Maximizing the Value of Mature Fields
80% of oil production from mature fields comes from the “Big Three” – the U.S., the Middle East & Russia.
A Holistic Approach to Mature Field Revitalization

INTEGRAL REVIEWS AND STRATEGIC PLANNING
- Reservoir Information Review
- Well(s) Information Review
- Field Optimization Plan

DATA ACQUISITION AND RESERVE EVALUATION
- Reservoir and Well Seismic Data
- Data Acquisition
- Reserve Calculation

PRODUCTIVITY ASSESSMENT
- Field/Well Productivity
- Appropriate Technology
- Revitalization Plan

COST/BENEFIT ANALYSIS
- Operative Cost vs. Profitability Study
- Drilling and Completion Optimization
- Personnel Proficiency

PARTNER WITH HALLIBURTON TO GET THE MOST OUT OF YOUR MATURE FIELDS.
Operators today face a two-fold challenge: the need to improve returns from their assets and mitigate the decline of new, major/giant field discoveries.

Mature fields account for over 70% of the world’s oil and gas production, with many in the secondary or tertiary production phases. The average recovery factor is 70% for gas and 35% for oil. Even smaller recovery rates are common due to geological characteristics, resource constraints, or operational inefficiencies from old technology. Increasing ultimate recovery in these fields, often with reduced resources, is a common dilemma. However, given the vast reserves remaining, every percentage-point increase in recovery could add two years to the global hydrocarbon supply.

Halliburton is successfully challenging the conventional thinking that improved and enhanced recovery activities are too costly and ineffective to be justified. Through our collaborative culture, we work with our clients to provide comprehensive solutions, “from insight to execution”, to maximize the value of their mature fields. Our innovative methodologies, combined with new techniques and technologies, are proving that revitalization activities can be economical, while increasing ultimate recovery by an average of 20% or more.
ABOUT MATURE FIELDS

Every producing reservoir has a life cycle. The primary phase is characterized by the recovery of hydrocarbons by natural mechanism such as its pressure. This period is marked by a high volume of production that declines relatively quickly. The secondary recovery phase includes the use of basic techniques such as injecting water into the reservoir or using artificial lifts to generate additional hydrocarbon flow and manage pressure. Secondary recovery activities have long been an industry standard.

A field is considered “mature” when overall production has declined significantly, following primary recovery efforts or when all of its “easy” hydrocarbons have been produced.

Increasing ultimate recovery of these fields can involve extending the peak production period of the field or flattening the decline curve itself through secondary, improved, and enhanced recovery methods.

However, extracting oil or gas from mature fields presents specific challenges. These fields are often marked by old equipment and infrastructure. Water can also be a problem, because mature fields produce far more water than oil, raising potential environmental issues.

Fortunately, new technologies are allowing greater percentages of hydrocarbon to be produced economically. Revamping facilities, “smart” infill wells, and the injection of gas, steam, or chemicals are all among the improved and enhanced recovery methods being successfully employed to give new life to mature fields.
Primary Recovery
This phase is characterized by the recovery of hydrocarbons from the reservoir’s natural pressure. This period is marked by a high volume of production that declines relatively quickly.

Secondary Recovery
This phase includes the use of basic techniques such as injecting water into the reservoir or using artificial lifts to generate additional hydrocarbon flow and manage pressure.

Improved Recovery
The improved recovery phase increases the sweep factors of the reservoir by drilling and completing smart infill wells, revamping facilities, and redesigning water flood schemes.

Enhanced Recovery
The enhanced recovery phase uses techniques such as gas, steam, or chemical injection and development of new facilities to recover more oil from the reservoir.

TERTIARY RECOVERY
HALLIBURTON HAS
THE SOLUTIONS TO
MEET ALL OF YOUR
MATURE FIELD
CHALLENGES
Mature Fields | 6

**RE-ASSESSMENT & PLANNING**

Maximized recovery is the goal in any mature field. In the past, operators shifted resources elsewhere once the “easy oil” was found and produced. With advances in new technology, getting as much as possible from your existing assets is becoming more and more feasible. Mature fields require more careful planning, especially during the re-assessment phase, in order to identify producible reserves that were previously missed or thought unobtainable. Halliburton knows how to help operators apply the right methods and technologies to redefine the value of these hidden assets.

