MADAR

ENERGY TECHNOLOGIES

MADAR TECHNICAL INSIGHT

Mature Carbonate Waterflood Opportunity

From Late-Life Diagnosis to Technology Pilot

An anonymized Oman field example prepared as a technical gateway for collaboration with international technology companies.

Reservoir	Lower Cretaceous platform carbonate
Field maturity	Production since early 1990s
Development	Horizontal wells + gas lift; water injection introduced late in field life
Challenge	Low remaining oil rate, high water handling, pressure depletion, compartmentalization
Opportunity	Surveillance, zonal injection control, conformance and selective completion pilots

Discussion draft • October 2026

CONFIDENTIALITY NOTE This paper uses anonymized and rounded data synthesized from client-supplied internal field-development, reservoir-engineering and resource-review material. Field, operator, block, well and concession identifiers are intentionally omitted. It is intended for technical discussion and partner screening only; external publication or commercial use should be subject to rights-holder review.

1. Executive Summary

A mature Oman carbonate field provides a useful example of the challenge facing many late-life waterfloods: a large volume of oil remains in place, but production is constrained by pressure depletion, rising water handling, structural compartmentalization and uncertainty over where injected water is actually moving.

The anonymized field began production in the early 1990s. By the end of 2014 it had produced about 3.8 MMstb of oil from roughly 32 MMstb STOIIP - a recovery factor of only about 12%. Reservoir pressure had fallen from about 3,000 psi to about 1,500 psi. Oil rate was about 0.3 kbopd while water production was about 3.0 kbwpd. Water injection had only recently started, at about 4.4 kbwpd, through three converted wells.

The strategic question is therefore not simply whether more water should be injected. It is where the water is entering, which flow units and compartments it is contacting, where mobile oil remains, and what technology can improve vertical and areal sweep without accelerating unwanted water production.

Madar proposes using this type of field as a technology-screening gateway: first diagnose the dominant flow mechanism, then select a targeted technology, then design a small pilot with measurable technical and economic KPIs. The objective is not to sell a tool; it is to prove a reservoir outcome.

2. Anonymized Field Context

Parameter	Anonymized field value
Reservoir	Shallow-water platform carbonate; multiple flow units separated by baffles
Depth	~5,600-6,300 ft
Gross reservoir interval	~180 ft
Oil quality	~38° API; low viscosity (~0.4 cP at initial conditions)
STOOIP	~32 MMstb
Production start	1993
Wells by end-2014	12 horizontal producers drilled; 6 active; 3 converted to injectors; 3 shut in for high water cut
Water injection start	May 2014
Pressure	~2,963 psi initial; ~1,500 psi by 2014
Recovery by end-2014	~3.8 MMstb cumulative oil; ~11.9% RF

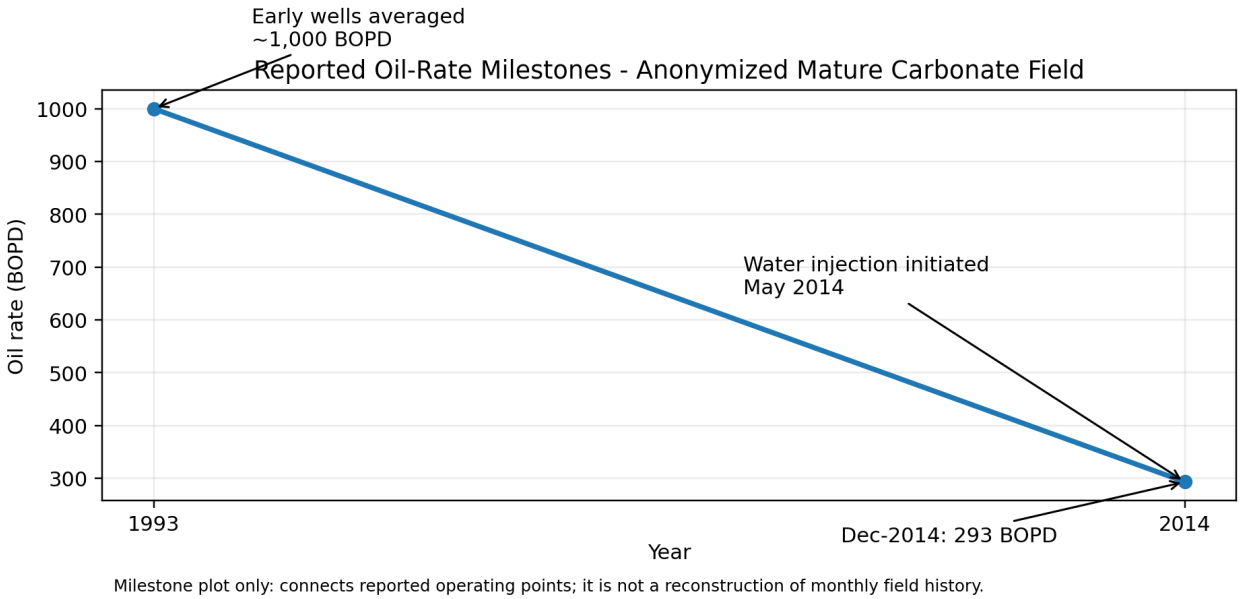


Figure 1. Reported oil-rate milestones. The line connects sourced operating points only and should not be interpreted as monthly history.

