IHS Markit™

ENERGY

Reservoir & Production Engineering

Software & Services

Contact Information

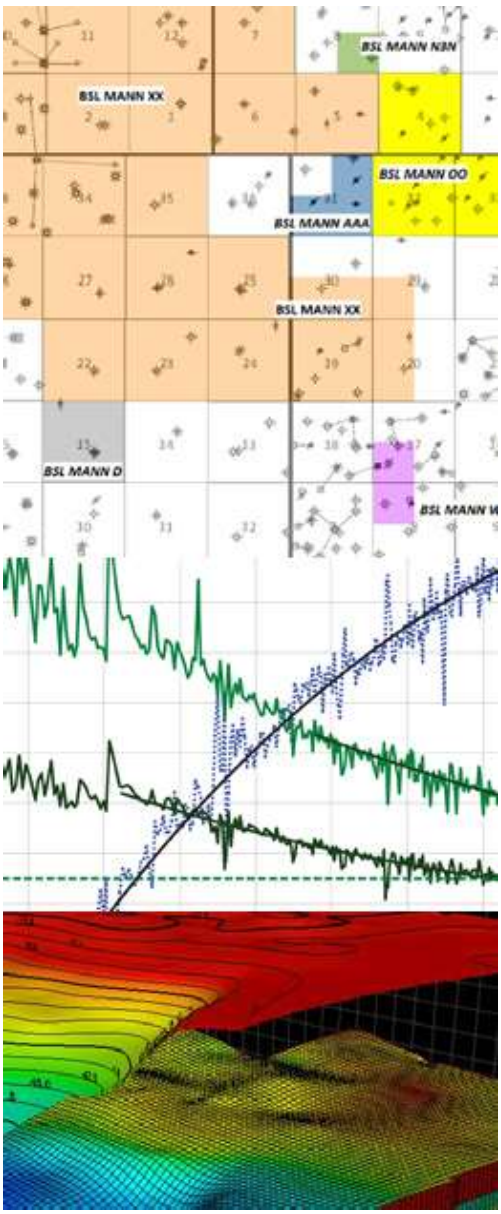
Email: info@banhill.com

Phone: +2348126556215, +2349067218604

Table of Contents

Software & Case Studies

Services



IHS Energy

As the industry's authoritative provider of information, analytics, and insight, IHS Energy is where organizations look first for market trends and to see the big picture. We help companies understand the interconnected, dynamic forces that shape the world's energy markets through our expertise in Economics and Country Risk, Chemicals, and energy dependent industries.

Our experts and analytical tools enable clients to continuously improve their strategy and operations across the entire energy value chain. We have a global network of 1200+ experts and consultants located in all key energy markets around the world ready to assist customers in oil and gas, power and coal companies, as well as energy ministries and agencies, renewable technology firms, and financial and energy services companies.

