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Decommissioning and Restoration – Fostering Excellence through Regulations, Innovation, and Sustainable Practices

30–31 JULY 2024 | BANDAR SERI BEGAWAN, BRUNEI

Repurposing a Producer Well to CO_2 Injector Well in Depleted Gas Field - CCS Project: An Improved Well Conversion Strategy

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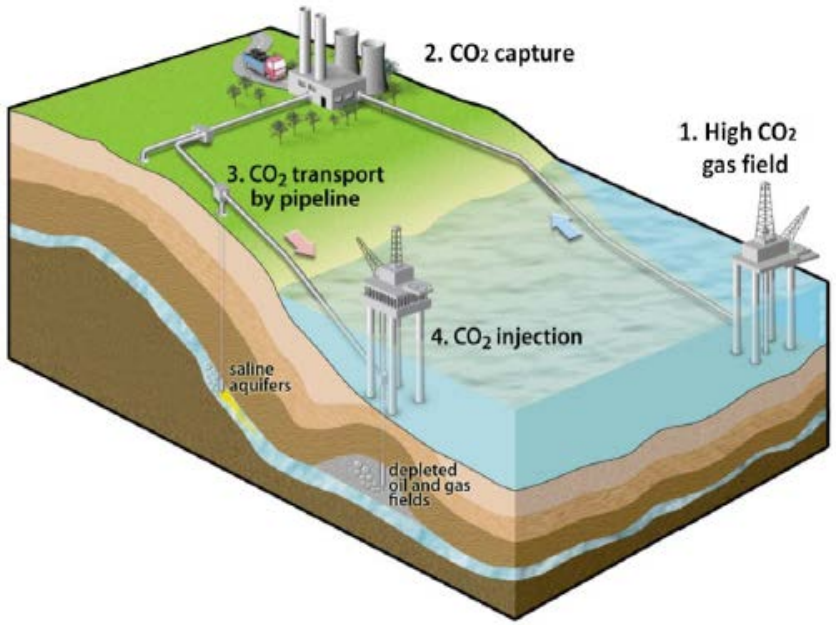
OUTLINE

- Introduction
- Background
- Well Integrity & Assessment Concept
- Well Conversion Strategy

  - New Technology Application
- Monitoring, Measurement & Verification (MMV) Plan
- Conclusion

INTRODUCTION

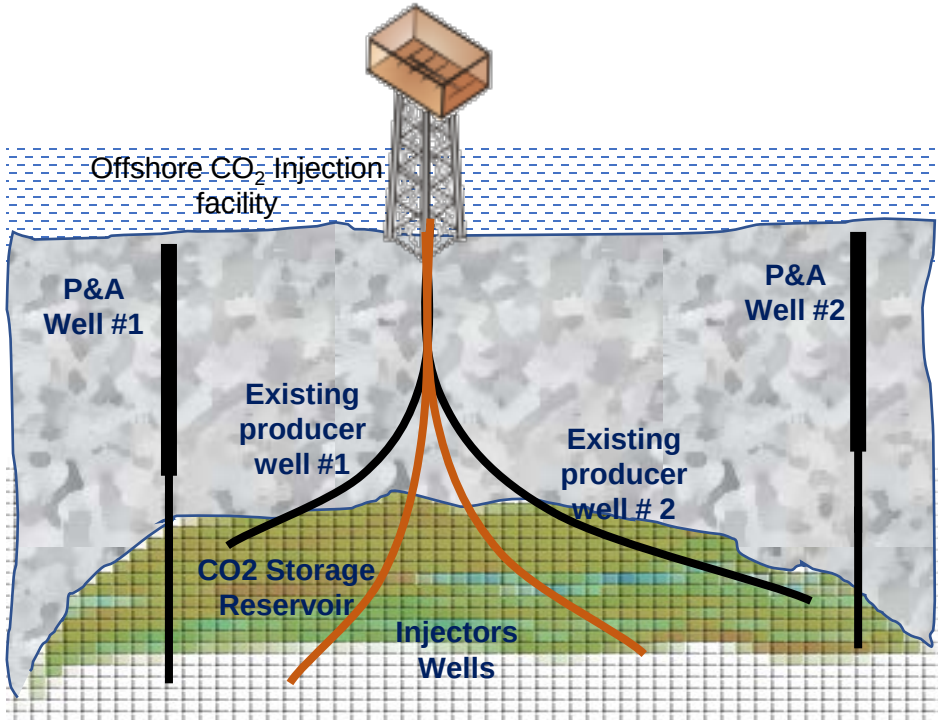


Using depleted gas fields as CO_2 injection sites is a common and promising method for carbon capture and storage (CCS). Depleted gas fields are often well-suited for CO_2 storage due to their geological characteristics.

