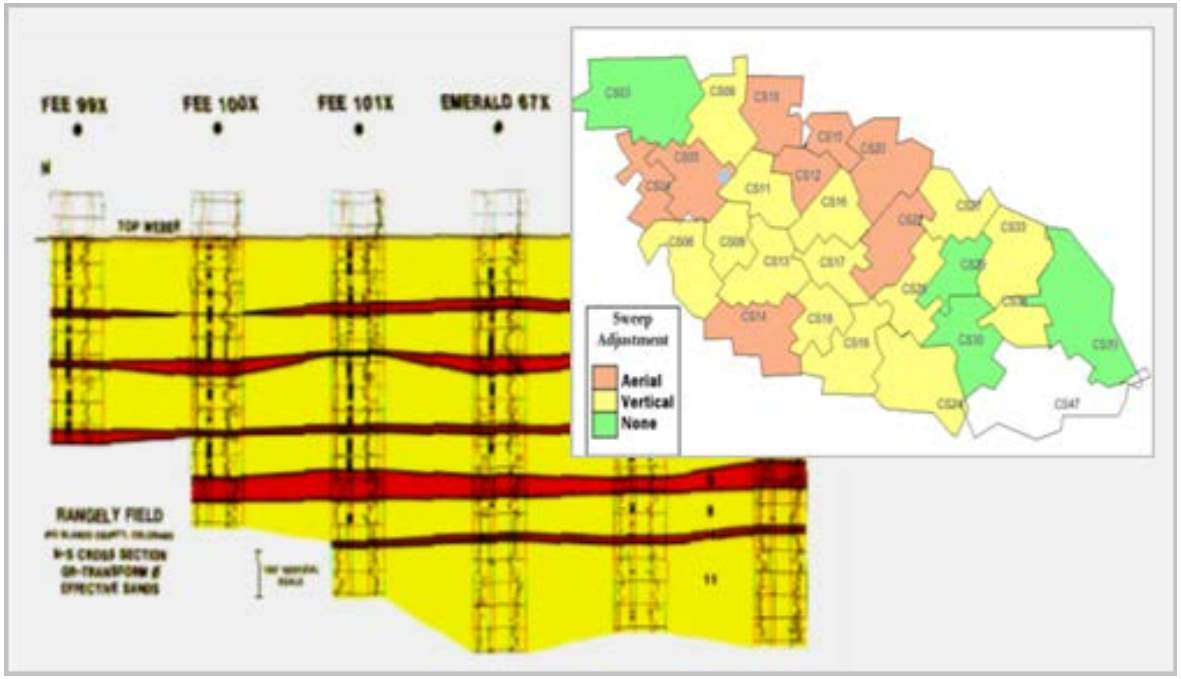
RWSU Projects and Opportunities

- **10-acre infill pilots implemented and under review.**
  - Three 10-acre pilot projects drilled from 1984-85, 23 10 Acre wells.
  - Two 10-acre producers drilled in 2010 and one10-acre injector drilled in 2013.
- **Sweep improvement**
  - Areal conformance by realignment.
    - 3 successful pilots and a larger project under review in the middle of the field.
  - Vertical or zonal conformance.
    - A large opportunity, challenging to wellbore equipment and condition.
    - Piloted a side track project to evaluate mechanical conformance improvement.
    - Considering a foam CO_2 trial and re-evaluating gel and foamed gel projects.

Side Track Project for Vertical Conformance Improvement

Description:

Increase production and ultimate recovery with a conformance improvement project, using recently acquired experience in sidetrack technology.



Opportunity:

After successfully drilling the Weber section on several 20-acre new drills and a sidetrack using a work-over rig, we initiated a pilot project to side track and enhance injection into under-processed zones, generating a positive response in the offset producers.