IHS Engineering Solutions

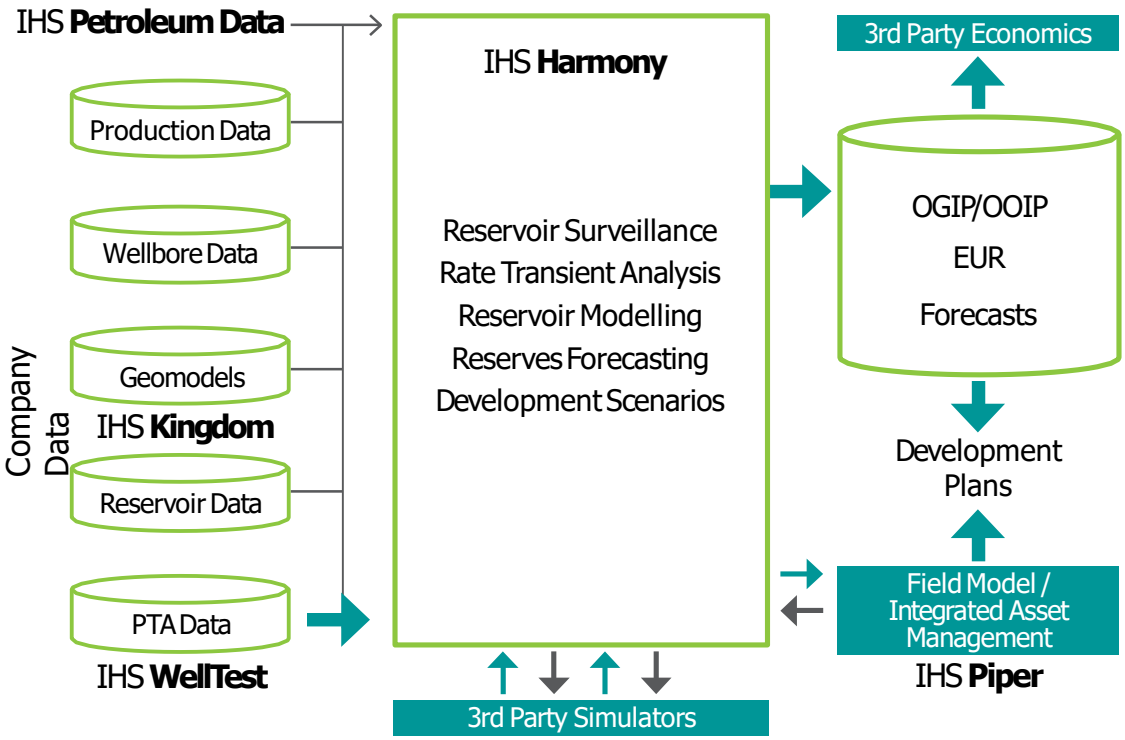
As an integral part of our petroleum engineering and geological consulting work, IHS develops products and services that are sold, supported, and used extensively in global markets. Our innovative software incorporates the latest in technology, and provides practical and advanced solutions for reservoir engineering and production optimization projects. We remain on the leading edge of research in reservoir engineering, and implement "best practices" into our software and services.

IHS Fekete Reservoir Engineering

IHS offers strength of expertise in the interdisciplinary cooperation between our team of reservoir engineers, geologists, geophysicists, petrophysicists, production engineers, simulation engineers, and computer specialists, all with one goal to help customers to optimize production. We can provide both short-term and long-term consulting services to provide answers, analysis, and interpretation of drilling and operations results.

We Focus on Connecting Data

The majority of an Engineer's time is spent moving data between different sources. IHS Engineering Solutions tightly integrate software with data to eliminate duplicate data entry and manual data transfers, allowing engineers to focus on their real work. Our tools connect directly to company databases, third party software and IHS data sources. Our integrated reservoir and production engineering suite allows organizations to quickly determine how subsurface behavior will affect production and how surface infrastructure plans will affect reserves. Designed by engineers, the software is practical and easy to use.

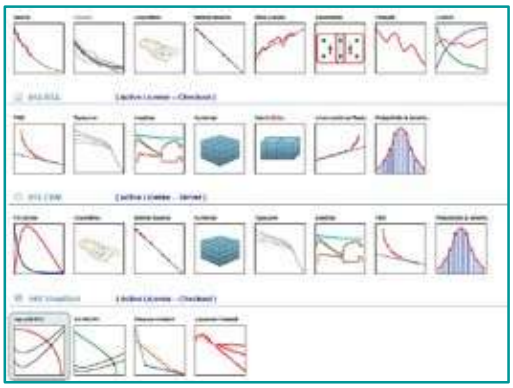


IHS Markit now offers Harmony in a single and multi-user capable platform where you can now perform well production forecasting using multiple methods in one powerful multi-user capable tool.

Well Performance Analysis Environment

A Comprehensive Desktop Engineering Application

Reservoir engineers rely on IHS Harmony every day to analyze oil and gas well performance and estimate reserves. With a full suite of robust reservoir engineering tools in one platform, Harmony drives work efficiencies and allows engineers to uncover unrecognized value through defensible scientific analysis. Create common corporate workflows to harness your company's technical expertise, and share interpretations to determine the best asset valuation and development strategies.

