Oxy CO_2 EOR Project
Discussion Draft MRV Plan

Presentation by Occidental Elk Hills, Inc. at California Energy Commission Staff Workshop for

HYDROGEN ENERGY CALIFORNIA (08-AFC-8)

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Sacramento, California

Presentation Overview

- Background
  - Oxy CO_2 EOR Project
  - MRV Plan Development
- Review of the MRV Plan
- Next Steps

History of Elk Hills

- One of largest oil fields in the U.S., over 75 square miles
- In operation for more than 100 years
- One of the most fully characterized oil fields in the U.S.
- Current and historic EOR operations include injection of brine water, nitrogen gas, methane and polymers

Oxy's CO_2 EOR Experience

- Global leader in applying EOR techniques
- Industry leader in CO_2 EOR
  - over 25 active CO_2 flood projects
  - injecting ~ 28 million tonnes per year
- Oxy follows time tested protocols to:
  - Ensure worker safety
  - Optimize use of CO_2
  - Comply with legal standards

MRV Plan Context

- Plan is tailored for the HECA AFC
  - OEHI would use CO_2 captured from HECA for EOR, resulting in CO_2 sequestration
  - As a related project, CEC must evaluate OEHI CO_2 EOR potential environmental impacts along with HECA impacts
  - MRV plan intended to measure and verify amounts of HECA CO_2 sequestered by OEHI CO_2 EOR Project
- Discussion draft only – still under evaluation by external peer reviewers and AFC stakeholders

The Role of an MRV Plan

- Identify and assess risk of potential leakage of CO_2 to surface
- Monitor behavior of injected CO_2
- Determine mass of CO_2 sequestered
- Establish reporting framework
- Describe site closure and post-closure monitoring

Oxy's MRV Plan Development

- Reviewing Institutional Models:
  - Proposed EPA Greenhouse Gas Reporting Rule Subpart W and Subpart RR
  - Proposed EPA UIC Class VI rules and comments
  - Existing UIC Class II permit criteria
  - Existing California environmental requirements
- Consulting with:
  - Internal experts from multi-disciplines across Oxy
  - HECA
  - External experts from various environmental groups
  - CEC through AFC process

Key Questions Addressed

- What does the OEHI CO_2 EOR Project entail?
- Why is Elk Hills a good location for the Project?
- How do we know CO_2 will not leak?
- How will OEHI monitor the CO_2 used for EOR?
- How much CO_2 will be sequestered?

- Site closure and post-closure monitoring (still under development)

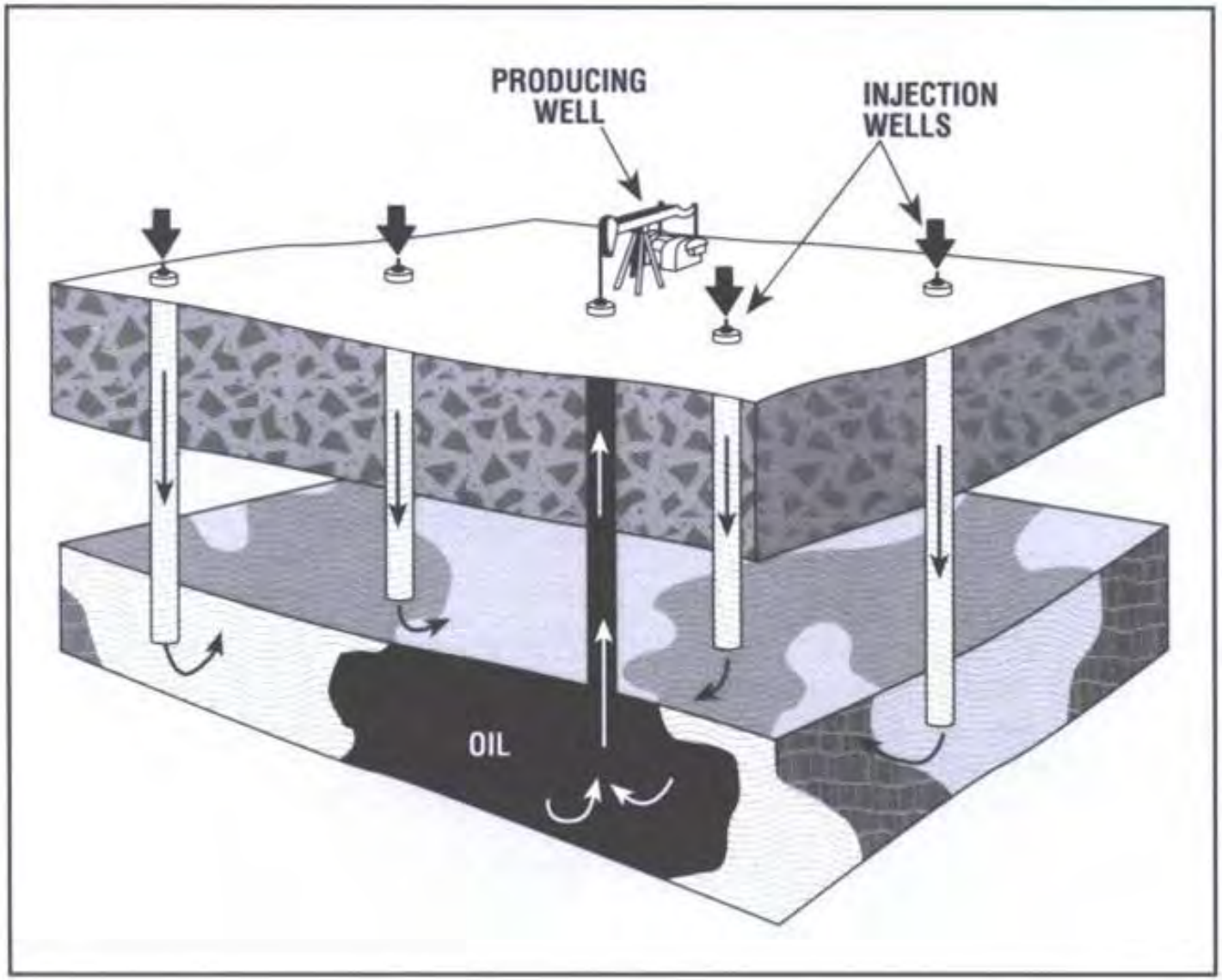
Overview of the Oxy CO_2 EOR Project MRV Plan