Side Track Project for Vertical Conformance Improvement

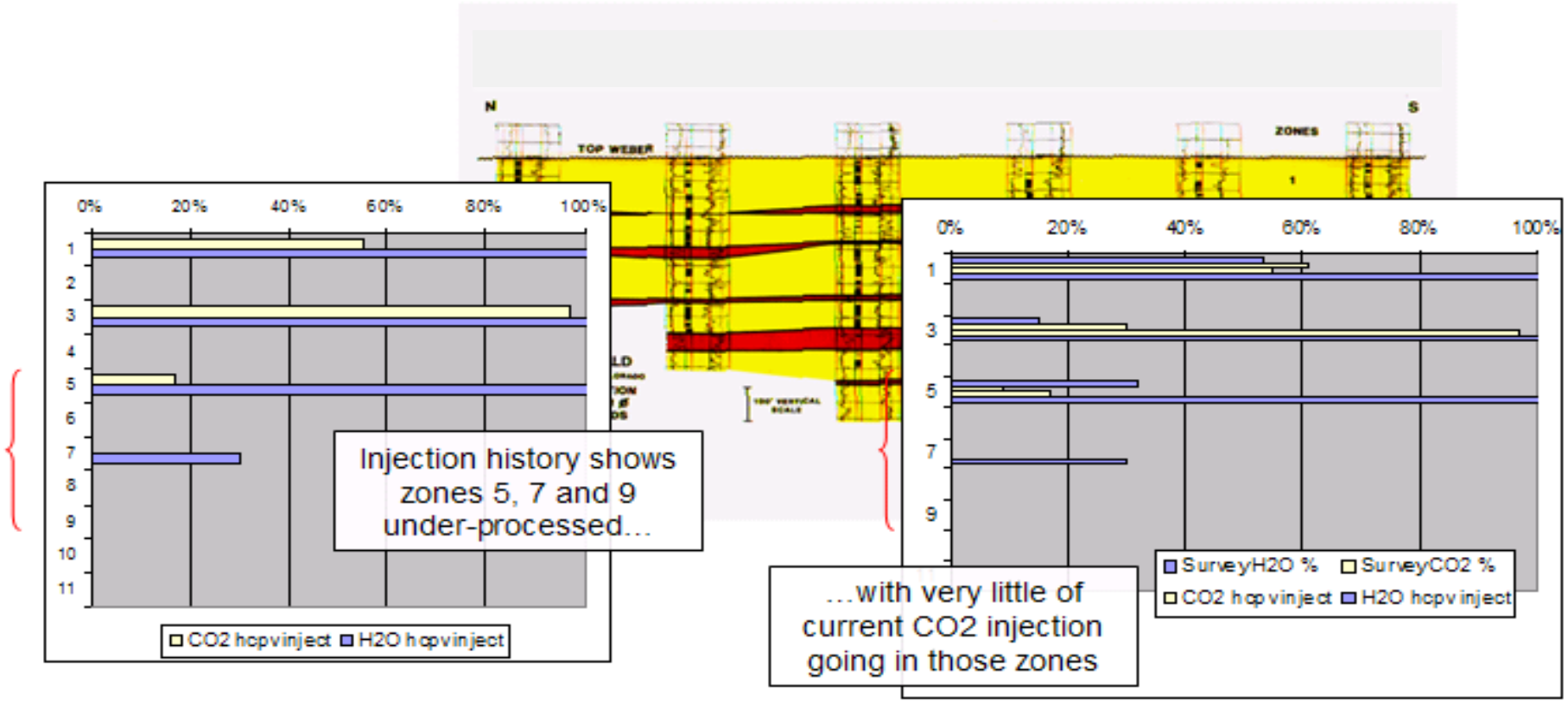
Project Scope:

- **Side-track existing injection wells w/ problems across the Weber,** i.e. broken injection profiles, failed SIE, poor casing, etc.

Alternative Selection Criteria:

- **Area with the potential for zonal conformance improvement.**
- **Wells close together to impact a project area.**
- **An area of high processing rate to see an early impact.**
- **At least 3+ zones present.**
- **Data to access the base line vs. the response.**
- **No additional work in area that may influence the project,** i.e. new drills, 10-acre pilot, realignment and expansions

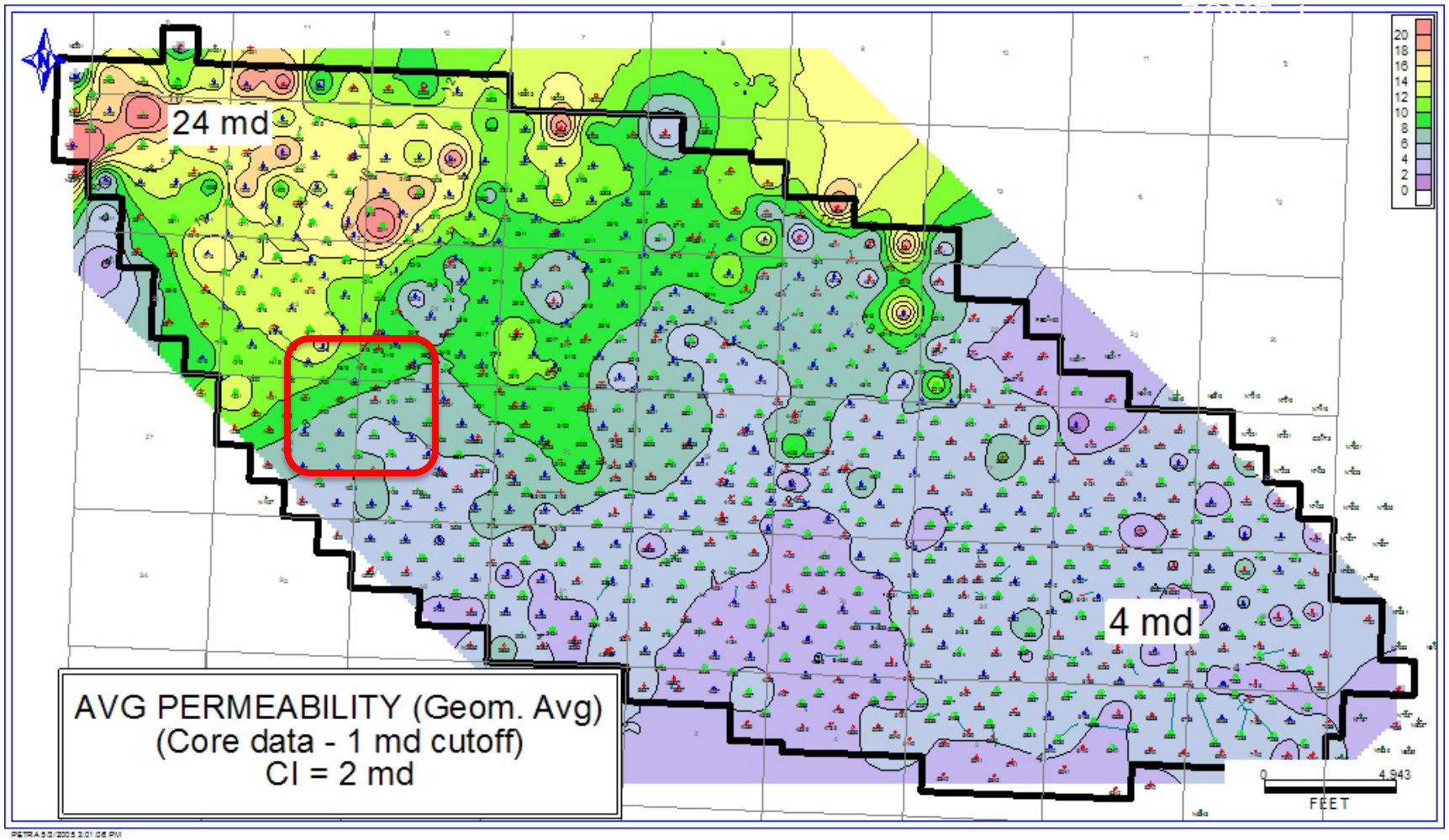
Rangely Weber Sand Unit
Vertical or Zonal Conformance