3. What the Field History Tells Us

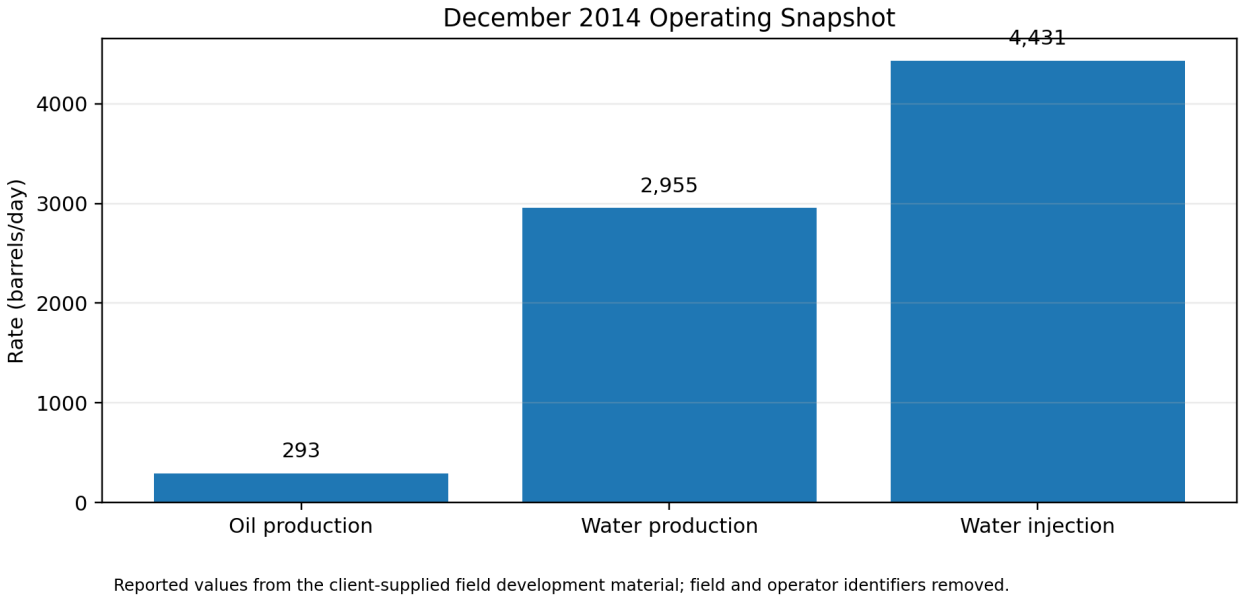


Figure 2. December 2014 operating snapshot: low oil rate relative to water production and injection is characteristic of a mature, water-handling-intensive opportunity.