Repurposing existing wells to serve as CO_2 injector wells is a strategic approach in carbon capture and storage (CCS) efforts. It can be more cost-effective and environmentally friendly compared to drilling new wells. However, repurposing the exiting wells comes with a set of challenges that need to be carefully managed i.e., well integrity issue.

BACKGROUND: Repurposing Existing Wells, Why is it important to CCS Projects?

- It is important to ensure CO_2 injected into the target reservoir will be stored without leakage.
- Facies characterization of sand unit with a thickness of 30m and above with extensive +/-10m coal/shale layer (seal) is considered as a good injection site.
- With the known challenges of repurposing the existing wells, it is important to assess structural integrity of the existing wells to ensure it can handle the pressures involved in CO_2 injection.



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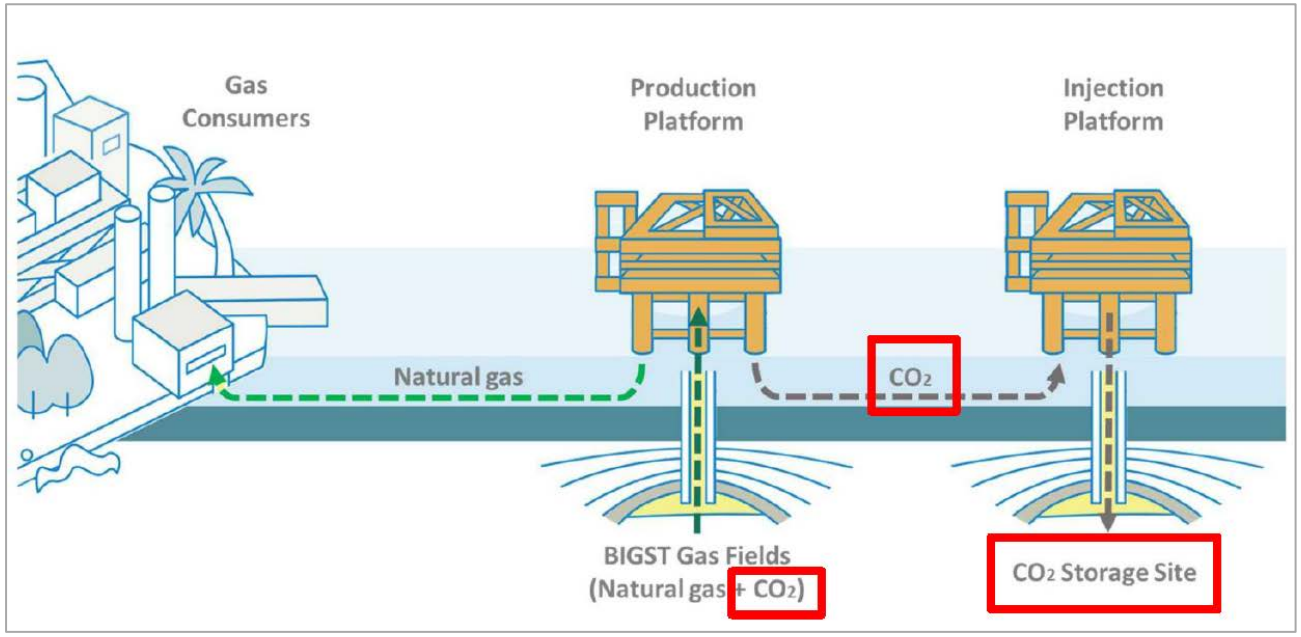
BACKGROUND: Field A, Offshore Terengganu, Malaysia