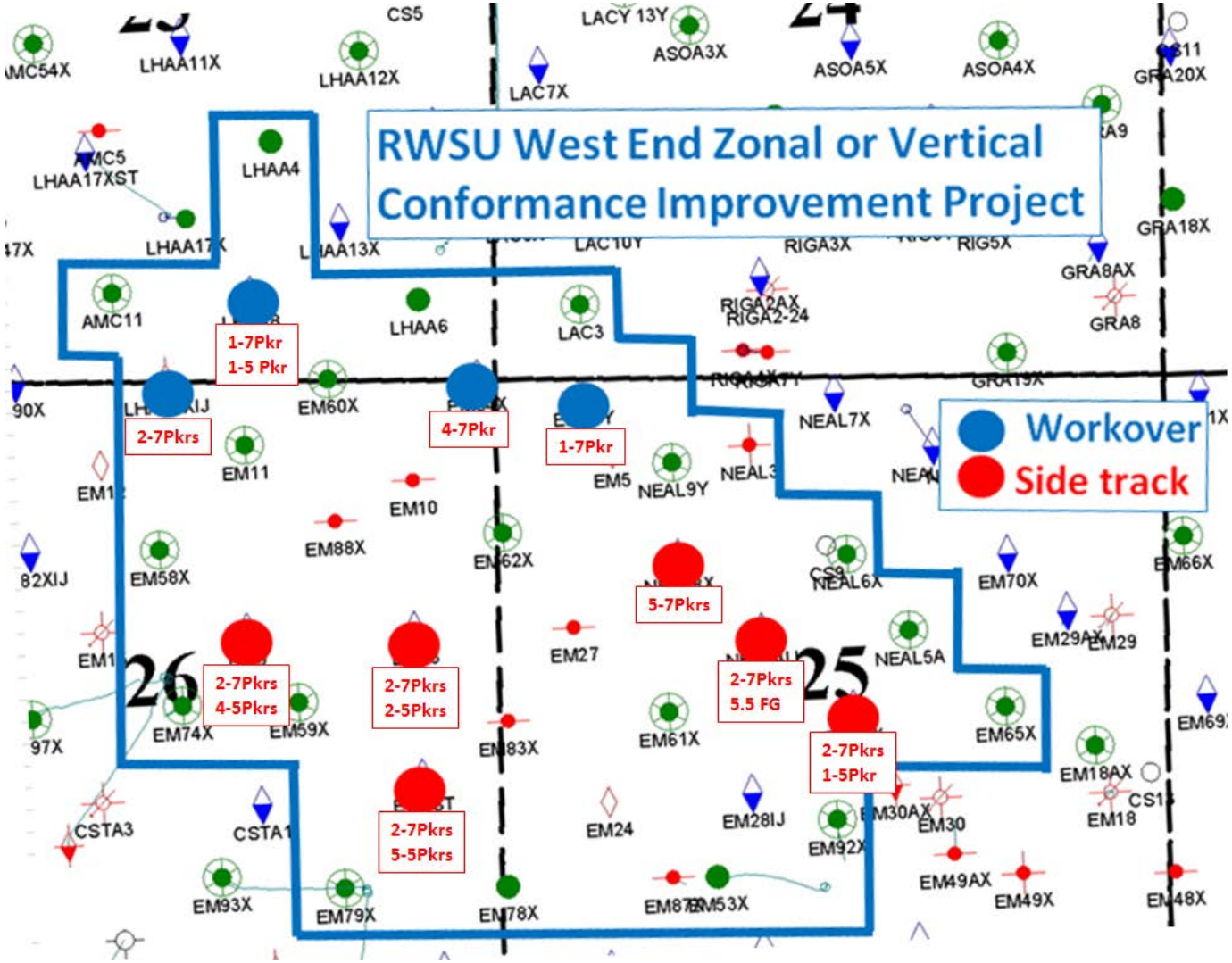
Here is an example of opportunity in lower zones (5, 7 and 9). These zones are estimated at 1.7 MMB OOIP, but are largely unprocessed with CO2.

Assuming a CO2 recovery of only 5%, would result in 85,000 Bbls of additional oil through improving conformance.