- Part 1 – Summary
- Part 2 – Detailed Project Description
- Part 3 – Monitoring, Reporting, and Verification
- Part 4 – Monitoring: Quality Assurance / Quality Control

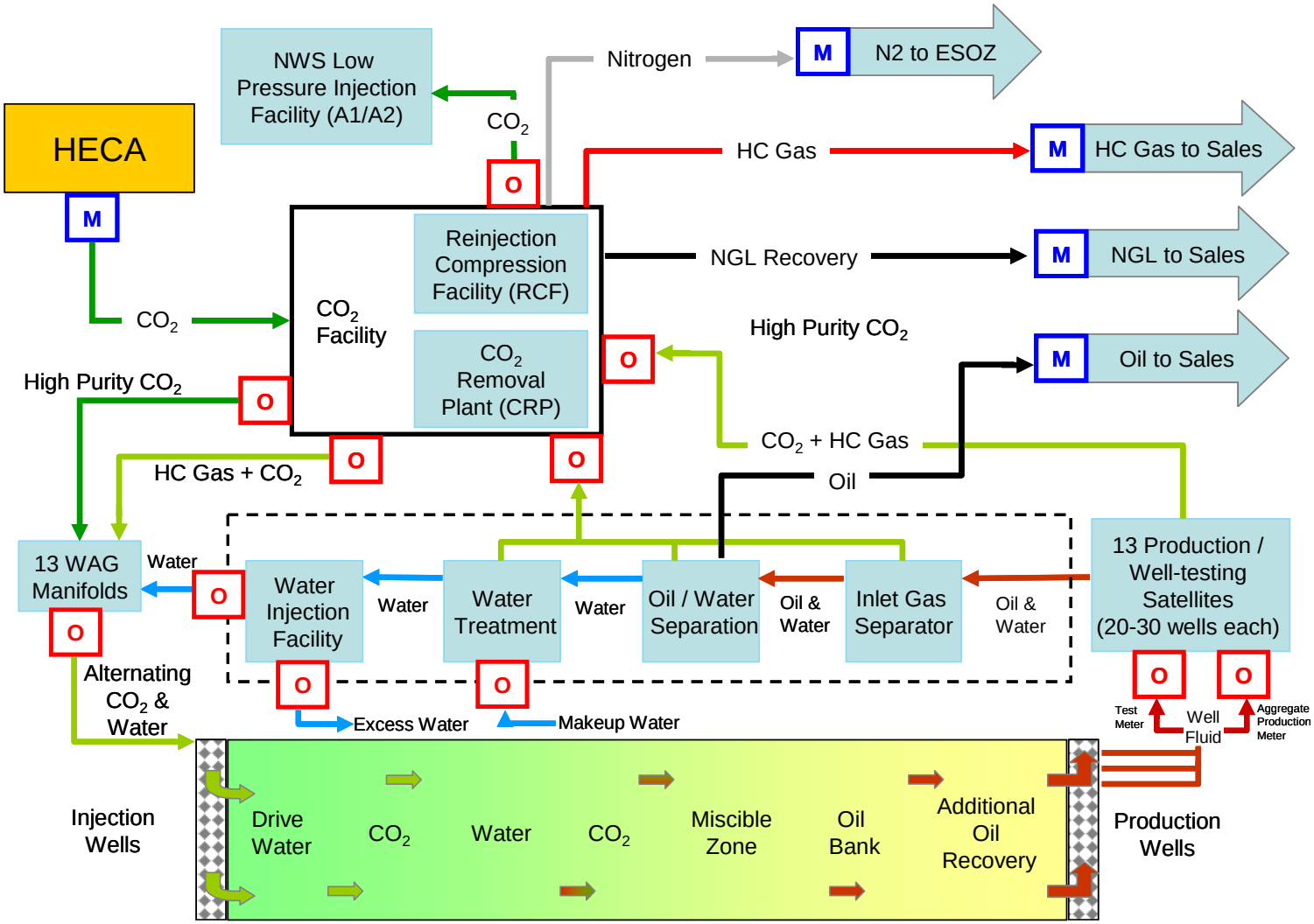
First – The Acronyms

- CO_2 – carbon dioxide
- EOR – enhanced oil recovery
- HECA – Hydrogen Energy California
- OEHI – Occidental of Elk Hills, Inc.
- Oxy CO_2 EOR Project – planned extension of OEHI's existing EOR operations using CO_2 from HECA