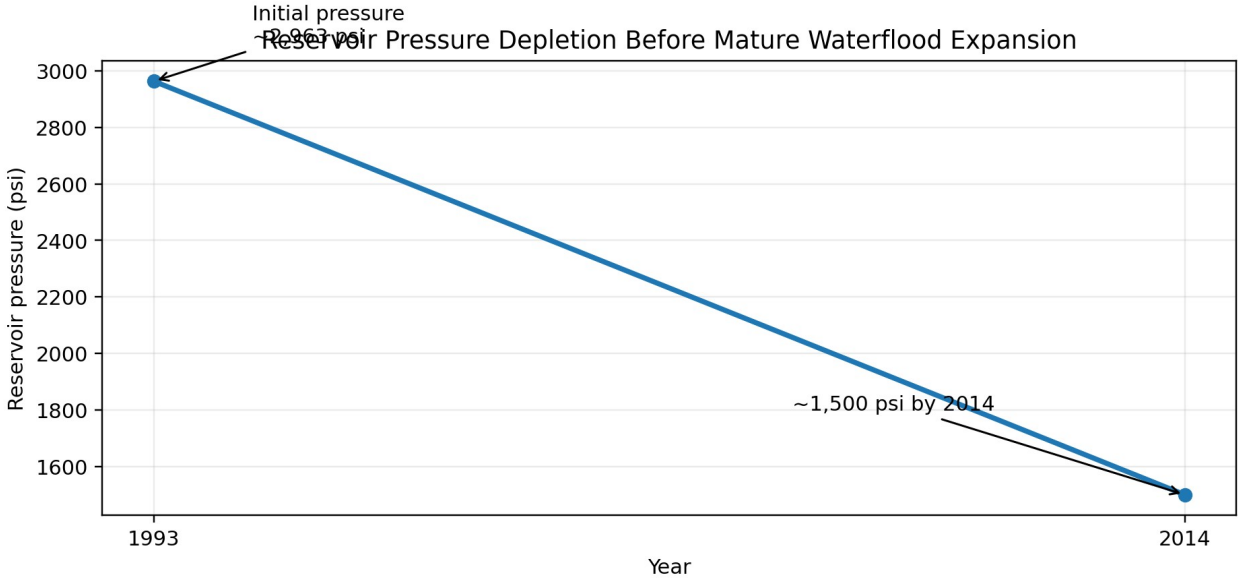


Figure 3. Pressure depletion from initial conditions to 2014, prior to a mature waterflood expansion program.

4. Reservoir Diagnosis - The Problem Is Not “More Water”

The source material describes a structurally complex carbonate reservoir with multiple faults, flow units and baffles. The two principal blocks appear to be in pressure communication, but local flow behavior remains controlled by heterogeneity, permeability architecture and well placement.

- Water injection was introduced late relative to the field age, so the quality of sweep - not simply injection volume - becomes the central question.
- Horizontal wells can create strong productivity but can also concentrate inflow or water entry into a limited part of the completion.
- Faults and baffles can either compartmentalize the reservoir or focus flow; the same field can therefore contain both poorly swept oil and fast water pathways.
- Low-viscosity oil gives a favorable mobility context, but conformance and connectivity still determine whether injected water produces incremental oil or simply recycles.
- The historical model indicated that additional producers and injectors could increase recovery, while later-life value increasingly depends on identifying remaining mobile oil and targeting the correct flow path.

5. Where New Technology Can Add Value

- Interwell connectivity diagnostics - tracer / nano-tracer, pressure-interference analytics and data-driven connectivity mapping to identify injector-producer communication and likely thief pathways.
- Zonal injection control - intelligent or remotely adjustable downhole control and zonal allocation to move water away from dominant high-permeability intervals and toward under-swept layers.
- Conformance control - temperature/salinity-tolerant gels, microgels, particles or other deep-profile-modification systems to reduce cycling through high-permeability channels.
- Selective completion / water control - mechanical isolation, selective recompletion or inflow-control systems to reduce unwanted water entry without sacrificing productive intervals.
- Digital waterflood optimization - pattern diagnostics, history matching, AI-assisted rate allocation and surveillance integration to convert field data into pattern-level decisions.