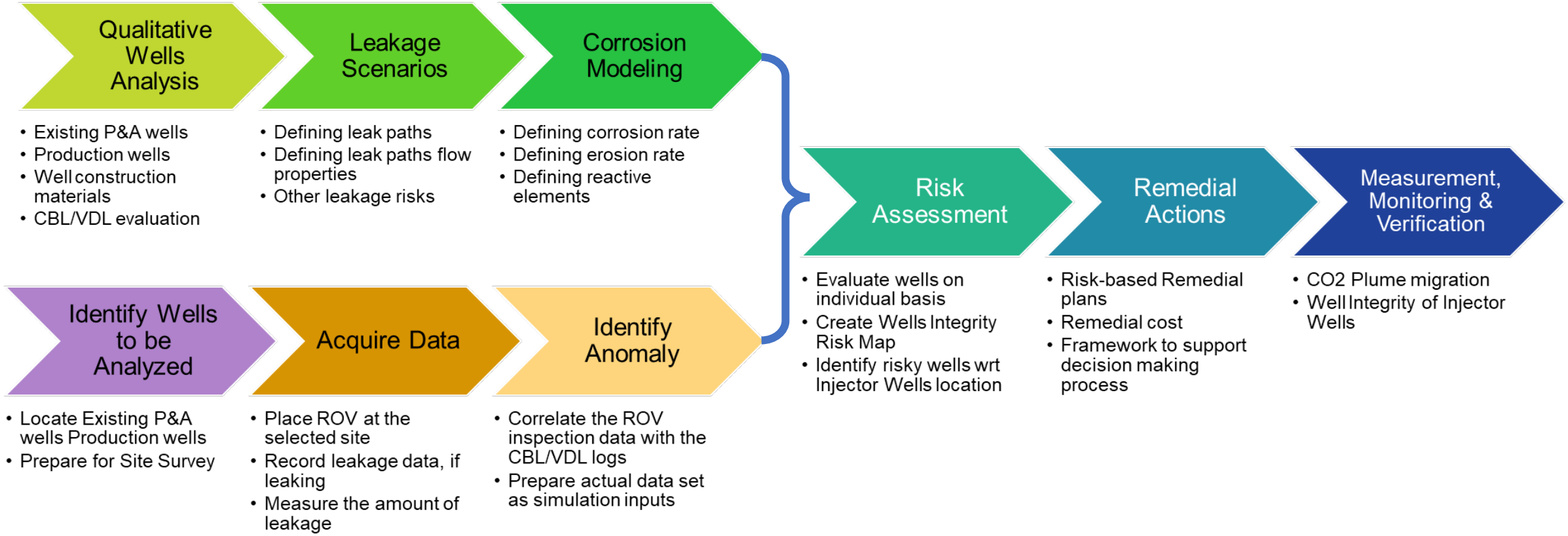
Location	230 km NE from Kerteh, Terengganu, Malaysia
Drilling History	• 7 exploration/appraisal wells (Drilled from 1969 – 2006) - Discovered in Oct 1969 • 34 development wells
First HC	March 1992.
Reservoir	• Non-associated gas reservoirs in Group B, D and E sands • Developed reservoirs: • Major sands: D-32/36, D-40, D-50/60, E-50, E-90/100, E120/130
Existing Platform	2 Platforms • Platform A – 27 Wells • Platform B – 7 Wells
Storage Capacity	• Estimated CO_2 storage capacity is 4.8 Tscf



Field Development Plan

WELL INTEGRITY & ASSESSMENT CONCEPT

- Leakage prediction modelling is conducted together with actual well information. Risk assessment of each well is then evaluated accordingly.
- Remedial actions are proposed based on the risk rating.
- Monitoring, Measurement & Verification (MMV) of injection site will be planned and proposed afterward.



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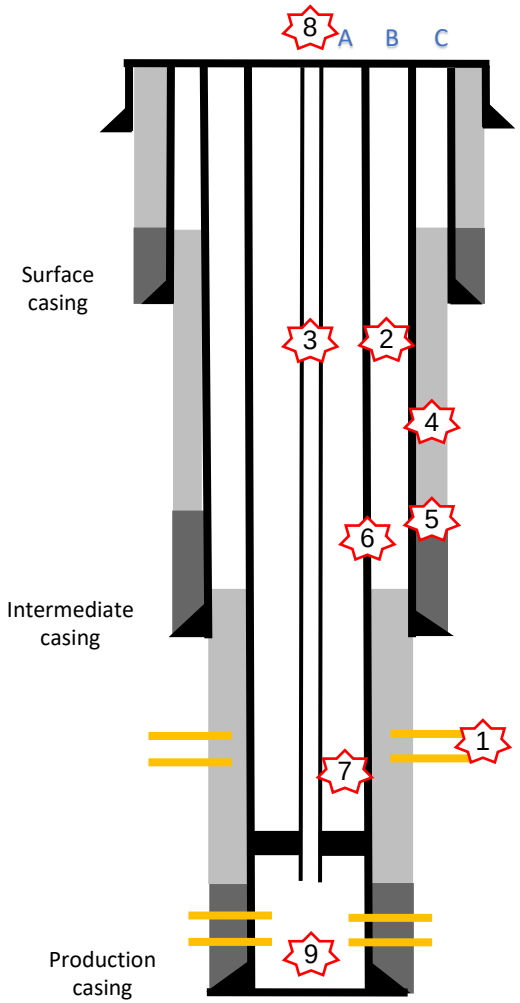
WELL INTEGRITY & ASSESSMENT CONCEPT - Screening Criteria