**Realizing the Full Potential from Your Mature Fields**

Through our team of over 350 experienced consulting professionals, Halliburton will work with you to get insight into your mature field and apply fit-for-purpose solutions to maximize their value. We do this by re-interpreting seismic data to identify unknown attributes, understanding the complex geomechanical forces at work in your reservoir, or performing detailed scenario analysis to produce a plan that best addresses your objectives. Determining if potential re-engineering or improvement operations can be profitable is a critical decision in mature field exploitation. Formulating that plan requires cross-disciplinary expertise that Halliburton possesses to help your organization get better performance from your declining assets.

Our project management group, with over 300 professionals, has the basin knowledge, infrastructure, and personnel to execute the plan. Halliburton can work with your team, or manage entire projects, so your people can focus on more pressing challenges.

**Identifying Bypassed Zones and Determining Remaining Recoverable Fluids**

When analyzing a mature field, best practice is to first identify bypassed zones and determine remaining recoverable fluids. Field reservoir management is needed to recognize the number of intervals involved, the age of the wells and the likelihood of oil being bypassed. Carbon/oxygen (C/O) logging can be used to identify zones with oil saturations and where additional recovery is feasible.

The Halliburton RMT Elite™ Reservoir Monitor Tool is a unique through-tubing C/O system, offering two to three times higher measurement resolution than other through-tubing C/O logging systems. The tool can be used to run continuous passes in low porosity formations while other systems can only be run in a stationary mode. It can also be conveyed into a well with tubing completions, unlike larger C/O systems that can only log through casing.

Formation saturation analysis using the RMT Elite tool and porosity data can be provided via Halliburton’s cased-hole formation evaluation interpretation software models:

- CarbOxSat™ model oil saturation analysis using C/O measurements
- SigmaSat™ model water saturation analysis using capture cross-section measurements (Σ)
- TripleSat™ model three-phase oil, gas, and water saturations using both C/O and Σ measurements
- Chi Modeling® computation service

From open-hole to cased-hole, coring or laboratory analyses, Halliburton offers multiple solutions that contribute to improving reservoir recovery.

**SPE 94664**

“Maximizing Net Present Value in Mature Gas Lift Fields”
O.Mora, Texas A&M University and Halliburton-Landmark, R.A. Startzman, Texas A&M University and L. Saputelli, Halliburton-Landmark

**SPE 108670**

“Optimizing Hydrocarbon Pay Estimates Using the Magnetic Resonance Imaging Logs in Development Wells of El Furrial Field, East Venezuela”
Maged Fam and Howard August, Halliburton; Milagro Maestre, Edgar Guevara, Milton Mendez and Luis Rondon, PDVSA E & P Venezuela

**SPE 88519**

“A Case Study of Carbon-Oxygen Logging Through Multiple Tubular Strings Offshore Indonesia: Reservoir Model Verification With Emphasis of Fluid Contact and Bypass Oil Identification”
Marvin Rourke, Halliburton Indonesia; Wahyu E. Prabowo, Susi Winarti, ConocoPhillips Indonesia Inc.
FIELD PRODUCTIVITY
How do you positively impact your total recovery when there are a myriad of factors in a mature field that can prevent you from doing so? Our multidisciplinary approach can help meet some of the most common mature field challenges. From accessing bypassed reserves, to maintaining pressure, to preventing lost time or premature abandonment, Halliburton continues our commitment to helping operators turn their mature fields into profitable ones.

