

Unlocking Water-Flooding Surface Challenges

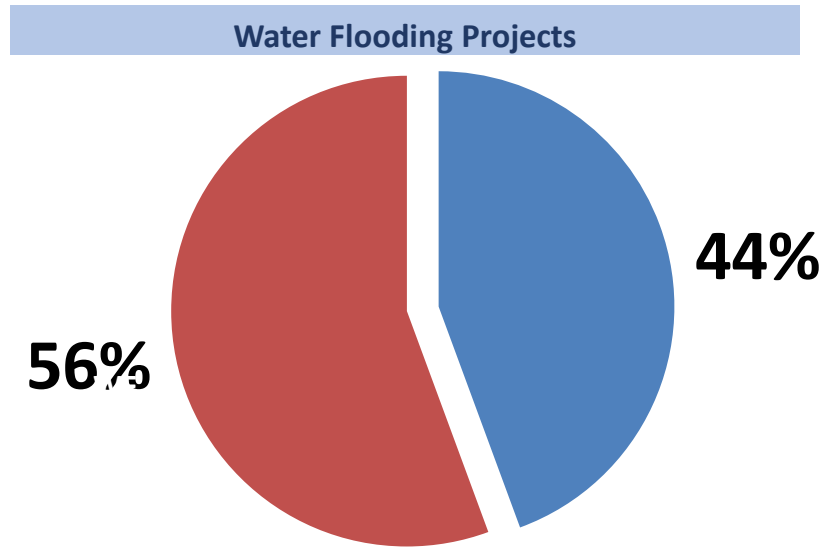
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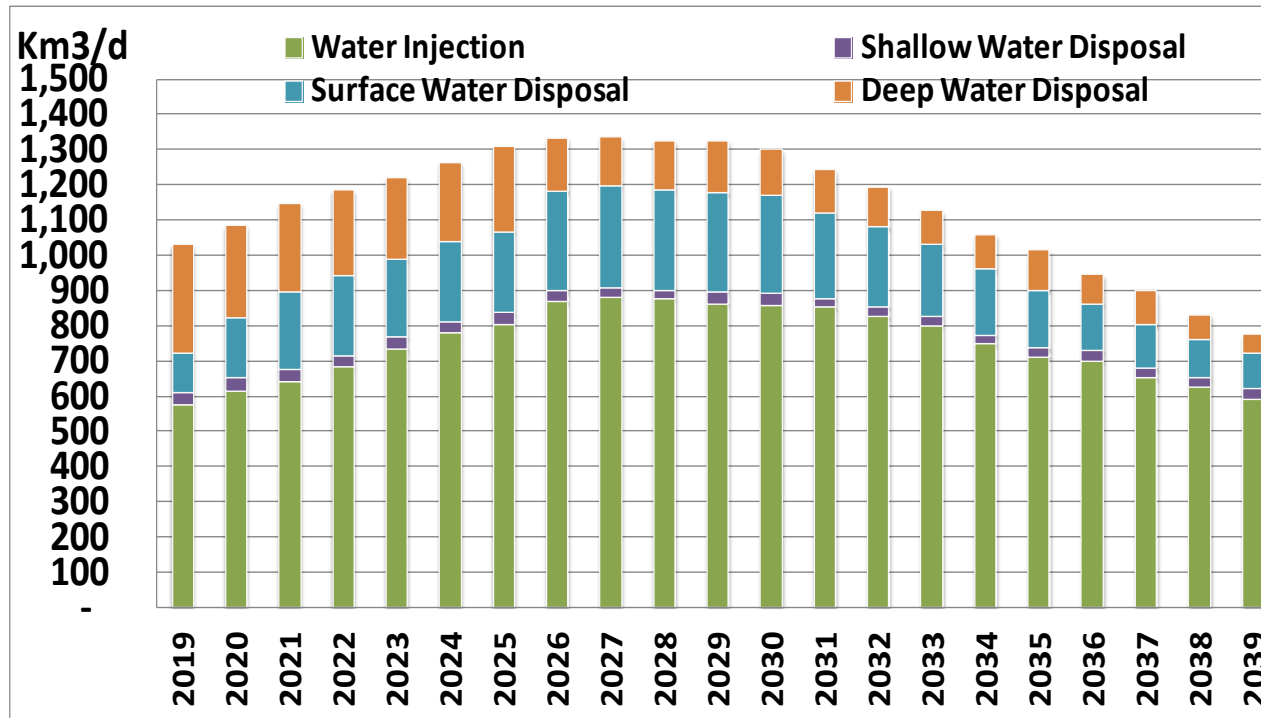
PDO Waterflooding Overview