Rangely Weber Sand Unit
Vertical Conformance Improvement Project Area



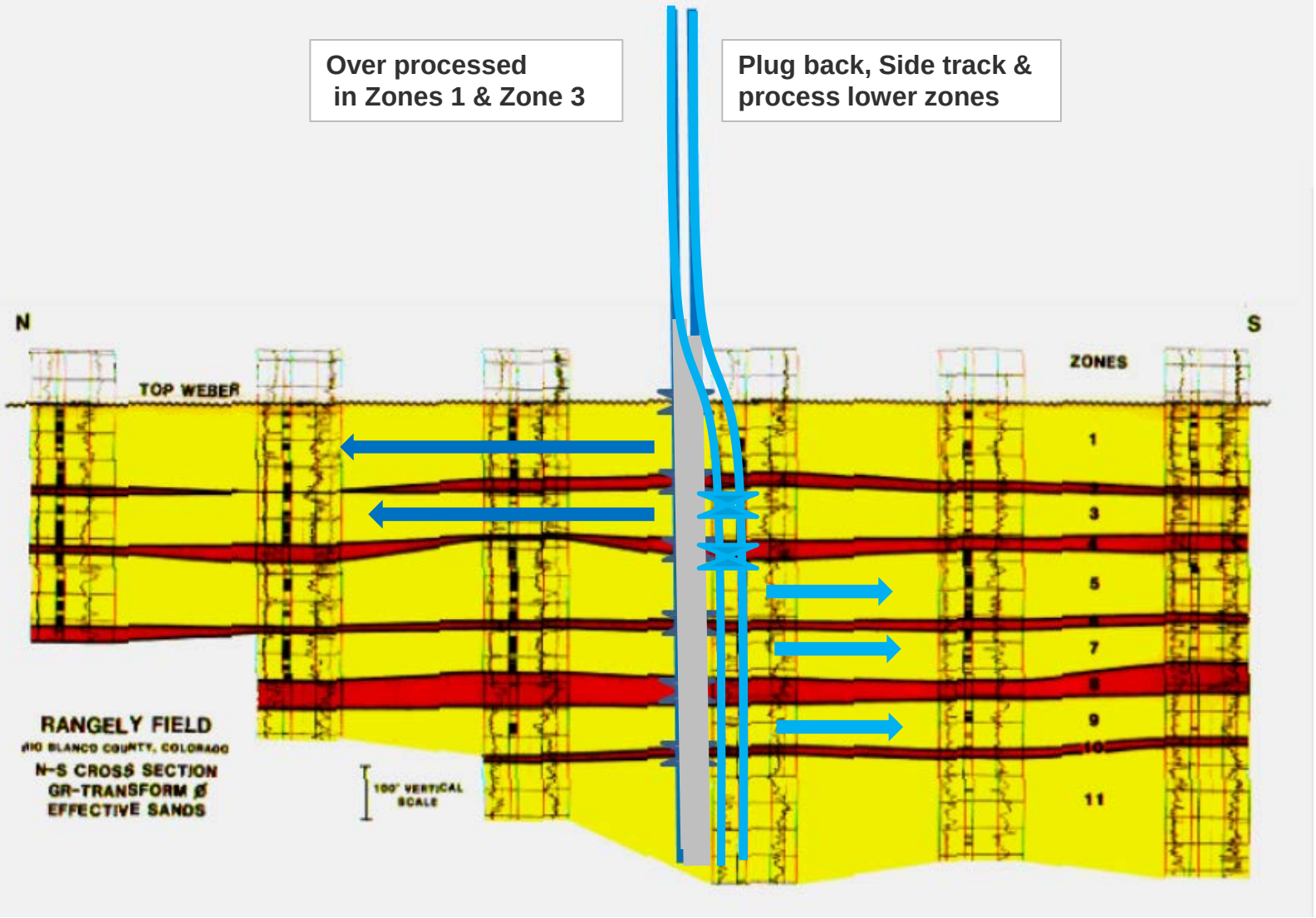
Vertical Conformance Improvement Project Area