No	Assessment Criteria	Requirement
1	**Reservoir access from the well**	The well has access to the intended reservoir (existing perforation)
2	**Casing Metallurgy & Connection**	• Corrosion Resistance Alloys • Premium Gas Tight
3	**Tubing Metallurgy & Connection**	• Corrosion Resistance Alloys • Premium Gas Tight
4	**Cement**	CO_2 resistance cement or conventional cement
5	**Cement Quality**	• 150m length of good cement above injection zone & across caprock • 60m of good cement via cement evaluation logs
6	**Sustained Annular Pressure (SAP)**	No SAP in A/B/C/D annulus
7	**Production Packer**	V0 rated packer (gas tight)
8	**Wellhead & Christmas Tree**	HH-NL rated
9	**Well Temperature**	< 225°F * Effect of cement degradation at high temperature

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WELL INTEGRITY & ASSESSMENT CONCEPT - Screening Criteria

No	Category	Item	Requirements	Justifications	Acceptable	Moderate risk	Not acceptable
1	Reservoir access from the well	Reservoir access	Well have access to planned reservoir to be injected.	Reservoir access would allow direct injections. No access no injections.	Well have direct access to preferred reservoir	Well penetrated reservoir, require perforation.	Well do not have access (Existing perforation do not have access)
2	Metallurgy & Connections	Production Casing (Flow Wet Area)	Corrosion Resistance Alloys Premium gas tight connections	Tubing material selection according to material selection chart, depending on injection permeate and reservoir contaminants	CRA according to CO2 Injection permeate planned i.e 25Cr, 22Cr, 17Cr… etc	13 Cr & Gas tight connection	Carbon Steel
3	Metallurgy & Connections	Production Tubing	Corrosion Resistance Alloys Premium gas tight connections	Tubing material selection according tp material selection chart, depending on injection permeate and reservoir contaminants	CRA according to CO2 Injection permeate planned i.e 25Cr, 22Cr, 17Cr… etc	13 Cr	Carbon Steel
4	Cement	Cement Type	CO2 resistance cement or conventional cement	Cement integrity	Slagment Cement, Class G and Class H HSR Portland based Cement		Other class conventional Portland based cement
5	Cement Quality	Annular Cement Evaluation	a. 150m length of good cement above injection zone & Across caprock b. 60m of good cement via cement evaluation logs	Annular cement integrity checks	a. 150m length of good cement above injection zone & Across caprock b. 60m of good cement via cement evaluation logs	a. <100m b. 30m-60m of good cement via Cement Evaluation Logs	a. <50m b. <30m of good cement via Cement Evaluation Logs
6	Sustained Annular Pressure	SAP presence in well potentially indicates integrity failure of the well.	a. No SAP in A/B/C/D	To ensure wells integrity, wells are not leaking.	No SAP issues in any annulus	SAP issues in Annulus A	SAP issues in Annulus B or C or D, require workover
7	Production Packers	Production Packers	a. V0 rated packers (gas rated)	To ensure packers properly rated	V0 rated packers		Non V0 rated packers
8	Wellhead & X-MAS tree	Wellhead & X-MAS tree to be a per specified specs	a. HH-NL rated	To ensure Wellhead and X-MAS tree utilized as per recommended in selection chart.	HH-NL	FF **To further evaluate with providers	EE
9	Well Temperature	Well Temperature	a.<225 deg F	Cement degradation at high temperature. Potentially existing well have experienced high temperature and compromise cementing.	<225 deg F	>225 deg F	

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WELL INTEGRITY & ASSESSMENT CONCEPT – Screening Result & Findings