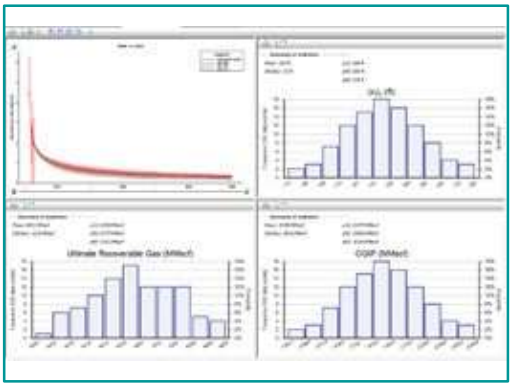


Extract Maximum Value Out of Well Performance Data as Efficiently as Possible:

- Reads most industry standard data formats, can connect to any ODBC registered production database and easily exports forecasts for economics evaluation into 3rd party applications or internal tools.
- Contains industry-leading data graphing and diagnostics tools.
- Contains comprehensive tools for the preparation, organization, reporting and querying of data.
- Connects directly to IHS Well & Production Data.

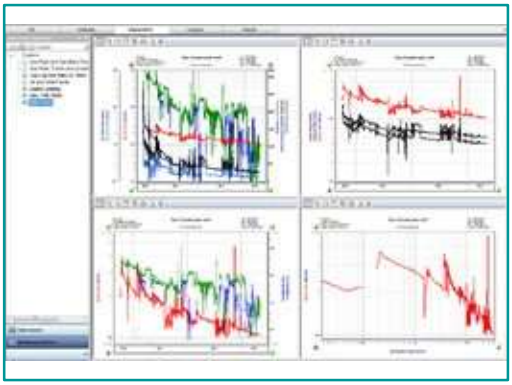
Make Better Technical Decisions by Bringing the Power of Advanced, Rigorous Reservoir Models to Every Engineer's Desktop:

- Provides sophisticated dynamic reservoir modeling in an easy-to-use interface.
- Contains industry-leading software tools for analyzing well performance in conventional, tight, shale and coal-bed methane reservoirs.
- Quantify uncertainty in production forecasting and reservoir characterization using a probabilistic approach (e.g. stochastic process); commonly referred to as Monte Carlo Simulation.



Reduce IT Overhead by Combining Multiple Applications into One:

- IHS DeclinePlus, IHS RTA, IHS CBM, IHS VirtuWell.

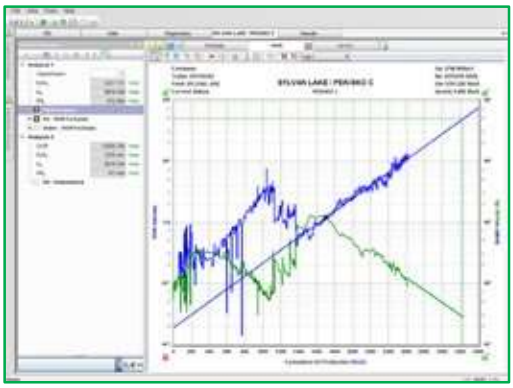


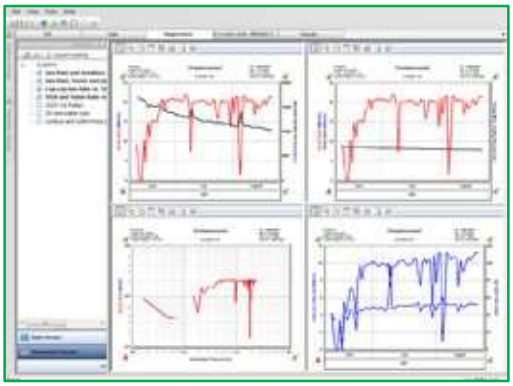
Create a Customizable, Collaborative Environment Where Engineering Knowledge is Shared:

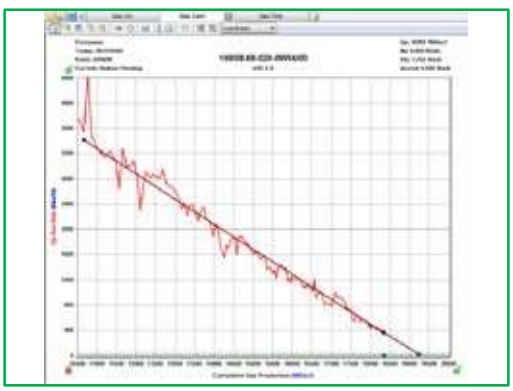
- Create custom templates and analysis workflows.
- Collaborate locally or remotely.
- Harmony Forecast and Harmony Reservoir allow for server-based multiuser collaboration. All data and results can be stored centrally for auditing purposes.