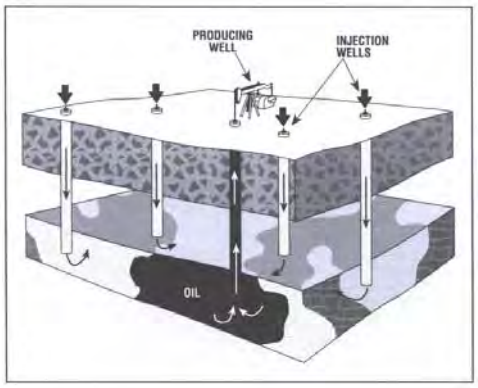
The CO_2 EOR Process



The Oxy CO_2 EOR Process



Field Flow Diagram




RCP - Compression

Gas/CO_2


CO_2 Rec. Plant

Gas Sale

Gas/CO_2

Oil, Wtr, Gas/CO_2


Prod. Well


Well Testing Satellite

Liquids


Central Tank Battery

Oil Sale

Water

CO_2 Recycle


CO_2 Supply Pipeline

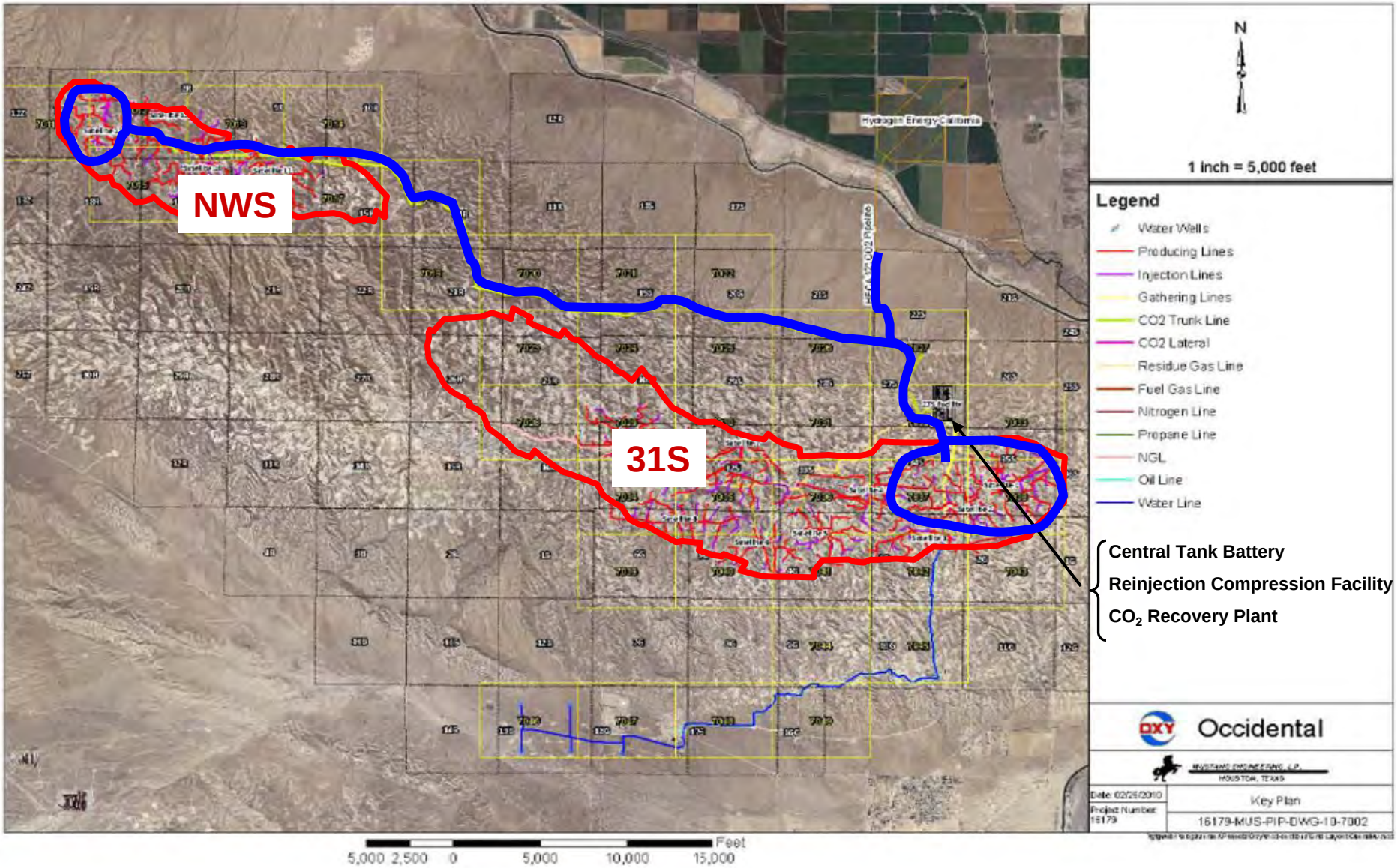
CO_2 Make-Up


Inj. Well

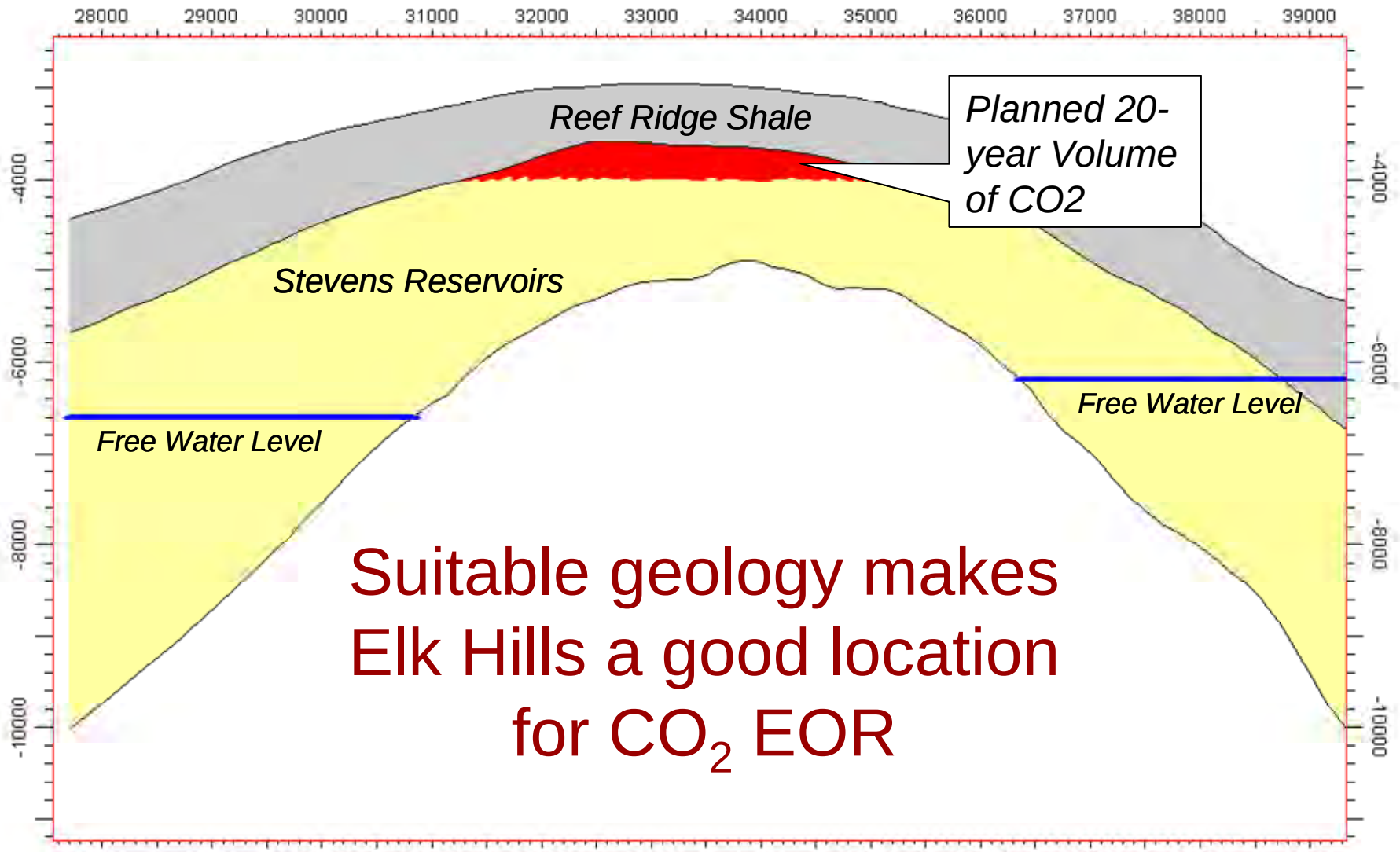
Water


Water Inj. Stat.