Accessing Bypassed Reserves Through Infill Drilling
Bypassed reserves are a common challenge found in mature fields. Understanding your reservoir is crucial, as is the development of a cost-effective drilling program, for getting the most out of your assets. Some of Halliburton’s solutions include:

- Replacing wells via slot recovery on constrained platforms
- Installing an advanced reservoir drainage multilateral system to minimize the capital expenditure required to tap marginal reserves
- Using the Evader™ gyro measurement-while-drilling (MWD) service to reduce environmental impact and pad size by allowing wells to be drilled off a platform or drill site pad that in turn reduces the project AFE
- The StrataSteer® 3D Geosteering service, along with geosteering specialists, to minimize risk during drilling
- The DecisionSpace Desktop® software tools to acquire and analyze well data in real time

DID YOU KNOW?
70% of worldwide oil and gas production comes from mature fields.
Secondary Recovery Techniques to Manage Pressure and Increase Production

In order to manage pressure in your reservoir and generate additional hydrocarbon production, secondary recovery techniques such as injecting water into the reservoir and using artificial lift technologies must be employed. Halliburton works with operators to review existing data and measure pressure to discover key factors causing pressure drop and underperformance in your reservoir. We then identify the right approach for revitalizing your mature field through application of new technologies, pressure maintenance schemes, and predicting future performance using geologic and simulation models.

Enhanced Oil Recovery Techniques to Reduce Residual Oil and Improve Sweep Efficiency

Enhanced oil recovery (EOR) techniques can increase production from mature fields containing bypassed oil. Making the most of EOR opportunities requires vast technological resources and Halliburton has the experience and knowledge to apply them in a cost-effective strategy.

Whether thermal or non-thermal methods are used, the objective of EOR is to reduce residual oil saturation and improve sweep efficiency while maximizing rate of return on capital and reducing operating cost. Non-thermal methods include chemical, microbial, and CO₂ flooding. But heat, primarily steam flooding, is the most favored and effective method of inducing heavy oil to flow.

Sweep efficiency is enhanced by conformance technology. Production logging and other methods—such as permanent monitoring with fiber optic sensors, called distributed temperature sensors (DTS)—can identify any variation in injection and production flows in the perforated zone. When significant differences are found, conformance technology is applied to seal or reduce the formation relative permeability in the perforations and/or the near-wellbore region with the highest flow rates. This allows more of the injected fluid to divert into lower-permeability intervals in the injection zone. The overall sweep efficiency can be substantially improved by this flow diversion. Besides chemical solutions like conformance technology, mechanical ones such as downhole devices and valves, i.e. “smart wells”, and wellbore placement technology are also effective.

Halliburton provides the sophisticated understanding necessary to get the most from EOR:

- An integrated approach to the way wells are planned, drilled, completed, and produced
- Development of “intelligent solutions” that take a long-term view of the life of the well
- Application of “smart well” technology that facilitates better production management

SPE 139376
“Marlim Field: An Optimization Study on a Mature Field”
Dirceu Bampi, Odair Jose Acosta, Halliburton

SPE 38494
“Design, Planning, Implementation & Management of a Multi-Lateral Well on the BP Forties Field: A North Seas Case History”
Jones, R.D., Rose, J., Lurie, P., Hibbert, E.D., BP Exploration Operating Company Ltd.; Butler, P., Freeman, A., Halliburton

SPE 134586
“Casing Drilling Application with Rotary Steerable and Triple Combo in New Deviated Wells in La Cira Infantas Field”
Edwin Lopez and Pablo Bonilla, Occidental de Columbia; Alfredo Castillo, Halliburton; Javier Rincon/Tecco
35% is the average worldwide recovery factor for oil.
WELL PRODUCTIVITY

In mature fields, remedial actions, such as corrosion prevention, sand and scaling control, well intervention, and water production pose specific, sometimes costly challenges that hinder the ability to maximize reservoir contact and production. Halliburton offers a portfolio of fit-for-purpose solutions that help maximize your well’s productivity.

Reperforating the Mature Wellbore

The near-wellbore region in mature fields can become damaged by silt and other fines that migrate throughout the production cycle. Shut-in pressure testing, which can be recorded in combination with production logging services (PLT) or as a stand-alone option, is one of the first methods used to identify the cause of production decline. Keeping the perforation holes clear is an important step to improving production. If the perforations in these intervals are partially plugged off, a near-wellbore stimulation or reperforating with high-penetration charges is needed.