- PDO Water-floods over 60 fields in both North and South directorates. This delivers 240 kbpd of production, sustaining about 40 % of PDO's overall production/reserves.



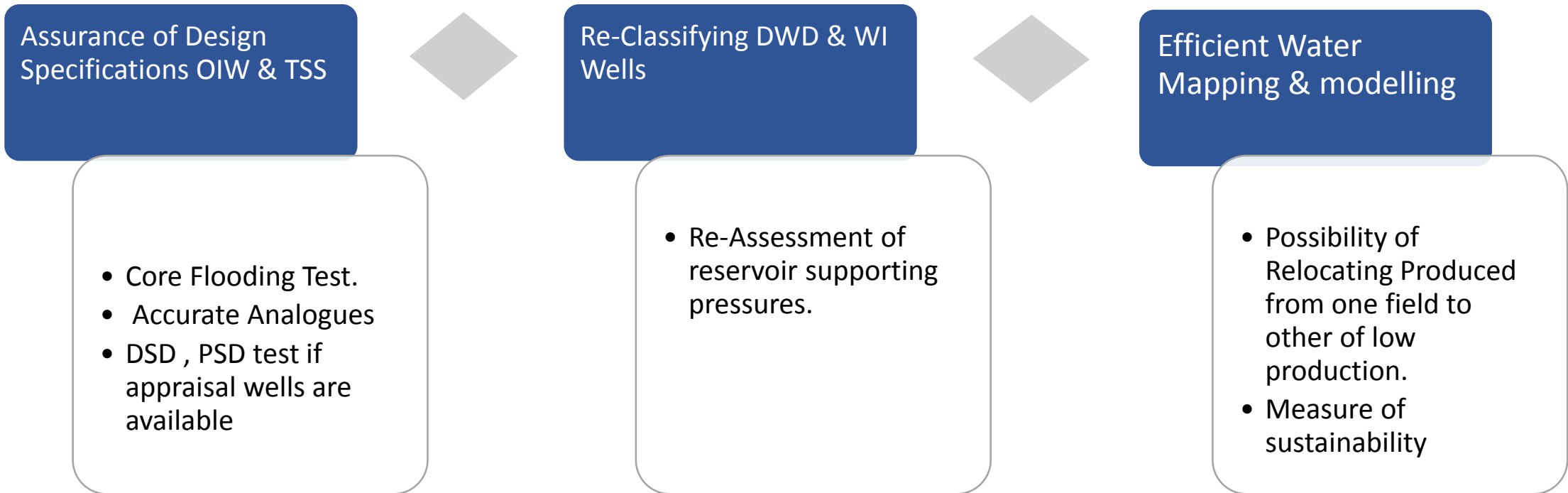
- 2016 Portfolio review increased the focus on developing satellite fields (SSFD) & increasing throughput in existing fields
- 2018 Waterflood Deep Dive identified improvement areas around 6 themes
- 2019 WF improvement plan aims to improve production by reducing field decline rates as a result of water-flood optimization
 - Getting the right amount of water, of the correct quality,
 - Improve sweep oil in the most effective way,
 - Reduce the OPEX cost of waterflooding.