The Oxy CO_2 EOR Project

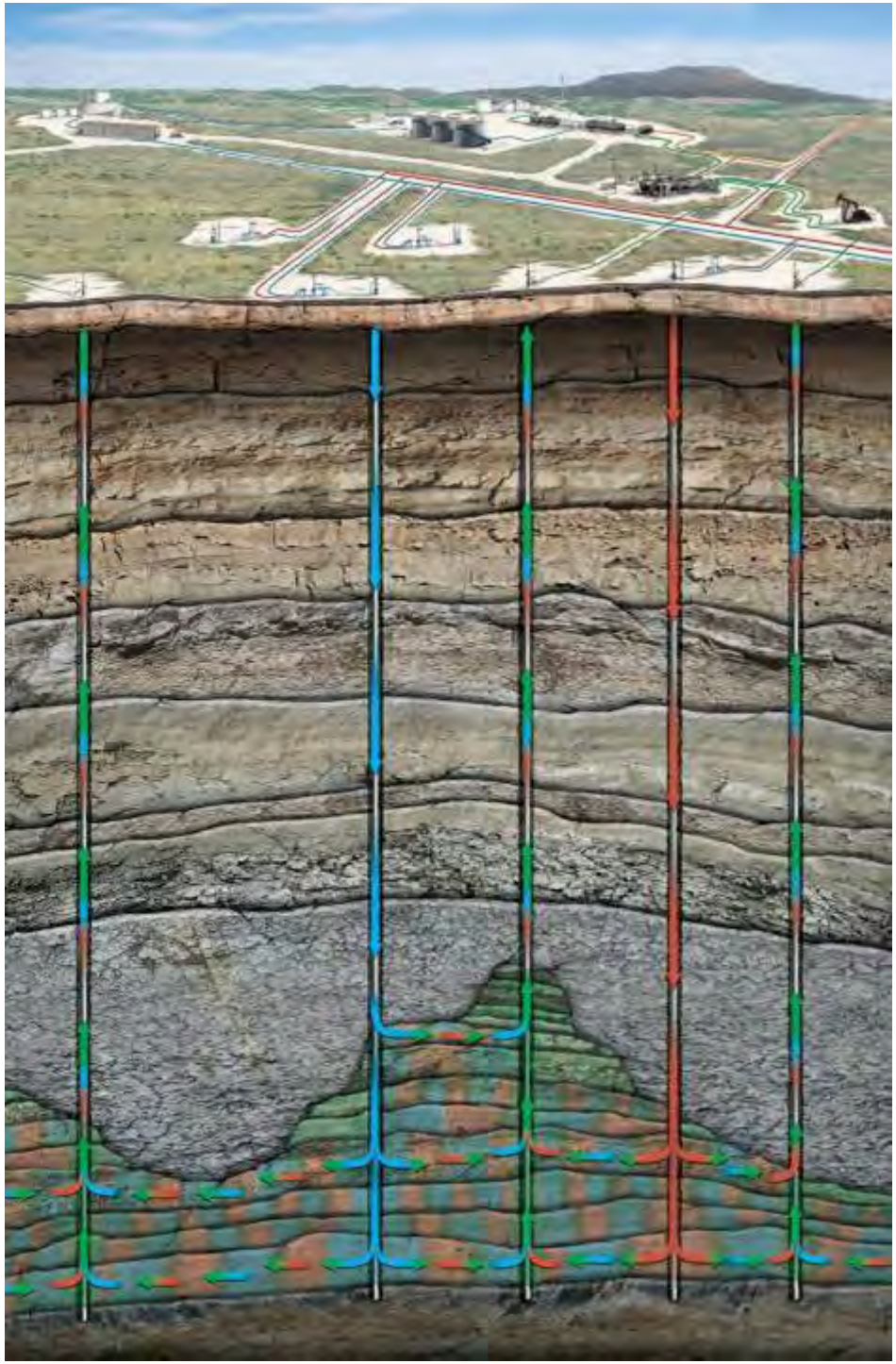


Why is Elk Hills A Good Location?