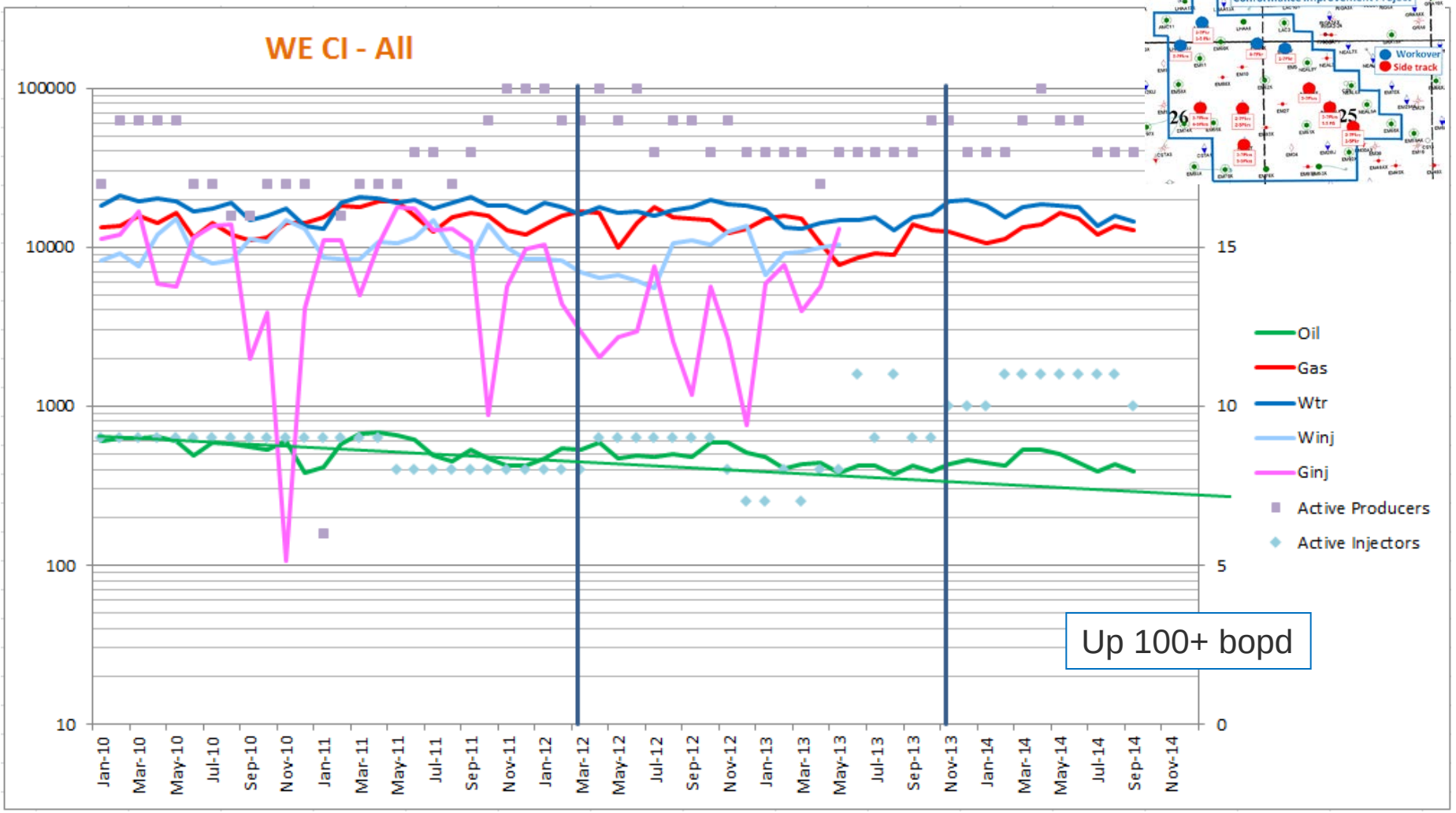
Well Work Procedure

- **Pre work:**
  - Enlarged the location to accommodate additional equipment.
  - Pull injection string, run work string & cleanout SIE w/ 1-1/4” drill pipe.
  - Pre-cut tubing w/ wireline between packers to expedite fishing SIE.
  - P&A’d the Weber section and set the base for the whip-stock.
- **Set whip-stock, cut window and drill side track wellbore:**
  - Required larger pump and 3-1/2” power swivel.
  - Install 5” L80 Hydril liner from 100’ above window to TD.
  - Install 5-1/2” L80 LT&C liner from hanger to surface.
  - Complete the lower zones, install packers and fiber-lined tubing.

Injector with SIE & broken profile



Conformance Improvement Project



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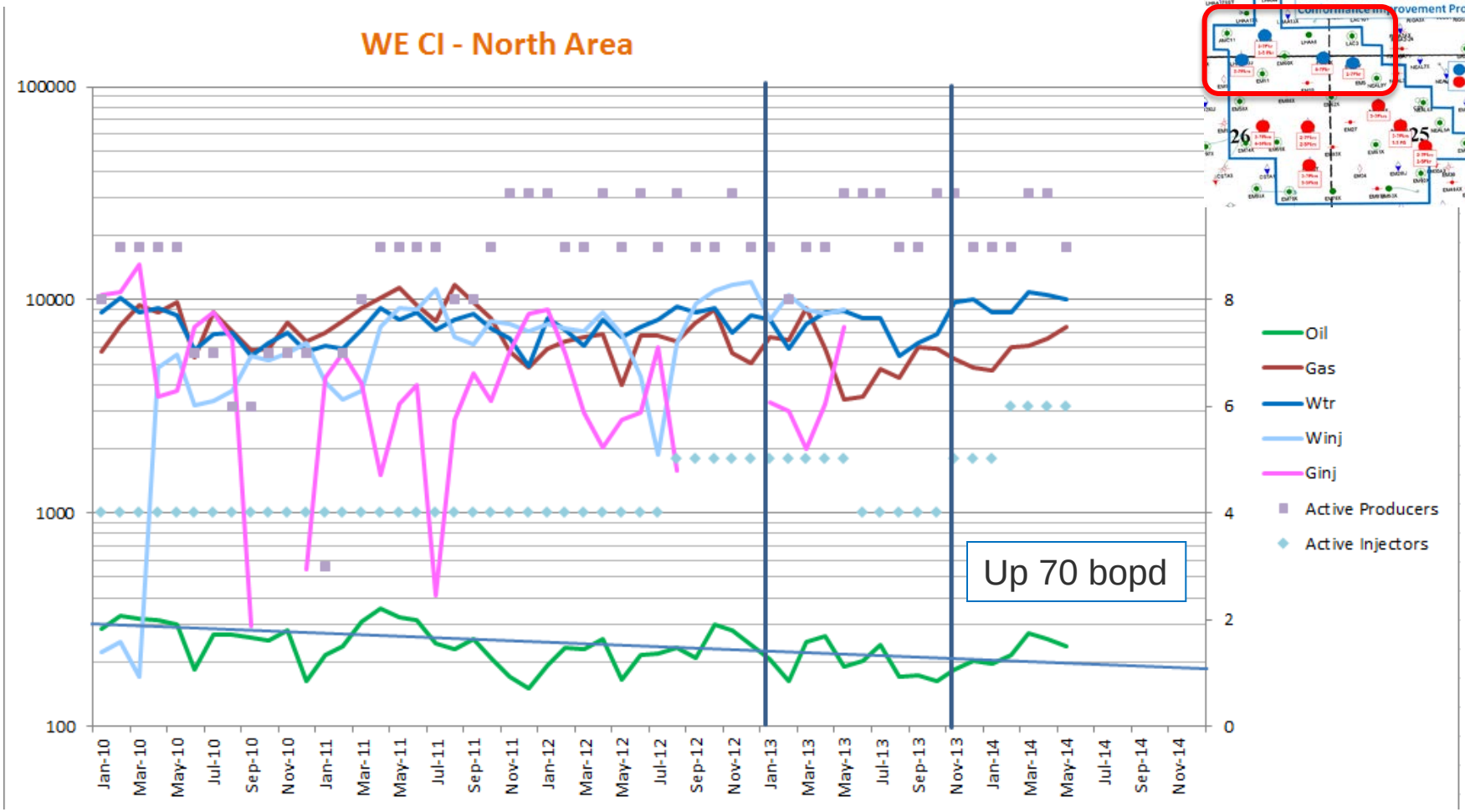