Latest Water Forecast Injection/Disposal



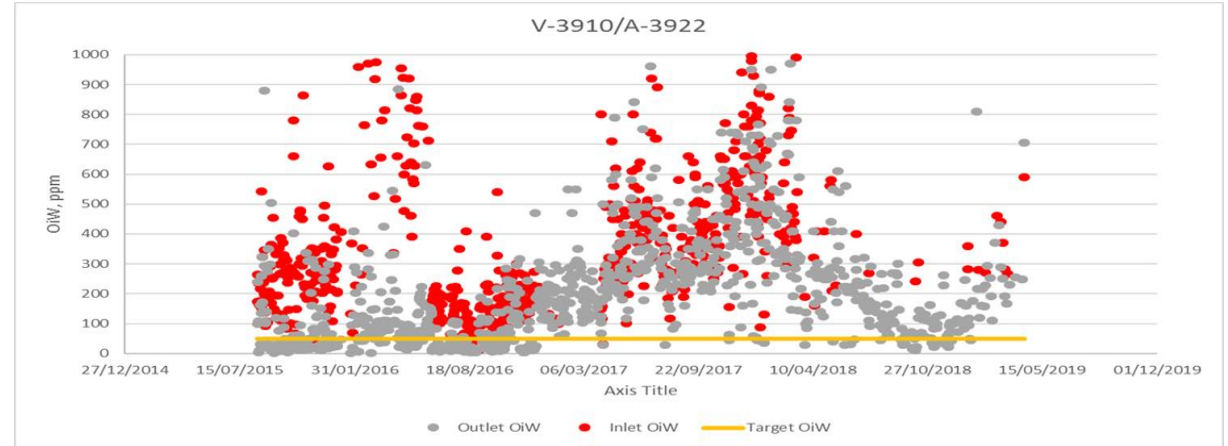
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Surface Solutions towards robustness in Water Flooding in PDO



Water Quality Health Checks Best Practices

- The right quality for the right field
 - Review the current basis & settings
- Target the areas where WQ having the biggest impact on injection decline for Troubleshooting
- Solving the persistent issues with Water Treatment
 - Hydro-cyclones
 - De-Sanders
 - GFTs
 - CPIs
 - Schmoo
 - Corrosion



Project Case: Changing Make-up Water Source From Aquifer to Produced Water Case in Field A

Project Objective:

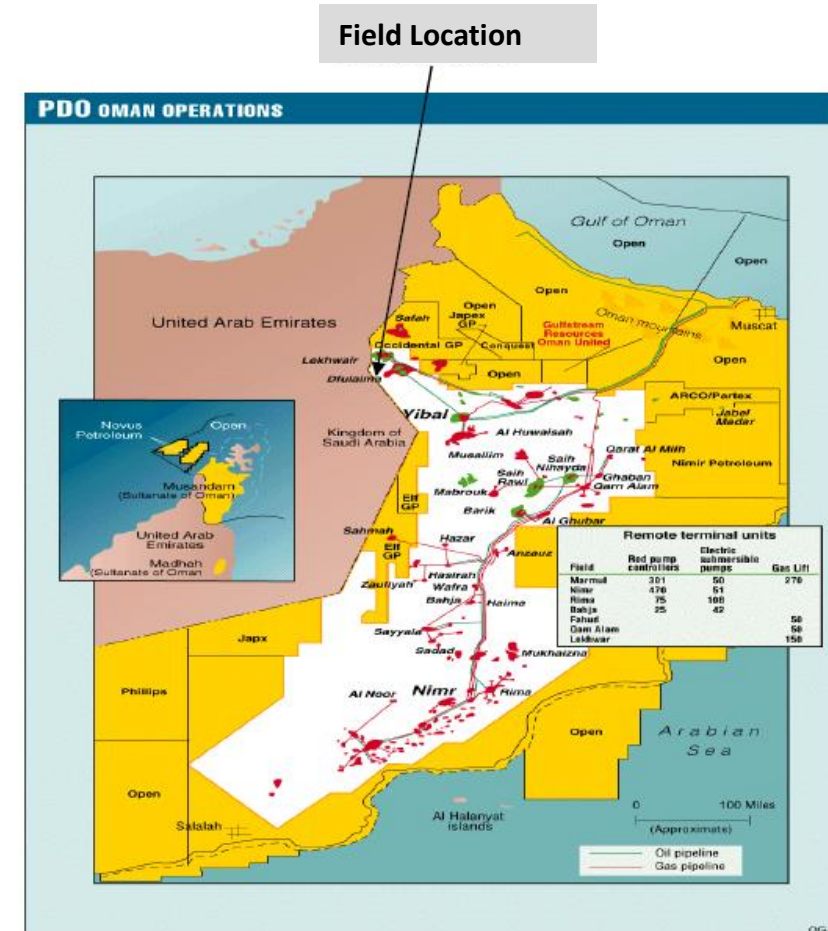
Due to Strict Regulations and sustainability reason it was required to move from using aquifer water to an alternate source.