Well Name	Pre-Screening for Well Conversion Criteria									
	Reservoir Access	Metallurgy & Connection (Casing)	Metallurgy & Connection (Tubing)	Cement Integrity			Sustained Annular Pressure	Packer (Material & Rating)	Wellhead/ X-Mas Tree Material	Temperature
				Cement Type	Cement Isolation (behind casing)	Cement coverage above caprock based on CBL/USIT				
1	Yes	9-5/8", 47#, L-80, VAM TOP - 2190m	4-1/2", 12.6#, 13Cr L-80, JFE Bear	G Neat	No info	No Info	Yes	13 CR Packer/ V0 Rated	FF-Trim. Solar Alert	309 °F
2	Yes	9-5/8", 40#, N-80, BUTT	3-1/2", 9.2# N-80, NEW VAM	No info	No info	No info	Yes	Carbon Steel/ No info	No info. FMC.	238 °F
4	Yes	9-5/8", 40#, N-80, BTC 9-5/8", 40#, N-80, BTC	3-1/2", 9.2#, L80 New Vam	7" and 3-1/2" liner using Slagment	No info	No CBL mentioned in DDR (1999)	Yes	No info.	No info. Old wellhead	309 °F
5	Yes	9-5/8", 47#, L-80, H/BOS - 2438m	4-1/2", 12.6#, Cr-13, FOX - 3329m	G Neat	No info	No info	Yes	13 CR Packer/ V0 Rated	No info. FMC 10K wellhead	309 °F

1. Based on the risk assessment, all wells are at high-risk category & none of the wells are suitable for direct conversion.
2. **Workover** is required for CO_2 well conversion.

Definition of Risk:
High risk : The well will fall under this category if more than one criteria are not fulfilled.

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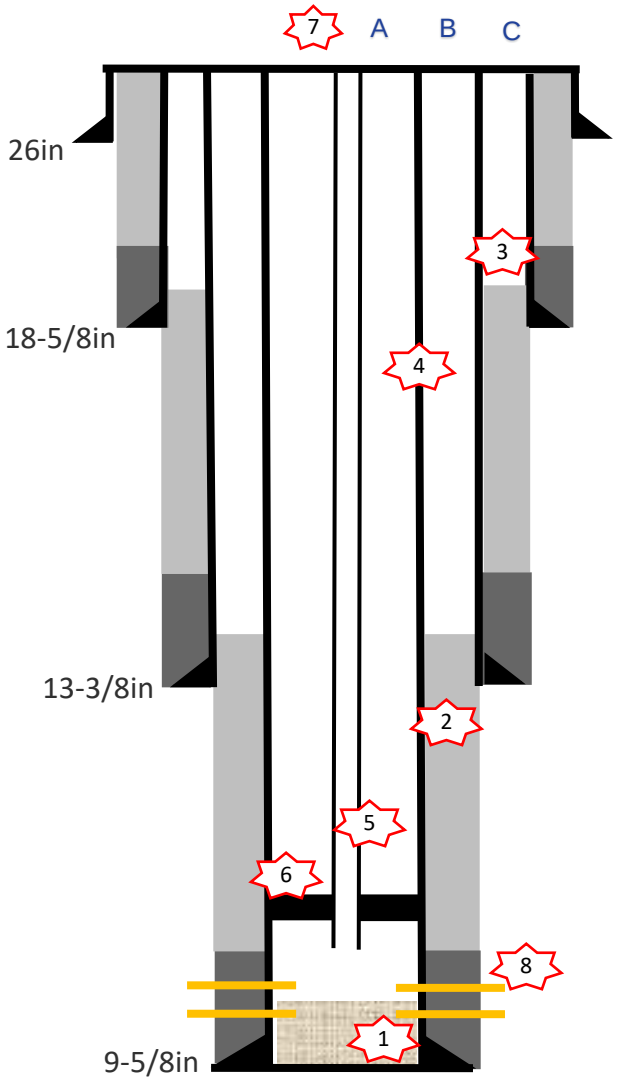
WELL WORKOVER & RE-COMPLETION CONCEPT



Recommended verification
1. Re-run cement evaluation log to confirm on cement quality. 2. Run VIVID log to detect any leak point(s) at casing or tubing. 3. Perform gas sampling to confirm the source of gas (SAP issue).