6. Pilot Concept for Technology Partners

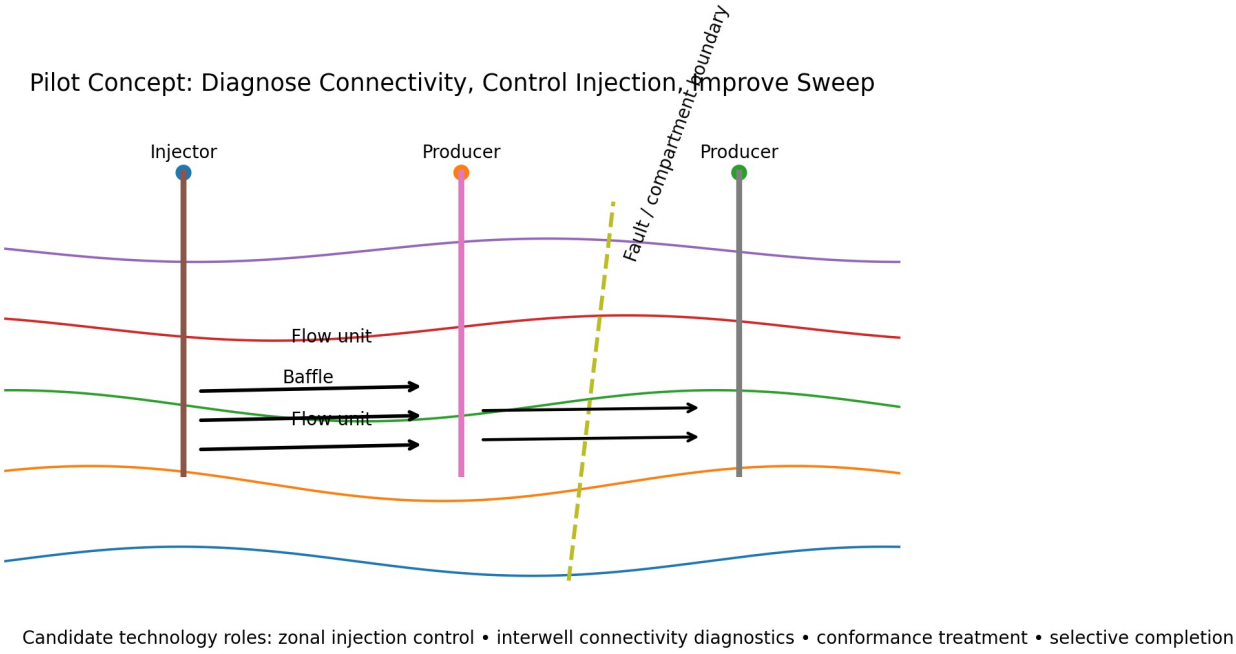


Figure 4. Conceptual pilot architecture: diagnose connectivity first, then control injection and verify whether sweep improves.

A first pilot should be deliberately small and designed to answer one reservoir question. A practical candidate is one injector with two to four offset producers in a pattern where water response, pressure support and remaining-oil potential can be measured.

Stage	Indicative duration	What is measured
Step 1 - Baseline	3-6 months	Injection and production rates, water cut, pressure, well status, PLT/tracer if available
Step 2 - Diagnose	2-6 weeks	Connectivity map, zonal allocation, dominant breakthrough mechanism, remaining-oil hypothesis
Step 3 - Intervene	Days to weeks	Apply zonal control, conformance chemistry, selective isolation or other screened technology
Step 4 - Verify	3-6 months	Oil response, water response, injectivity, pressure, tracer/PLT response, operational reliability
Step 5 - Scale	Decision gate	Economic value per barrel injected; repeatability across patterns; commercial deployment case

7. Proposed Pilot KPIs

- Incremental oil versus an agreed baseline or decline forecast.

- Reduction in produced-water rate and/or water cut where water-control is the objective.
- Improvement in injection allocation to under-swept zones.
- Change in injector-producer response time and pressure communication.
- Injectivity retention and absence of formation damage.
- Operating reliability, intervention complexity and HSE performance.
- Incremental oil per barrel of injected water and full-cycle economic value.

8. What Madar Is Looking for from Technology Companies

Madar is interested in cooperation with technology companies that can demonstrate field-proven performance in mature waterfloods and are prepared to work from a reservoir problem rather than from a product catalogue.

- One or two strong field cases with before/after data and a clear failure/success definition.
- Operating envelope: temperature, salinity, mineralogy, permeability, fracture intensity and completion constraints.
- Data required to screen a candidate pattern or well.
- Pilot equipment, chemicals, personnel and logistics requirements.
- Typical pilot cost range and lead time.
- Expected monitoring program and decision criteria for scale-up.
- Willingness to co-develop an Oman pilot with Madar as the local technical screening and operator interface.

9. Why This Is a Useful Cooperation Gateway

This anonymized field represents the type of opportunity that exists across mature Oman assets: substantial oil remains, water handling is material, reservoir heterogeneity matters, and conventional waterflooding alone does not answer the key question of where injected water goes.

For a technology company entering Oman, the most valuable first step is therefore not a broad sales presentation. It is a technically screened pilot proposition tied to a real reservoir mechanism and measurable field KPIs.

Madar can provide the bridge between the two sides: translate operator data into a technology problem statement, challenge the applicability of the proposed solution, define a field pilot, support operator engagement, and independently evaluate the outcome.

MADAR COOPERATION PROPOSITION

Reservoir problem → independent diagnosis → technology screening → pilot design → operator engagement → measured scale-up

10. Discussion Questions for a Potential Partner

- Which mature-waterflood problem does your technology solve best: connectivity, zonal allocation, thief-zone conformance, producer water control, or digital optimization?
- What is the strongest field example that is technically comparable to a fractured or heterogeneous carbonate?
- What minimum data are needed to screen an Oman candidate?
- Can the technology be piloted on one well or one pattern before a larger deployment?
- What would constitute a technical success after 3-6 months?
- How would you structure a first Oman demonstration commercially?

Source Basis & Use Limitation

The technical basis is an anonymized synthesis of client-supplied internal Oman field-development, production-review, reservoir-characterization and resource-review material spanning 2006-2024. Data have been rounded and stripped of field, operator, well and concession identifiers. Figures 1-3 use only reported milestones or end-state values; no raw monthly production dataset has been reproduced. This document is a discussion paper, not a reserves statement, competent-person report or investment document.

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