Business Drivers:

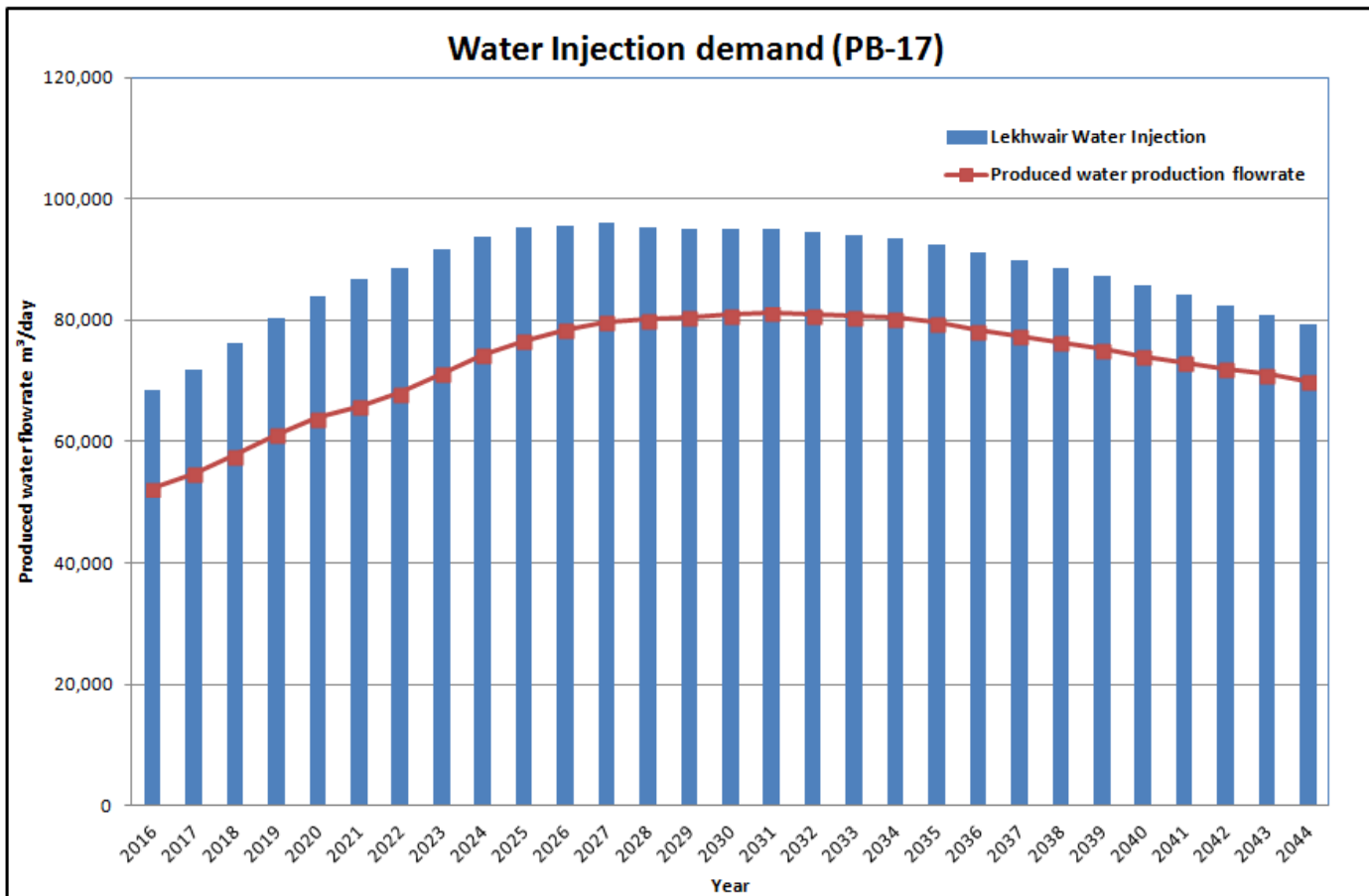
- De-risk water flood dependency on Aquifer water supply
- Maximize Water flooding Suitability