No	Issues	Remedial Actions
1	Sands build up/ Fish in the hole	• Perform sands cleanout operations. • Fish/mill the fish.
2	SAP issues in annular “B”	• Restore well integrity via caprock restoration. Perform P-W-C across caprock at 9-5/8” casing.
3	SAP issues in annular “C” * Not recommended	• Cut and pull existing 9-5/8” casing. • Restore well integrity via caprock restoration. Perform P-W-C across caprock at 13-3/8” casing.
5	Incompatible tubing metallurgy	• Pull out existing tubing. • Re-run new tubing (13cr or higher).
6	Incompatible production packers	Re-run new packer (V0 rated).
7	Incompatible WH / Xmas Tree	Replace WH/Xmas tree as pre required specification.

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WELL CONVERSION STRATEGY – What's the difference?

Initial Plan

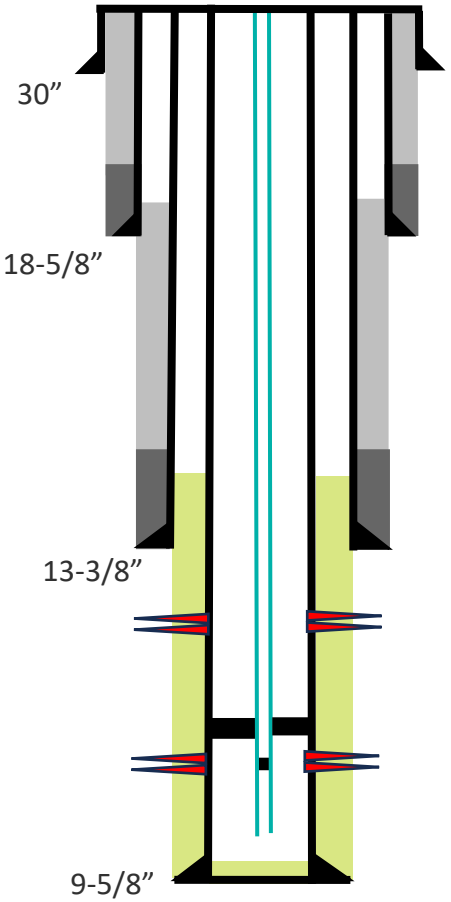
Wellhead as per CCS requirement HH-NL material for high concentration CO_2.

Cement with CO_2 resistance cement

Run new tubing with fiber optics

Caprock restoration via PwC

Remediation at perforation zones – squeeze cement



New Strategy

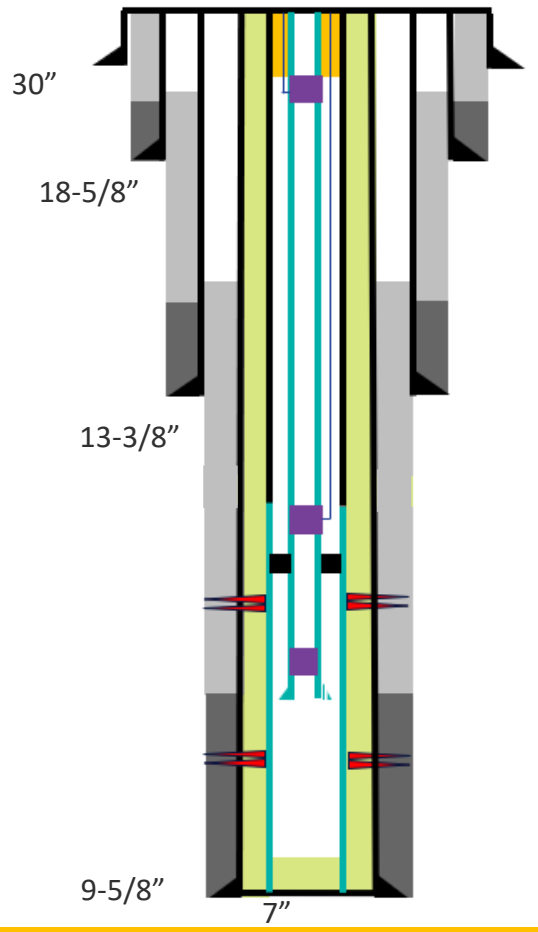
Wellhead as per CCS requirement HH-NL material for high concentration CO_2.