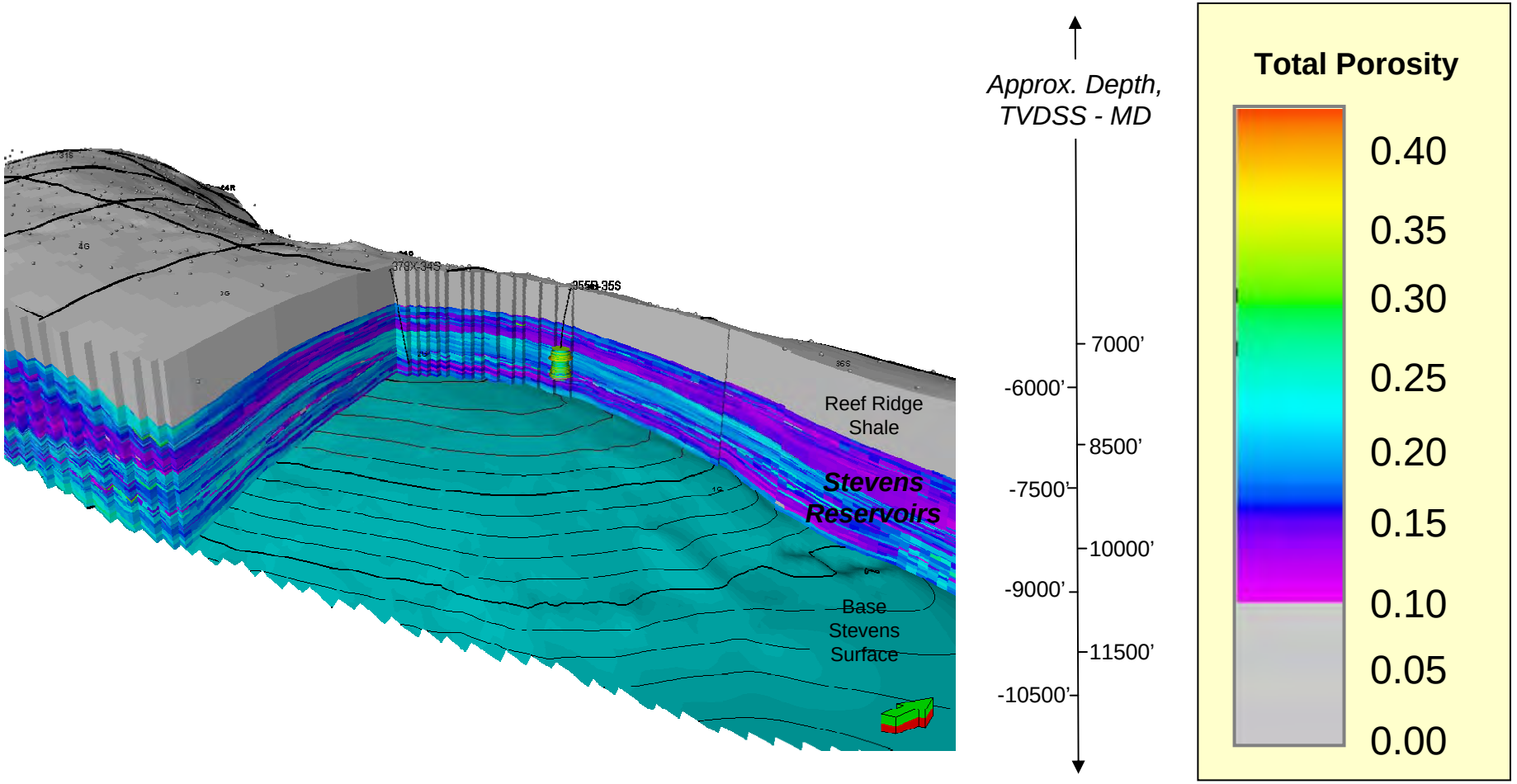


Multiple Seals

- Elk Hills has a number of seals and production zones that have contained separate pools of oil and gas for millions of years



Multiple Layers Within the Stevens Reservoirs



How Do We Know That CO_2 Will Not Leak to the Surface?

- Assessed leakage pathways:
  - Faults & Fractures
  - Natural and Induced Seismic Activity
  - Existing Well Bores
  - Previous Operations
  - Pipeline & Surface Equipment
  - Overfill Through Lateral Spillpoints
  - Dissolution of CO_2 into Formation Fluid
  - New Drilling
- OEHI has determined: No identified leakage pathways that would result in significant loss of CO_2 to the atmosphere

Faults & Fractures

- No known transmissive faults or fractures that transect the Reef Ridge Shale interval
  - Based on 3-D imaging, and other production information, such as unique oil-water contacts, pressures, and temperatures of the Stevens and the overlying Shallow Oil Zone reservoirs
- Injection pressures unlikely to propagate a fracture through the Reef Ridge seal
  - There is a large difference between MMP and pressure that would compromise seal
  - Risk of overpressure can be fully mitigated by controlling injection pressure
  - Injection pressure is measured and OEHI control system can perform automatic shutdown