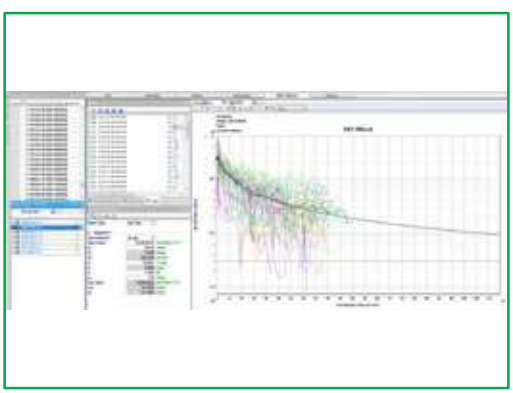
Production Analysis & Reserves Evaluation

Best-of-Breed Reserves Evaluation and Management Tools









Production Data Analysis:

Analysis methods in IHS DeclinePlus and IHS Forecast (multi-user) include:

- Arps, including limiting decline.
- Stretched Exponential, Duong, and multisegment methods.
- Type Well.
- Volumetrics and Material Balance for gas and oil.
- Ratio analysis and associated forecasting.

Advanced Workflows:

- Mix and match appropriate analysis techniques into a single workflow.
- Force consistency of results between methods by linking analysis.
- Develop, save, and share hierarchies, plot templates, data grids, and custom workflows.
- Foster a consistent analysis approach across teams of analysts.

Reserve Evaluations:

- Assign reserve classifications to wells or group forecasts.
- Consolidate forecasts based on classification and hierarchy.
- Connect to industry standard economic tools.
- Automatic consolidation updates.

Type Well Analysis:

- Normalize well production to create a type well.
- Average, P10, P50, or P90.
- Apply type wells to new locations or wells with limited data.
- Normalize rates on attributes like horizontal length, number of stages, or net pay.

Evaluating Tight Gas Using Traditional Methods

Objectives:

- Identify appropriate analog wells for type well forecasting.
- Create type well decline curve for use in undeveloped locations.
- Apply type well decline curve to wells with limited production history and adjust to well performance.

Background:

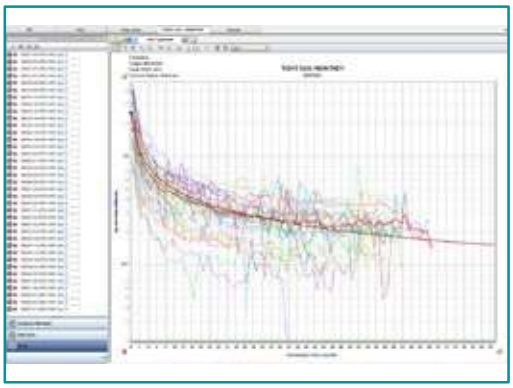
- Tight gas play in Northeast B.C.
- 37 producing wells in area of interest, 2 with limited production history.
- 10 planned well locations requiring forecast for proved plus probable undeveloped reserves.

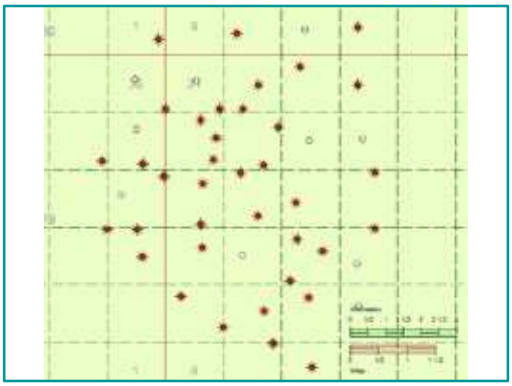
Analysis:

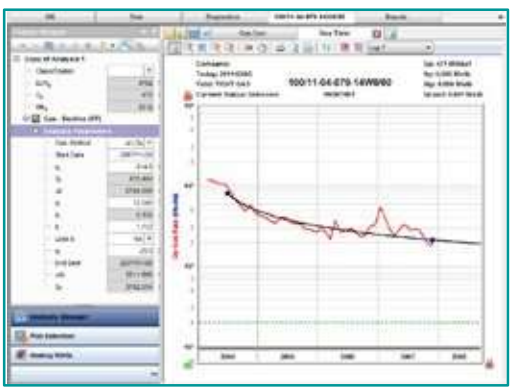
- Use type well decline to create average forecast for the area.
- Apply type well forecast to wells with limited history and well locations.
- Create consolidation for field total production and compare to consolidation without locations.