Halliburton has long been known for the breadth of its perforating technologies. Today, we offer solutions for more demanding well conditions. Our ultradeep-penetrating MaxForce™ shaped charges provide a means to bypass near-wellbore damage and improve well productivity. We can also develop custom charges to maximize effective penetration into specific reservoirs. Using MaxForce charges with Halliburton’s SurgePro™ Service produces even better results. The SurgePro software accurately simulates peak pressures and surge effects created by different charges and guns. It helps identify the optimal combination for your well conditions, and is essential in designing effective dynamic, underbalanced perforating programs that maximize perforation cleanup.

Sand Control in Producer Wellbores

The Halliburton sand-consolidation system, SandTrap™, allows producers to take advantage of through-tubing while offering significant improvements over older sand-consolidation systems. It can be applied to recomplete existing sand-producing intervals or to complete previously untapped pay zones in existing wells. It can be placed either with jointed tubing and a service packer or with coiled tubing or through production tubular. SandTrap™ can also be used in supported openhole completions incorporating stand-alone screens or perforated liners and sand control remediation to stop sand production from a damaged or failed sand control completion. This service can provide access to new reserves without the expense of a rig-based workover. And aqueous-based version, SandTrap ABC™ is compatible with foam, allowing longer intervals to be treated.

Reduce Unwanted Fluid Production

Predicting water influx problems, selecting candidate wells for water control treatments, and justifying expenditures are critical to developing improved reservoir management strategies. Optimum reservoir-management strategies begin with an understanding of the water source from the reservoir under both production and injection conditions. Halliburton offers a complete range of economical, customized solutions including our QuikLook® Conformance Simulation Service—which allows the economic outcome of a water management treatment to be accurately predicted—and a broad variety of chemical solutions to mitigate water problems that vary from in-situ crosslinked water-based polymers, to swelling/superabsorbent polymers, to relative permeability modifiers, to cement-type materials.
Improve Completion Performance and Efficiency by Restricting Inflow of Unwanted Fluid

Inflow of unwanted fluid (water or gas) in mature fields can cause production issues and increase completion costs. In response to this challenge, Halliburton engineered part of the completion string to react to the presence of water or gas in surrounding formation fluid.

Using the principals of dynamic fluid flow, the EquiFlow® autonomous inflow control device (AICD) increases flow resistance in the presence of water or gas. This is done by choking back production of unwanted fluid without the need for electrical, hydraulic, or mechanical intervention. The EquiFlow® AICD provides production control without any moving parts, intervention from the surface, additional installation time, or a reduction of internal pipe diameter while helping to stimulate oil production.

The EquiFlow® AICD is easy to install and extremely effective when combined with zonal isolation systems, such as Halliburton’s Swellpacker® isolation systems. Installed as a unit at the end of each screen joint, the EquiFlow® AICD can be configured for a specific reservoir, yet it is simple, robust, and easily combined with all types of sand control screens.
Maximize Reservoir Contact and Production through Acidizing

Halliburton's STIM2001™ simulator, along with our carbonate and sandstone acid-stimulation processes, brings new levels of precision and cost-effectiveness to acidizing. The STIM2001 software can evaluate the reasons for lost production in one well or a series of wells, and then rank the wells studied according to the best value for each stimulation dollar spent. Obtaining optimum results from any of the various formulations and procedures depends on a thorough understanding of formation mineralogy. The system can determine the wells’ skin value, the damage mechanisms in play, applicable remedies, and the ideal production rate. It can guide fluid selection, recommend fluid diversion programs, simulate fluid flows in both sandstone and carbonates (including wormholing), and automatically generate reports based upon single-entry data.

A full range of acid treatments is available to help boost production. Matrix acidizing treatments can improve connectivity with the near-wellbore region. Fracture acidizing treatments can be designed to penetrate deep into lower-permeability rock. Results of formation evaluations using both Carbonate 20/20™ and Sandstone 2000™ services provide input data for the STIM2001 matrix simulator, a solutions-oriented software package that can effectively guide stimulation selection, including acidizing, fracturing, and reperforating.