Caprock restoration via section mill

Cement with CO_2 resistance cement

Run new tubing with fiber optics

Run new 7” casing inside 9 5/8” casing



** No remediation at perforation as the leak point is unknown

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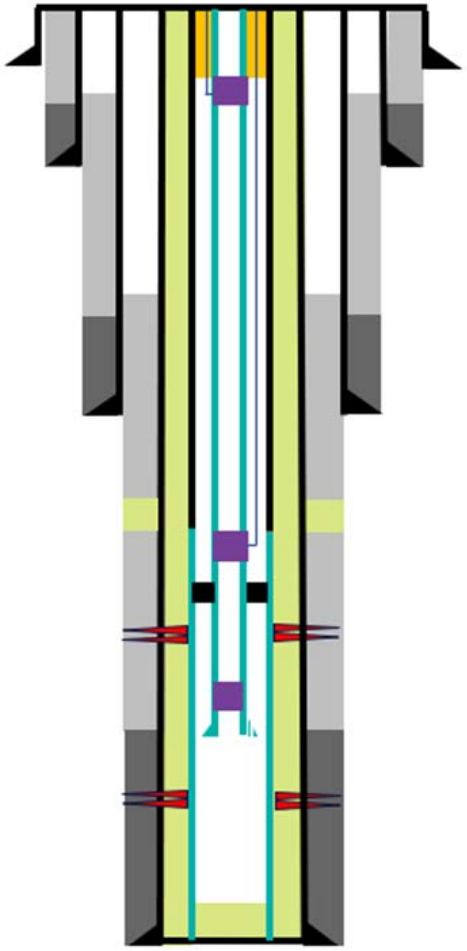
WELL CONVERSION STRATEGY – New Technology Deployment



1. **Geopolymer Cement – CO_2 resistance cement**
2. **SAP remediation**
   Slot recovery Inspection – to confirm Top of Cement (TOC)
3. **Casing Repair Tool**
   Example of available technology (for consideration): Bismuth-based sealing Technology
4. **Fiber Optics - Monitoring**