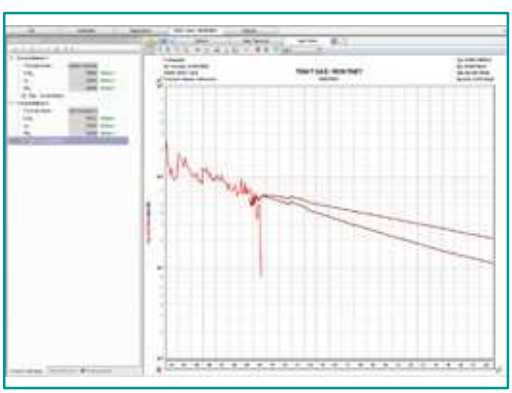
Results:

- Type well decline based on the average performance of wells.
- Undeveloped locations added to GIS.
- Type well forecast applied to undeveloped locations and wells with limited production history.
- Consolidations based on reserve types for economics.



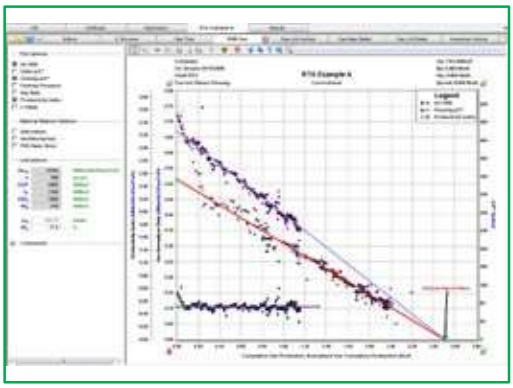


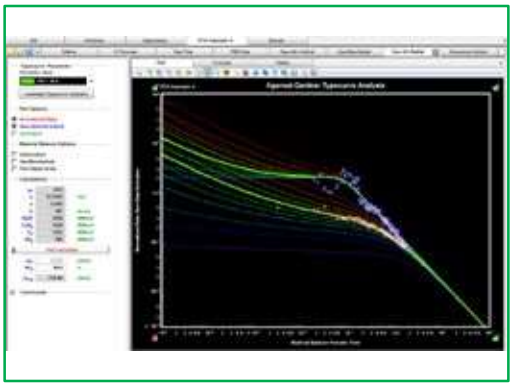


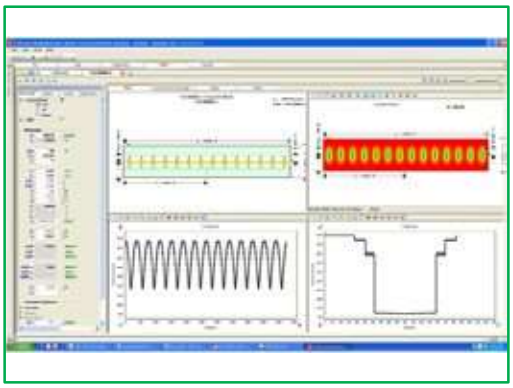


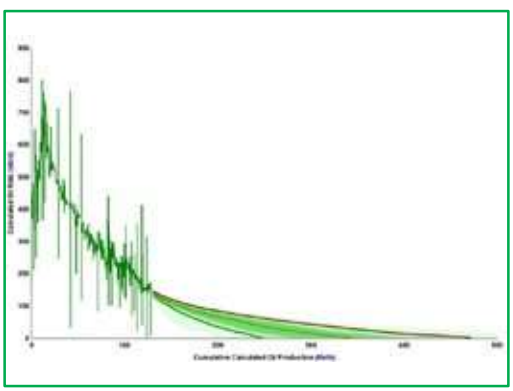
Rate Transient Analysis

Put Your Production and Flowing Pressure Data to Work









Estimate Hydrocarbons in Place:

IHS RTA provides multiple independent techniques for estimating original oil and gas-in-place (OOIP/OGIP) and expected ultimate recovery (EUR) without the need for shutting in the well.

Reservoir Characterization:

Access the most comprehensive collection of production- based methods available for determining permeability, drainage area and stimulation effectiveness. Methods range from straight-line analytics and type curves to analytical and numerical models with history matching.