Water Flooding Specifications:

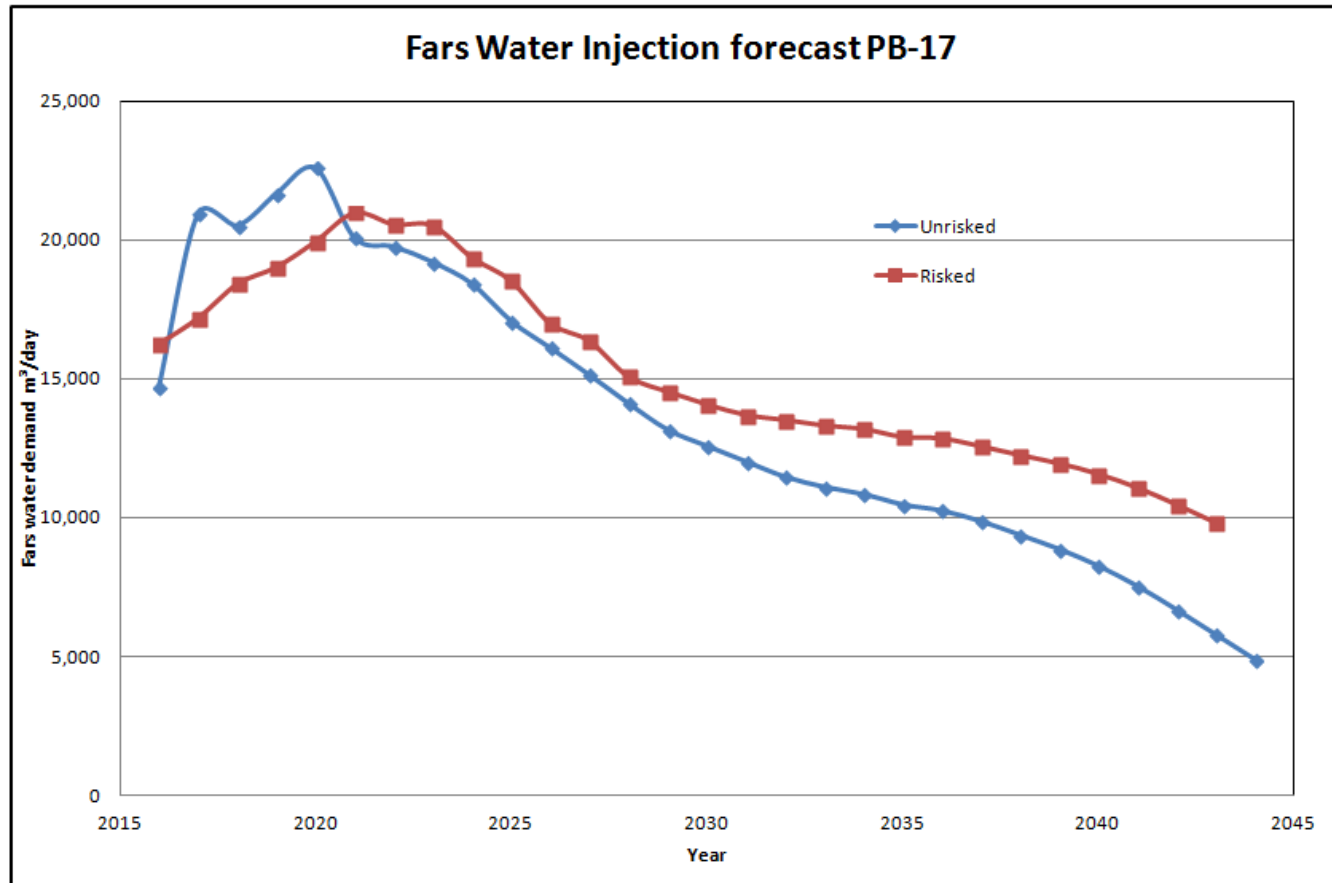
Parameter	Water injection specification
Oil in Water	<50 ppm
TSS	<10 mg/l
Dissolved H2S	As Low as possible
Dissolved Oxygen	<10 ppb