**OTC 15129**
“Revitalizing a Mature Sand-Prone Field by Installing Enhanced Gravel-Pack Completions – A Case Study”
Mohamed Zaini B. Md Noor, Kasim B. Selamat, Abdullah B. Kasim, Petronas Carigali Sdn. Bhd., and Sharifudin Salahudin, Halliburton

**SPE 125788**
“Openhole ICD Completion With Fracture Isolation in a Horizontal Slimhole Well: Case Study”
Dustin Young, Mohammed Al-Muraidhef, and Peter E. Smith, Halliburton, and Mohammad Zaki Awang, Saudi Aramco

**SPE 113695**
“Coiled-Tubing-Conveyed Proppant Treatment Yields Increase in Production Efficiency and Return on Investment”
Zeke T. Peak, Matte B. Montes, and David Natenberg, Halliburton and Mark Durkee, ConocoPhillips

**SPE 142291**
“Successful Control of Water Production in Slimhole Completions in a Tight-Gas Sandstone: South Texas Case Study”
Robert Rodriguez and Ryan Hall, SPE, Halliburton, C.M. (Mike) Pawlik, SEPCO; and Jordan Ciezobka, Gas Technology Institute (Formerly Halliburton)

**SPE 130655**
“High-Temperature Conformance Field Application Through Coiled Tubing: A Success Case History”
G. Ramirez, G. Arredondo, Pemex; J. Chapa, R. Macias, J.E. Soriano, Halliburton

**SPE 124394**
“Swellable Packers Provide a Brownfield Water Management Solution in Open and Cased Hole Histories Including Straddles, Plugs, Slimhole Sidetracks and Testing in Corroded Casing”
Khaled M.M. Al Douesei, SPE, ADCO, and Chris Barnes, SPE, Dustin Young, SPE, and Peter E. Smith, SPE, Halliburton

**Did You Know?**

2.4 trillion barrels of known oil reserves are concentrated in fewer than 1,500 giant (>100K b/d) fields
WELL ABANDONMENT

Well abandonment is a natural part of the drilling lifecycle. For over a hundred years, wells have been drilled, produced, and finally abandoned. Historically, well productivity and costs determined when a wellbore was abandoned. Today, however, environmental and regulatory concerns add to this complexity. For operators, this dilemma is compounded by the wide variety of conflicting regulations, sometimes even within the same country.

Halliburton’s experience across the globe can help operators navigate the ever-changing, complex process of well abandonment. We’ll help you protect your remaining reserves, safeguard the freshwater sources penetrated by the wellbore, and prevent surface pollution, all while meeting regulatory requirements.

DID YOU KNOW?

70% is the average worldwide recovery factor for conventional gas
Stuck Pipe Recovery

Stuck pipe recovery can be costly. When it's time to abandon the reservoir, an operator may want to recover as much casing as possible to be recycled, scrapped, or for regulatory compliance. Halliburton's Free Point Tool offers one-trip analysis of stuck drillpipe, collars, tubing, coiled tubing, or casing. It measures changes in the magnetic field of a pipe in a single trip, providing a continuous log. The resulting data can be easily read and interpreted by any field personnel or a Halliburton professional. Additionally, Halliburton has trucks, skids, and crews dedicated to pipe recovery for quick response to customer's needs.

Some recovery operations require severing the pipe for operations to continue. Halliburton offers various jet cutters that can be used in a wide variety of applications. The Split Shot** Cutter uses a linear-shaped charge to split tubing and casing collars vertically. They come in different sizes, lengths, and temperature ratings. The Drill Collar Severing Tool, a tool of last resort, uses an explosive collision device to create a high-energy blast capable of shearing large, heavyweight drillstrings.

Halliburton also offers alternative high-precision tools. Chemical cutters**, available for applications from coiled tubing to 8 5/8-inch casing, uses chemicals that, when mixed with an oil/steel wool mixture, creates a reaction that builds pressure and temperature. This opens the severing head, and the chemical is expelled, cutting the tubing or casing. Stuck pipe, then, becomes easier to retrieve.