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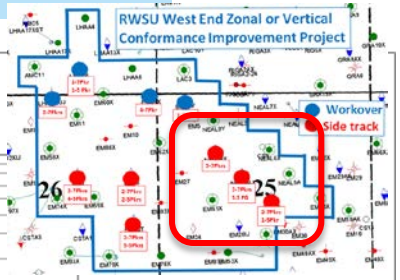
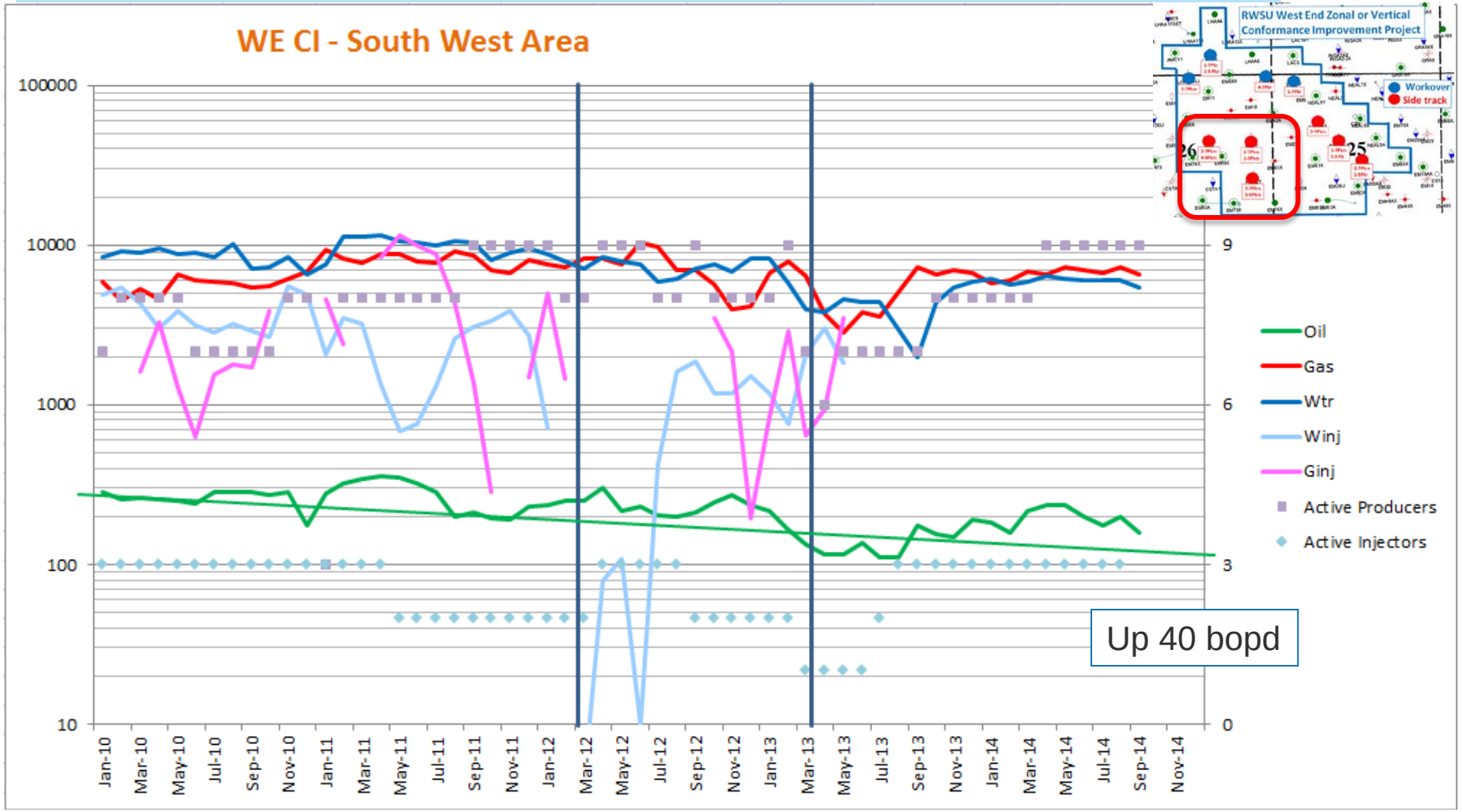


Conformance Improvement Project



West End Conformance Improvement Project Lessons Learned

- We worked closely with experienced personal from the work-over rig, fishing and tool companies to develop a successful procedure.
- Coil tubing cleanouts through packers and mandrels (SIE) are difficult. We drilled out with 1-1/4" drill pipe and then made wire-line cuts to fish SIE.
- Fishing SIE in old wellbores is unpredictable. The minimum objective was to fish at least to the bottom of zone 3 and plug zones 1 & 3.
- Cutting the window and drilling the side track was executed well at 130'/day.
- Extra lead time was required for the 5" Hydril connections for handling tools, the cement shoe, float collar and the hanger.
- Liner were run in two stages: The 5" Hydril liner was installed and cemented in the sidetracked wellbore, then the 5-1/2" liner was installed to surface. To ensure cement to surface in this low reservoir pressure area of the RWSU.
- Ran cased hole logs, PNL or CNL with CBL to pick perforations.