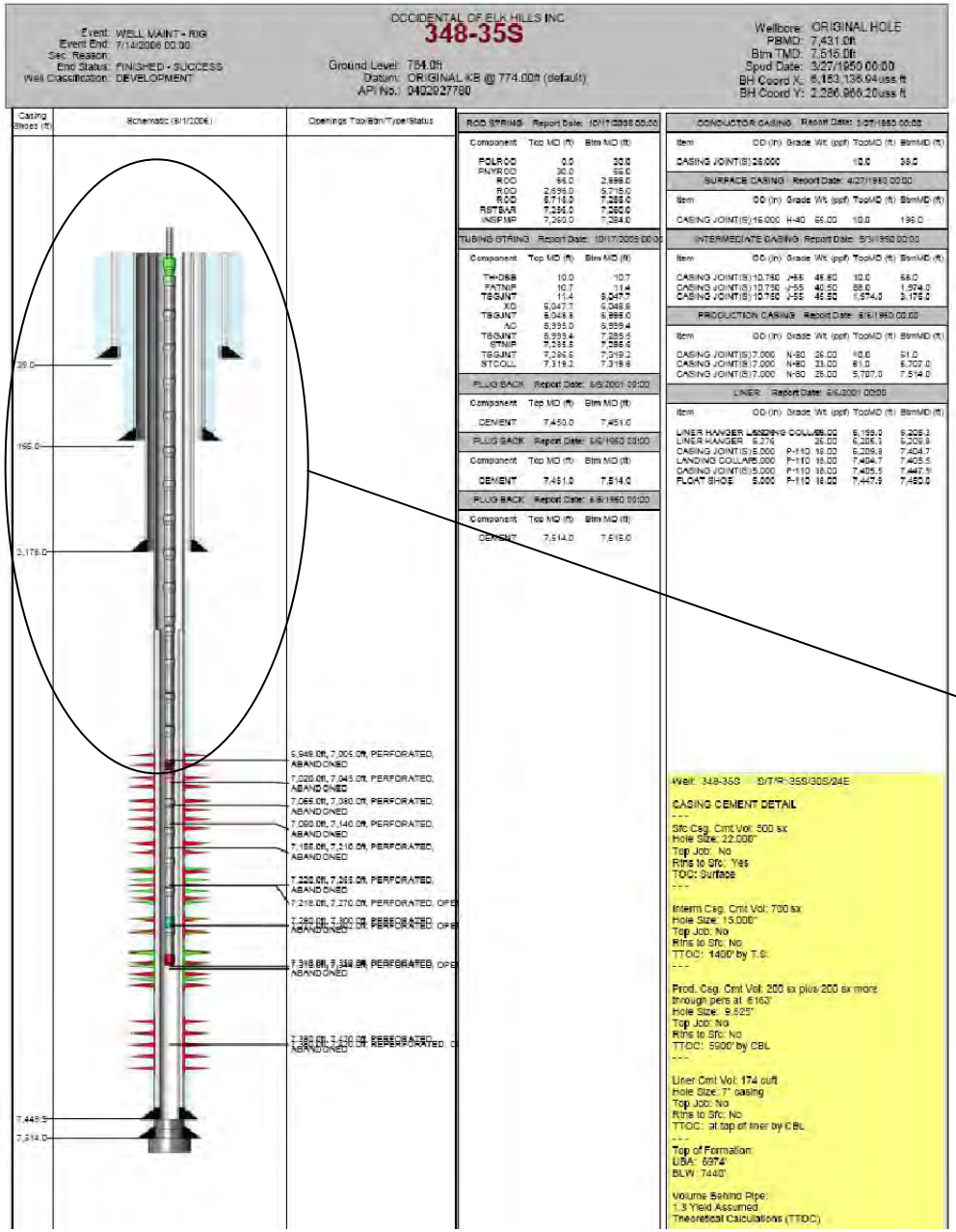
Natural / Induced Seismic Activity

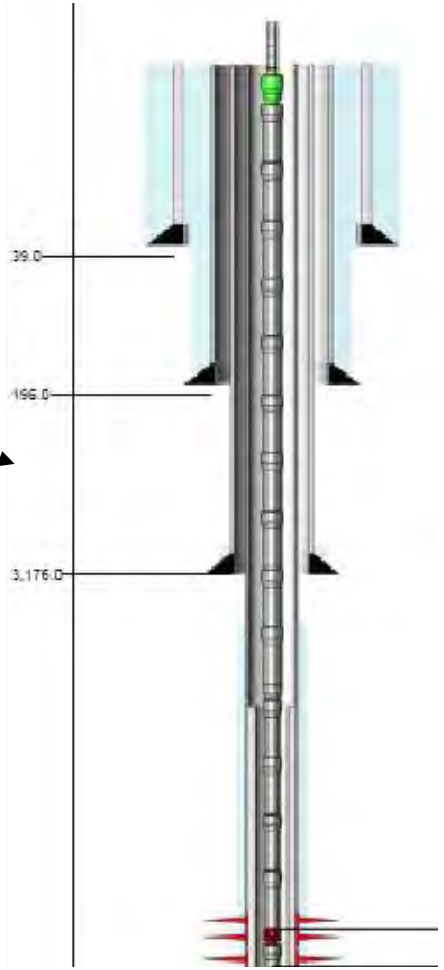
- Natural seismicity of magnitude 3 to 6 is not likely to impact field operations and is highly unlikely to lead to leakage of any injected CO_2 from the EHOF
  - Based on decades of historical data for earthquake effects on wells in oil and gas operations in Southern California
  - Based on the geological setting of the EHOF, which is in relatively soft and shallow sediments (~ 5,000 feet below ground surface)
- Induced seismicity risk is very low
  - Terralog study shows order of magnitude smaller than natural seismicity

Existing Well Bores

- Comprehensive database of all wells due to unique ownership history
- OEHI demonstrated that existing well bores do not pose a threat of leakage from existing production operations
  - Permitting gas and water injection wells for the past 10 years
- OEHI continues to maintain all well bores in a manner that prevents creation of a leakage pathway from the targeted portions of the Stevens reservoirs to overlying intervals
  - Mechanical-integrity testing of injection wells, proper construction of production wells, and demonstration of well integrity at closure

Well Integrity





Previous Operations

- Reef Ridge provides barrier between Shallow Oil Zone and Steven reservoirs
  - Vertical separation of 1400 feet
  - Demonstrated presence of a measured pressure differential between SOZ and Stevens reservoirs
  - No evidence of fluids movement
  - Extensive wellbore database