Operating Diagnostics:

Use customizable diagnostics "dashboards" with built- in plotting functions to identify and account for data correlation problems, wellbore configuration changes, liquid loading in gas wells, measurement errors, changes in water/condensate yields and other important operational issues. Other diagnostic plots in IHS RTA can identify aquifer pressure support, well interference and well productivity loss.

Unconventional Oil and Gas Analysis:

Access practical, industry-leading tools for analysis of unconventional reservoir performance that combine proven empirical and analytical techniques. The Unconventional Reservoir Module (URM) is a simple yet robust tool for quickly evaluating reserves and providing bulk reservoir characterization.

Efficient, Yet Rigorous Forecasting Tools:

IHS RTA offers a comprehensive suite of easy-to-use analytical and gridded numerical models. Our new "Hybrid" model is a numerical model with analytical model-like speeds. Models support conventional and unconventional completion types. Complex dynamics such as dual porosity, pressure dependent permeability, rock compressibility, relative permeability, multiple layers and adsorbed gas can be modeled. Reduce history match time using automatic multi-parameter regression and forecast different operational scenarios to maximize returns.

Fast, Probabilistic Forecasting that Honors Production:

Unlike most probabilistic forecasting tools, IHS RTA allows users to create model based, probabilistic forecasts which honor the production history. Forecast uncertainty is reduced with each data update. The module runs much faster than traditional simulators, so can be applied to a large number of wells in a practical time frame.

Where Should I Drill my Next Well?

Objectives:

- Identify the optimal drilling location for an infill well.
- Determine if offset wells are interfering with the original producing well.
- Estimate total reservoir OGIP.

Background:

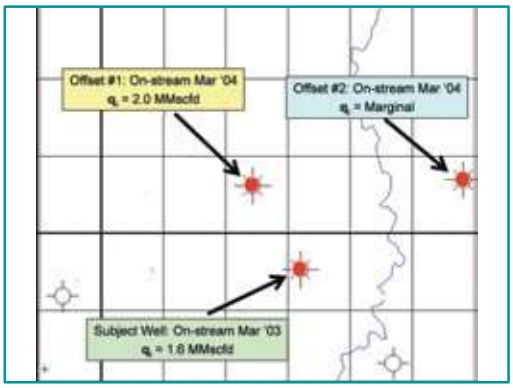
- Conventional gas reservoir in western Canada.
- Field had produced for one year.
- Limited shut-in data but good flowing rate and pressure data.
- Optimize production of producing wells.
- Three wells in study:
  - Primary well came on at 1.6 MMcfd.
  - First offset came on at 2.0 MMcfd.
  - Second offset was marginal producer.

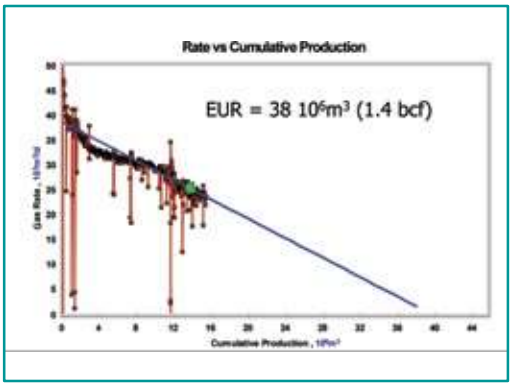
Analysis:

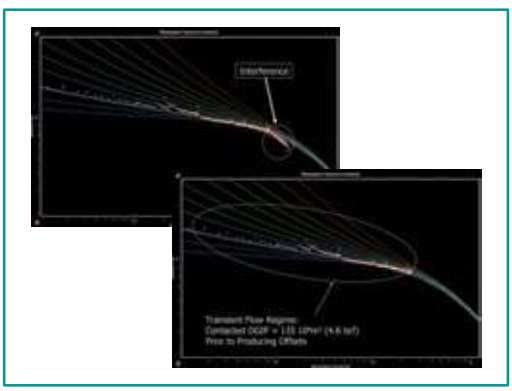
- Traditional decline analysis (rate data only):
  - Identified ultimate recovery of ~1.4 Bcf.
  - Inconclusive about interference effects.
- Advanced decline analysis methods (using flowing rate and pressure data):
  - Estimated minimum reservoir OGIP of 4.8 Bcf.
  - Confirmed interference between original producing well and first offset well.
  - Defined drainage area and boundaries for each well.