West End Conformance Improvement Project Lessons Learned

- **Scoping future conformance improvement projects:**
  - Continue to utilize an integrated technical team (Tenant #10)
    - Project selection: Earth Scientist, Reservoir, Production & Completion Engineering
    - Project execution: Wellsite Managers, Tool Pushers, Tool Hands & Fishermen. Rangely draws from a deep pool of experience & support.
- **Optimizing for the Future.**
  - Manage injection target rates, monitor BHP, keep above MMP.

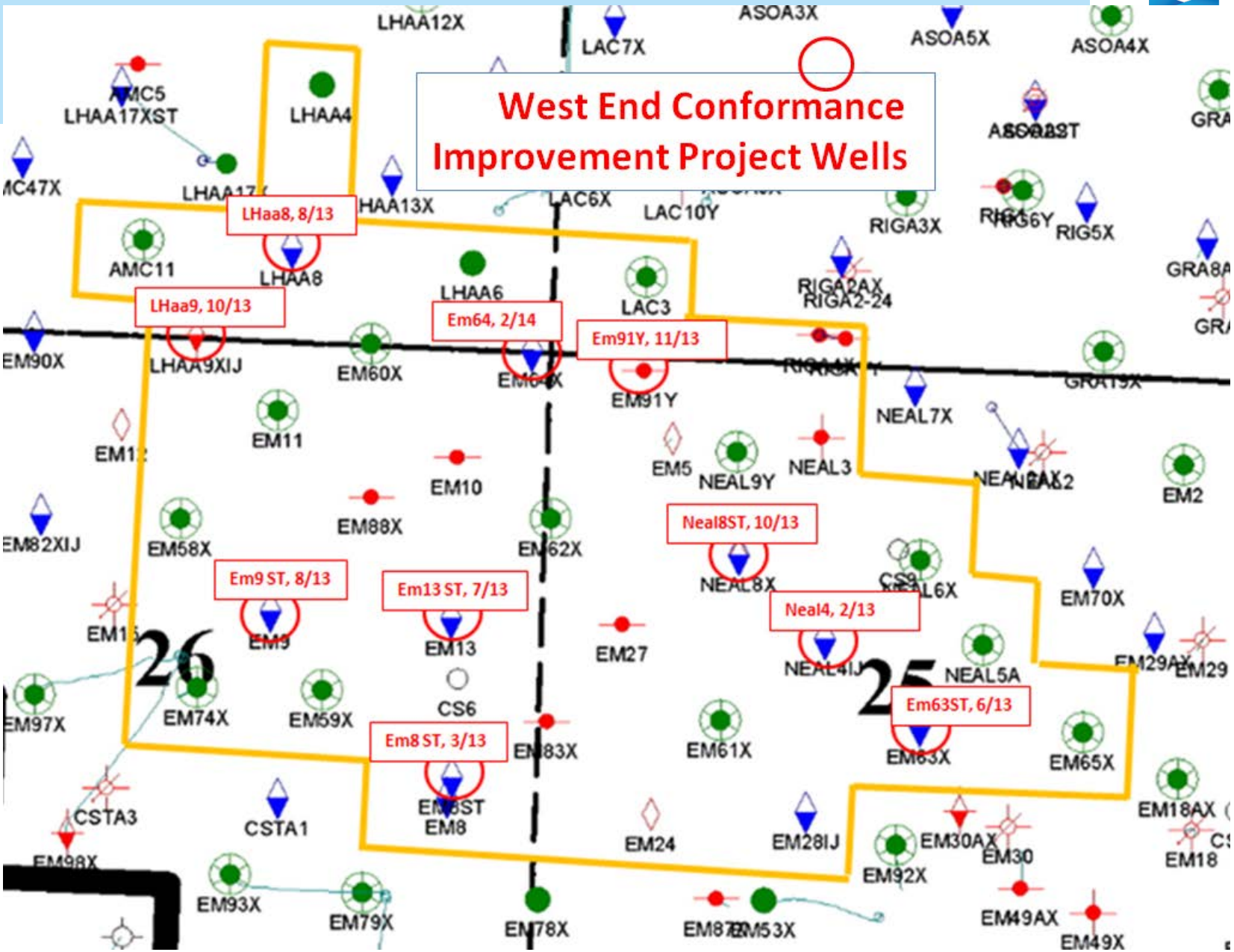
    Be aware of the logistics for shut-in of CO_2 Trunks to Install WAG skids.
  - Run injection profiles, before & after on both water & CO_2.
  - Be aware of production loss from plugging back over processed zones.
  - Schedule a sequence of side track jobs to optimize the operation.