Water flooding Demand



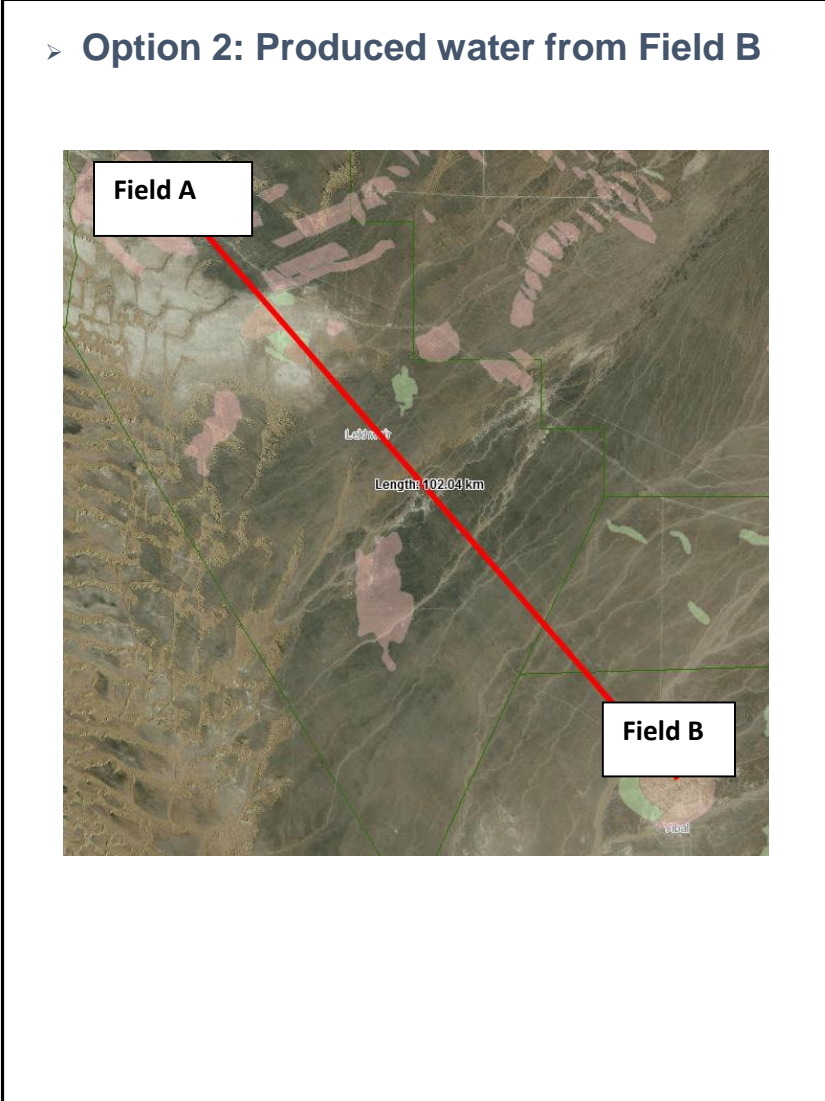
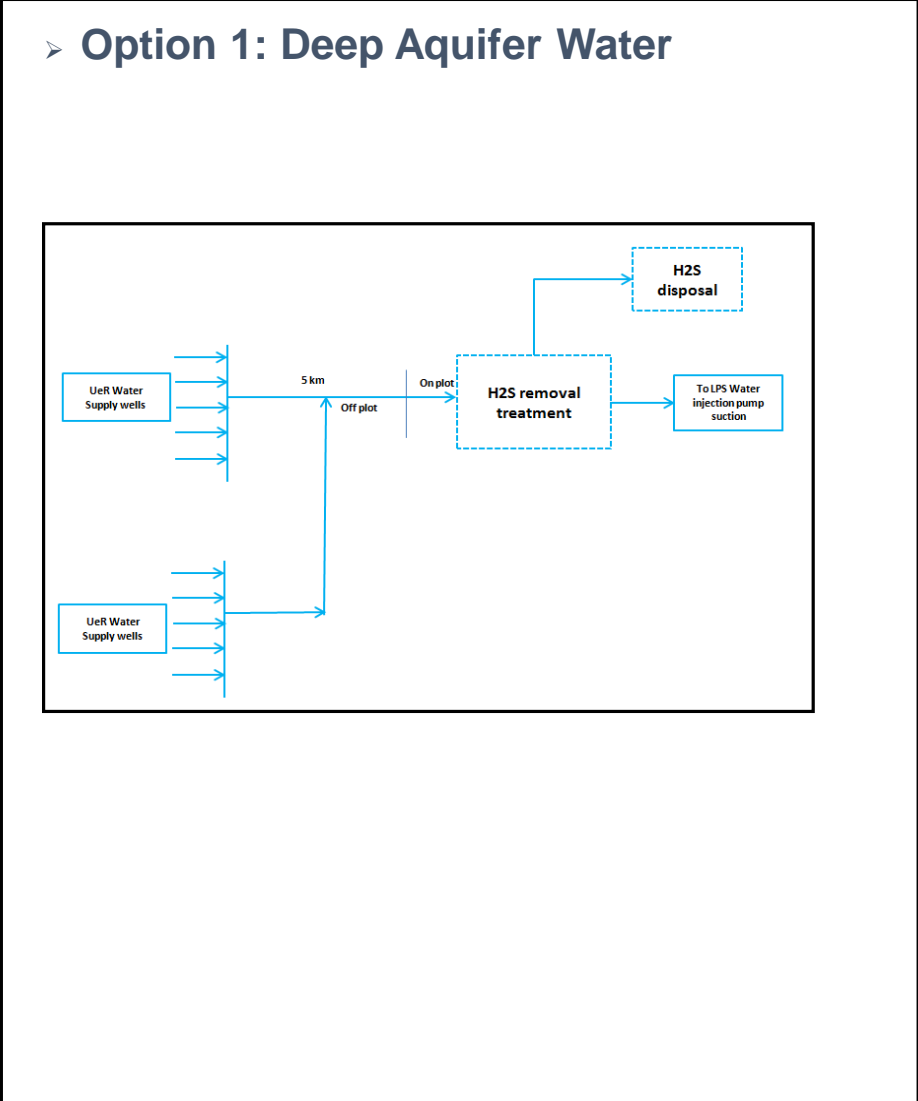
Exiting FARs Aquifer Injection Forecast