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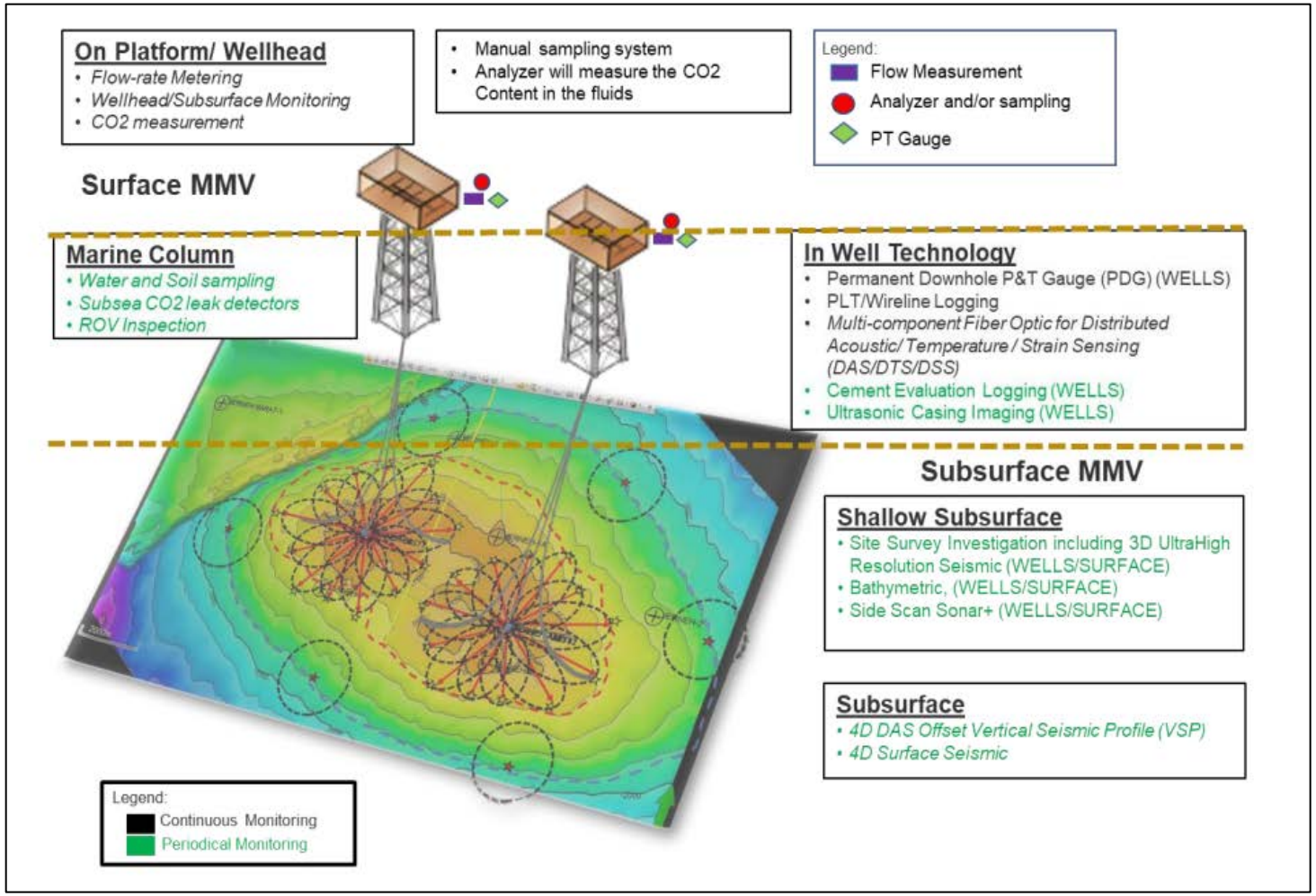
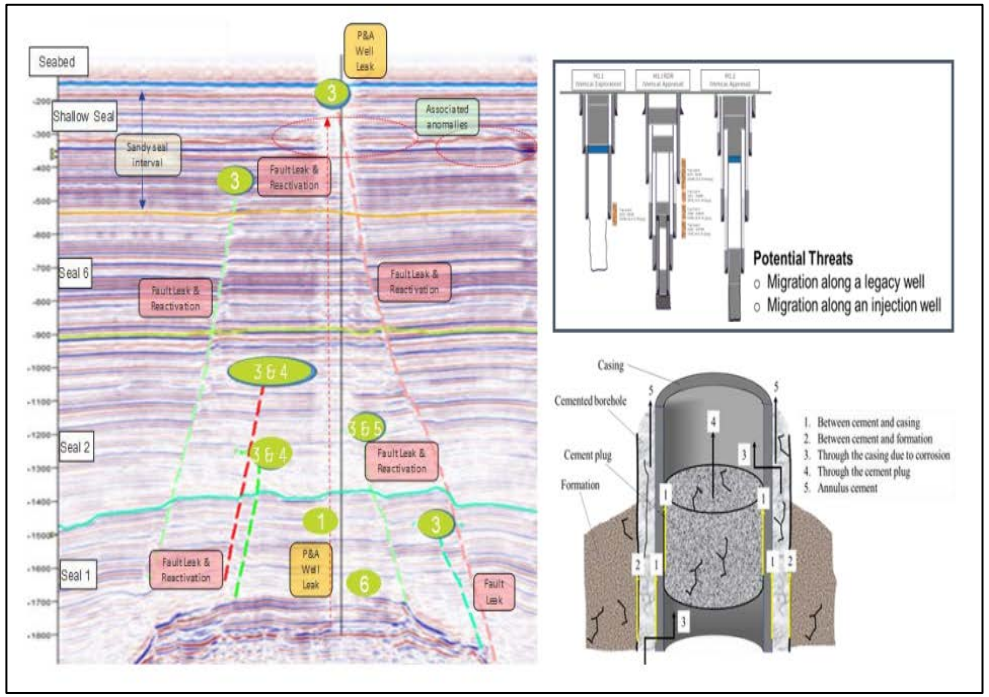
MONITORING, MEASUREMENT, VERIFICATION (MMV) PLAN



Master MMV Plan



Potential leakage pathways

CONCLUSIONS

- Repurposing existing production wells provide multiple benefits, which ultimately translates to cost saving.
- However, it is crucial to evaluate the existing wells condition to ensure wells that are considered for conversion are technically suitable as CO_2 injectors.
- Existing production wells generally contain multiple issues, i.e. SAP, sands, leaks, which require to be remediated prior to re-completion work.
- Re-purposing existing production wells into injector wells is doable but highly complex. All integrity issues must be remediated to meet CCS requirements.
- Caprock restoration must be performed and new casing to be run to mitigate SAP issue and non gas tight connection.
- New technology should be explored and utilized during workover job. Also, to ensure good integrity throughout injection period, i.e. CO_2 resistant cement & fiber optics (monitoring).
- MMV Plan should be in place to monitor plume migration in CCS field & wells condition.

ACKNOWLEDGMENT

BIGST Team – Joint Team between JX Nippon & PETRONAS

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