Summary

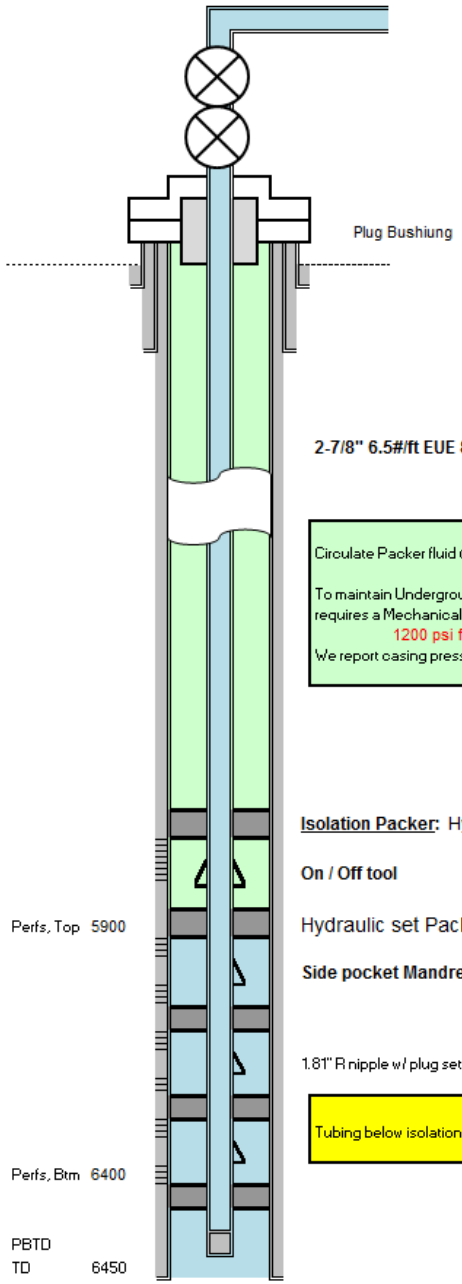
- A large opportunity exists to improve the ultimate recovery at Rangely through vertical conformance improvement.
- Plugging and corrosion of equipment in the injection wells has reduced the effectiveness. Removing SIE is very difficult and costly in old wellbores.
- Where selective injection equipment has been removed, there is no mechanical control of injection fluids within the Weber Sand formation.
- We can side-track and drill a wellbore parallel to the P&A'd wellbore and re-completed in the under-processed zones.
- The plug -back and side-track is one alternative to improve vertical conformance.
- A 10-acre injector may be required to achieve vertical conformance in certain areas of the Rangely Weber Sand Unit.

Thank You

BACK UP SLIDES



Current Wellbore



2-7/8" 6.5#/ft EUE 8rd Fiberlined tubing

Circulate Packer fluid @ 10,000 ppm (KW132) in to the tbg/csg Annulus

To maintain Underground Injection Control (UIC), the Colorado Oil & Gas Commisions (COGCC). requires a Mechanical Integrity Test (MIT) from the isolation packer to surface every 5 years.
1200 psi for 15 min w/ less than 10% loss
We report casing pressure and injection rate monthly to the COGCC.

Isolation Packer: Hydraulic set Packer or TAM FreeCap packer in bad casing

On / Off tool

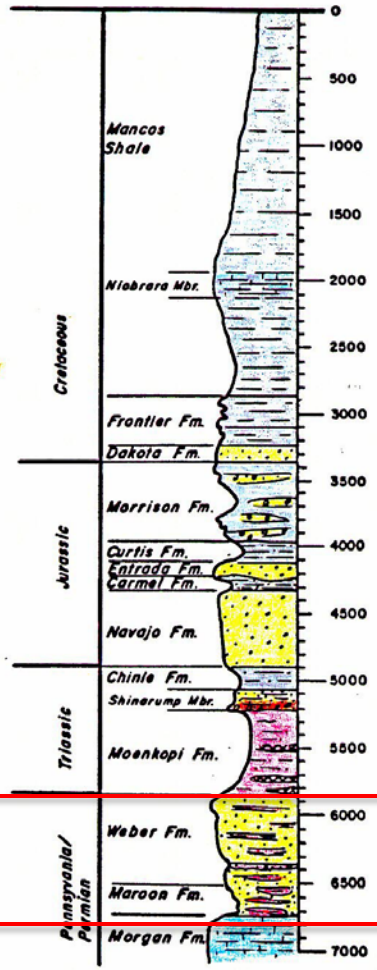
Hydraulic set Packer or TAM FreeCap packer in bad casing

Side pocket Mandrel w/ orifice to adjust rate

1.81" R nipple w/ plug set

Tubing below isolation packer is Externally fiberglass wrapped

Geologic Section at Rangely



Stratigraphy of the Rangely Anticline Rio Blanco County, Colorado

ERA	PERIOD		FORMATION	LITHOLOGY	THICKNESS
MESOZOIC	Upper Cretaceous		Mancos Shale (Colorado)		2700 ft.
			Dakota Sandstone		70 ft.
	Jurassic	Upper	Morrison Formation		650 ft.
			Curtis Formation		100 ft.
			Entrada Sandstone		150 ft.
			Carmel Formation		50 ft.
		Lower	Navajo Sandstone		600 ft.
	Triassic	Upper	Chinle Formation		150 ft.
			Shinarump Congl.		30 ft.
		Lower	Moenkopi Formation		600 ft.
	Permian		Phosphoria Formation		100 ft.
PALEOZOIC	Pennsylvanian		Weber Sandstone / Maroon Formation		1100–1200 ft.
			Morgan Formation		1500 ft.
			Molas Formation		100 ft.
	Mississippian		Madison LS		500 ft.
	Devonian (Silurian)		Chaffee Formation		80–100 ft.
	Ordovician		Manitou LS		200 ft.
	Cambrian		Lodore Formation		400–500 ft.
Pre–Cambrian			Uinta Mtn. Group		12,000 ft.