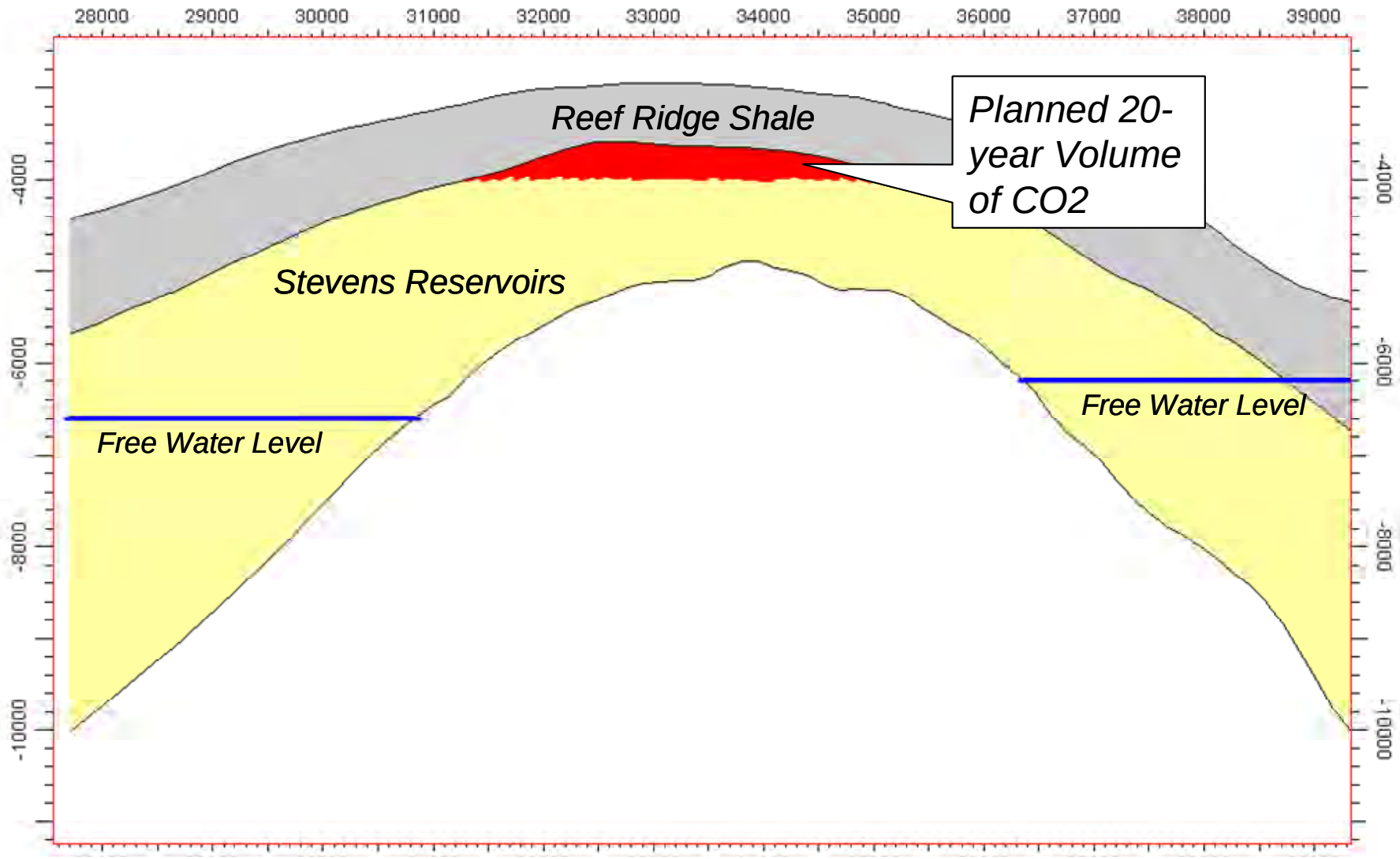
Pipeline & Surface Equipment

- The facilities and pipelines will utilize materials of construction and control processes and that are common to new CO_2 EOR projects in the oil and gas industry
- Operating and maintenance practices will follow industry requirements
- The unique and centralized automation and control system currently in use at the Elk Hills Unit will facilitate excellent operational control and ensure the safety and reliability of the facilities

Overfill Through Lateral Spillpoints

- There are no reasonable injection scenarios that would lead to overfilling the reservoir with CO_2 to cause a horizontal spillover
  - The oil bearing strata – which represent the target injection zones – are above the free-water levels
  - The lateral spillpoints in the 31S and NWS structures lie below the free-water level
  - The Project will produce roughly the same volume of fluids as it injects, creating additional voidage
  - The volume of CO_2 to be injected over the 20-year life of the Oxy CO_2 EOR Project is only ~ 3% of the reservoir pore volume

Management of Spillpoints



Dissolution of CO_2 into Formation Fluid

- OEHI believes this is not a likely pathway for leakage from the Stevens
  - Overfill through lateral spillpoints is not a reasonable scenario
  - Evidence from past production shows no influx of formation fluid and the injection volume is not expected to be sufficient enough to induce an outward flow of formation fluids past these spillpoints

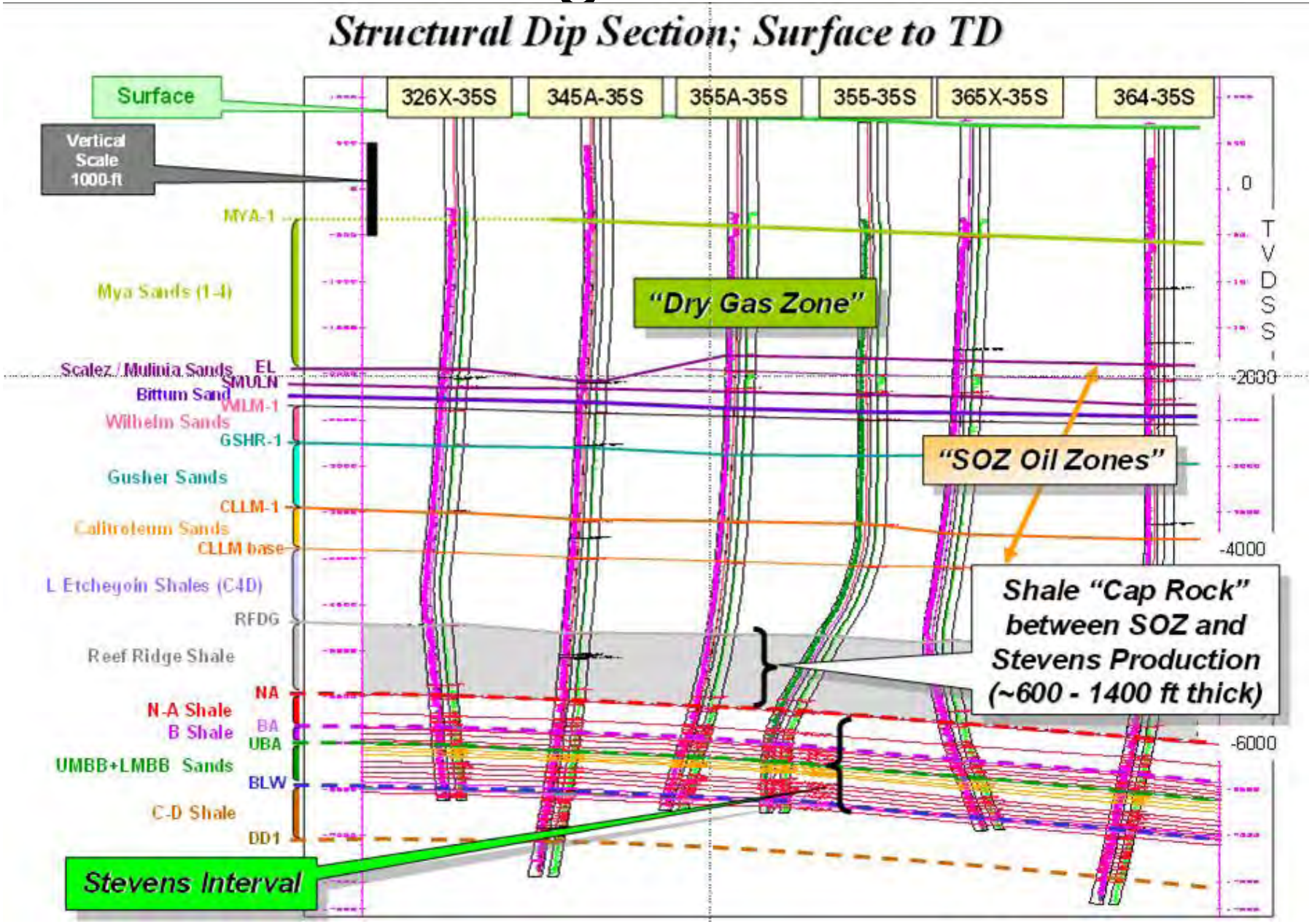
New Drilling

- Several DOGGR regulations and guidelines specifically address zonal isolation during well construction
- These regulations and guidelines are intended to ensure that wellbores pose no significant risk of leakage