Plasma cutters such as the “X” Radial Cutting Torch (XRT****) system uses proprietary fuel to create a controlled thermal event that generates plasma with very high temperature and pressure. A smooth, non-flared cut is the result and is optimal for recovering stuck pipe.

*Split Shot is a registered trademark of Owen Oil Tools
**Chemical cutters are manufactured by Chammas Cutters Inc or Pipe Recovery Systems Inc.
***XRT is a registered trademark of MCR Oil Tools

Effective Well Abandonment Designs

Halliburton has the proven resources and experience as a single-source supplier for all the services needed to efficiently and effectively execute well abandonment designs in your mature field.

The cornerstone of our approach, we believe, is an industry game-changer. We use one project core team that works on every aspect of your well abandonment project. Specialists, by discipline, are brought in only when needed to save the operator time and money. This multidiscipline team, led by supervisors, can report directly to operators who have ultimate control of the project.

This cross-functional approach can be applied to just about any mature field abandonment project. From fluids, cementing, coiled tubing, and hydraulic workover groups to wireline and perforating, this expertise can be put to work for you.

**PETSOC 015**
"Innovative Cement Plug Setting Process Reduces Risk and Lowers NPT"
T. Marriott, H. Rogers, S. Lloyd, C. Quinton, Halliburton

**SPE 125446**
"Plug Setting Aid Retooled for Up-Hole Down-Dip Plug Back Application Enables Pin Point Slurry Placement in Complex Up-Dip Wellbore" - Hank Rogers, Donny Winslow and Paul Boddy, Halliburton
HALLIBURTON ADVANTAGE

Halliburton collaborates with operators to provide comprehensive solutions, from **insight to execution**, to maximize the value of their mature fields. Our comprehensive solutions consist of:

- **Complete Asset Management** via our group of 650 industry-leading consultants and project managers

- **Entire Field Optimization** via specialized mature field drilling and formation evaluation services. That is, enhanced reservoir drainage via optimized infill well patterns, architecture, and visualization

- **Individual Well Optimization** via conformance chemistry, production hardware, and a fully integrated well intervention capability

- **Well Abandonment Designs and Execution** via integrated services consisting of, but not limited to, logging, pipe recovery, and cementing

DID YOU KNOW?

30 mature giant fields make up half of the world’s oil reserves
PROJECT EXPERIENCE

With decades of experience, Halliburton has the expertise to help operators get the most from their mature fields. We’ve been involved in all the major oil-producing provinces across the globe. From innovative technologies to knowledgeable, seasoned professionals, Halliburton brings these components together to navigate the complex tasks associated with getting the underdeveloped resources from your mature fields in a cost-effective and time-sensitive manner.
HSE AND SERVICE QUALITY SAVE TIME, RESOURCES, AND MONEY—ALL IMPORTANT FACTORS IN ANY OPERATION

Arguably, mature fields need more emphasis on Health, Safety, and Environment (HSE) and service quality than other types of fields. Increasing hydrogen sulfide and carbon dioxide concentration levels during waterflood operations increase risks to operating personnel and speed up equipment corrosion. HSE processes and procedures must account for these reactions.

Halliburton delivers consistent documented work processes, including global and embedded risk mitigation, to better control risk at the job site. In turn, our quality reviews drive continuous improvement in HSE and operational excellence. Higher service quality reduces costs for operators, a much needed requirement for a mature field.

Historically, wells were drilled with oil-based fluids. Halliburton now offers a family of environmentally friendly, water-based fluids that perform as well as or better than oil-based fluids while minimizing the environmental impact.

A CULTURE OF SAFETY

Ask any of our employees and they will tell you we live and breathe a safety culture. Our culture at Halliburton dictates how personally and seriously we take our responsibility for effective HSE. Through various safety-first programs, we understand that accountability is the key to the sustainability of our company, customers, and communities.
What’s *your* Mature Field challenge?
For solutions, contact your Halliburton representative, or visit us at www.halliburton.com/maturefields

To learn more, scan code with QR reader app on your smartphone.
Sales of Halliburton products and services will be in accord solely with the terms and conditions contained in the contract between Halliburton and the customer that is applicable to the sale.