Water Analysis for different water sources:

Component	Units	Option 1 Aquifer water	Option 2 Field B Produced water
OIW	ppm	NA	<25 ppm
Sodium	mg/l		60,000
Calcium	"	20,000	16,350
Magnesium	"	2000	2000
Chloride	"	87,000	127325.1
Sulphate	"	1000	1000
Bicarbonate	"	50	120
Total dissolved solids	"	150,000	200,000
Total hardness	mg/l as CaCO3	55,000	49,000
Total Suspended Solids	Mg/l	<5 mg/l	<10 mg/l
H2S in Liquid Phase	mg/l	270	<10

Water Source Options



Water Sources Options

	Field A Deep Aquifer	Excess PW from Nearby Field
Technical Robustness	<ul style="list-style-type: none"> Needs H2S removal /stripping H2S Management System (Conversion to Sulfur). Complex . 	<ul style="list-style-type: none"> New 100 Km Pipeline from Field B to Filed A. Utilization of Disposal Pumps Less complex
Operability / Maintainability Robustness	<ul style="list-style-type: none"> Will add Additional equipment to operate and maintain H2S Management System (Conversion to Sulfur) Complex . 	<ul style="list-style-type: none"> No additional equipment to Operate and maintain
HSE	<ul style="list-style-type: none"> Minimum exposure to human and environment No Harmful waste generated/No elemental Sulfur handling issues 	<ul style="list-style-type: none"> No H2S Exposure
Life Cycle Costs (CAPEX and OPEX)	- Capex > 150 mln US\$	<ul style="list-style-type: none"> Capex <90 mln US\$