Monitoring Leakage Pathways

1. Use of monitoring wells
2. Visual inspection of facilities and wellsites
3. Monitoring of the CO_2 injection

Monitoring Above the Seal



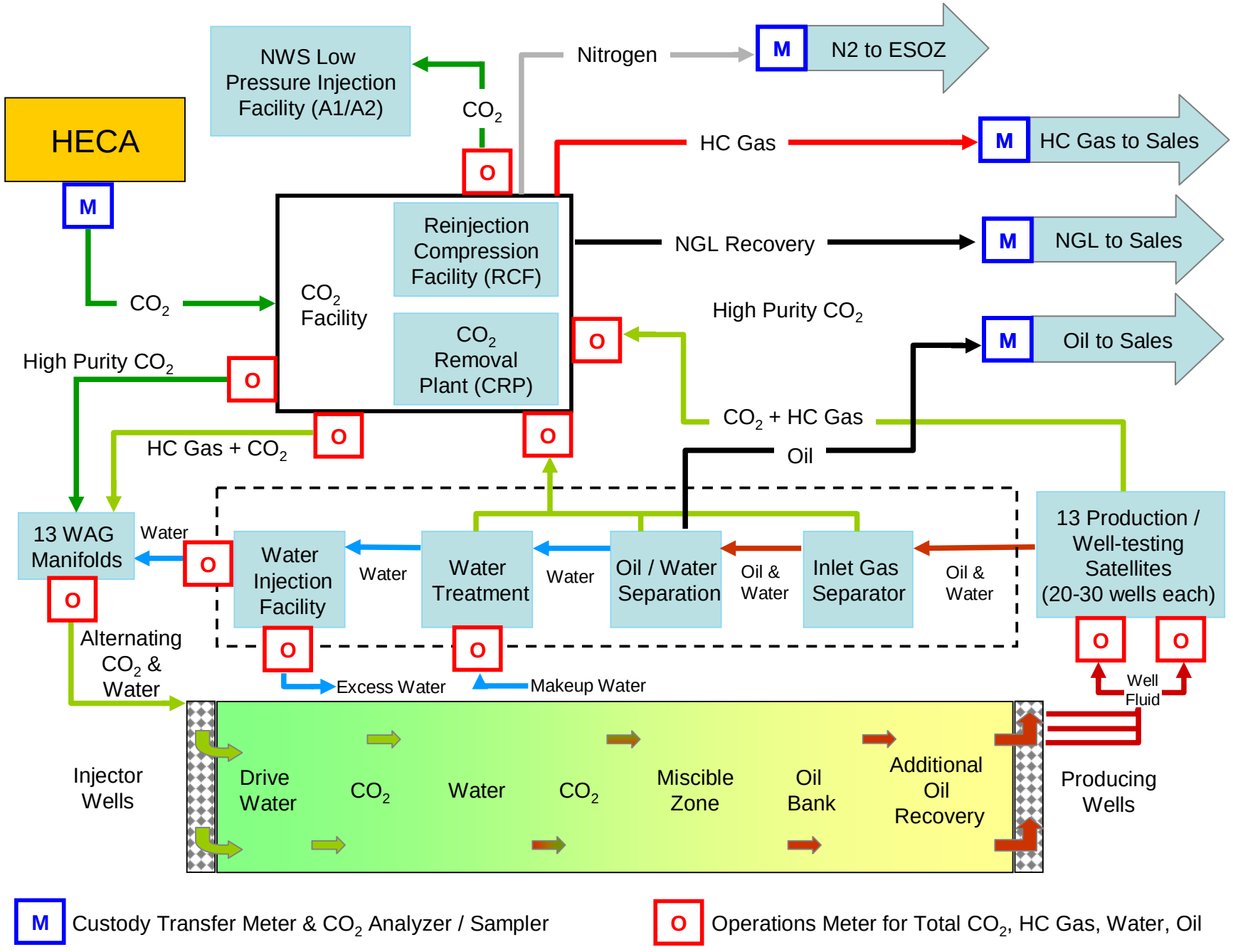
Visual Inspection

- When CO_2 leaks it decompresses
  - highly audible
  - rapid cooling that forms visible vapor or ice
- The oil fields being used for this project are contained in relatively small areas
- OEHI teams perform daily facility inspections and weekly well-site inspections

Monitoring the CO_2 Injection Operations

- Full-field simulation model
  - Storage capacity
  - Pressures
  - CO_2 behavior
- Injection and performance plan
  - Projection of rate and volume of CO_2 injection
- Performance tracking
  - Variances indicate opportunities to enhance model or improve performance
  - If variance indicates migration from the Stevens reservoirs, OEHI will report it promptly

OEHI's Monitoring System



Measuring Incidental and Operational CO_2 Losses

- OEHI currently reports measured and estimated incidental and operational emissions under air quality permits
  - Emissions sources include: valves, connectors, flanges, open-ended lines, compressor equipment, vents, pumps, meters, and other potential fugitive sources
- OEHI plans to follow similar procedures during CO_2 EOR and anticipates being consistent with proposed US EPA GHG Reporting Rule (and ARB conformed rule)
  - Procedures in place to estimate incidental and operational CO_2 losses

How Much CO_2 Will Be Sequestered Through EOR?

Material Mass Balance Equation:

CO_2 transferred to OEHI

- CO_2 measured in products moved offsite
- CO_2 emitted through leakage (if any)
- Incidental and operational losses of CO_2

= CO_2 Sequestered

Other Items in the MRV Plan

- Data Handling
- Missing Data Procedures
- Reporting and Recordkeeping
- Monitoring System Maintenance
- MRV Plan Adjustments

Closure Considerations

- Elk Hills is an active field that will be producing oil and gas for more than 20 years from startup of the HECA project
- OEHI will comply with applicable regulatory requirements for closing and plugging wells and conducting monitoring
- OEHI is considering appropriate approaches to long-term monitoring given the specific characteristics of the site, operations, and the need to demonstrate sequestration

Next Steps

- Complete closure discussion
- Obtain and address feedback
- Submit MRV Plan