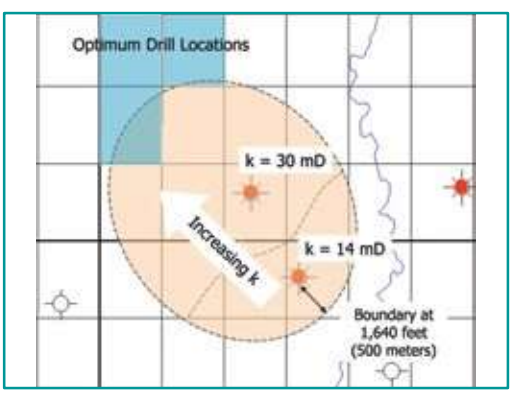
Results:

- Provided justification to support the planned infill drilling program.
- Confirmed that one offset well was interfering with the original producing well.
- Generated estimate of reservoir OGIP that was substantially higher than predicted by traditional decline analysis.
- Identified optimal drilling location for new well.





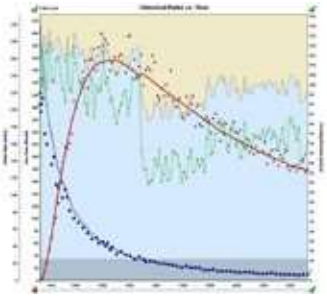




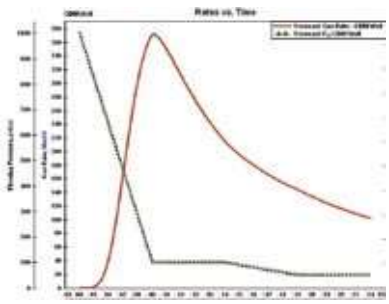
Coalbed Methane Reservoir Analysis

Practical Toolkit for CBM Engineering Needs

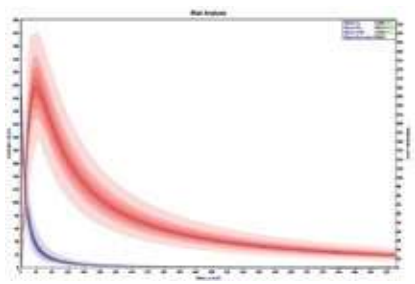
History matched data. Regions on the plot illustrate the liquid lifting/loading possibilities.



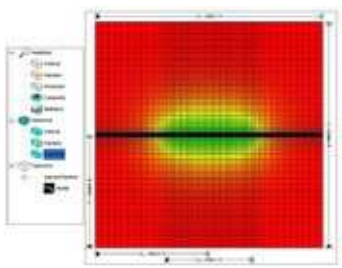
Gas production forecast based on variable bottomhole flowing pressure.



Likely span for gas and water rates obtained from Monte Carlo simulation.



(a) Model selection tool (b) A plan view of pressure propagation in a numerical horizontal well model.



Production Data Analysis:

Use type curves and reservoir models to match the production data and flowing pressures. Use the matches to estimate properties such as permeability, skin, and drainage area and to diagnose problems such as liquid loading, interference and change in operating conditions.

Production and Field Optimization:

Forecast well performance using variable bottomhole flowing pressure and skin. Evaluate the benefits of compression, stimulation, and infill drilling. Quickly import reservoir properties into IHS Piper to design and optimize your gas gathering system.

Reserve Estimation:

Multiple analysis tools are available to estimate the original-gas-in-place (OGIP), expected ultimate recovery (EUR), and recovery factor. These include deterministic methods such as volumetrics, static and flowing material balance and traditional decline analyses as well as probabilistic risk analysis using Monte Carlo simulation.

Modeling Capabilities:

Analytical and numerical models can be utilized to characterize a reservoir. Apply single Vertical/Vertical Fracture/Horizontal numerical well models to history match the production or generate post-history forecast for multi- phase (Gas-Water) production. Apply single Vertical/Vertical Fracture/Horizontal/Composite/ Multilayer well-reservoir models for single phase history match and production forecast.

Multi-Layer Capabilities:

Multiple layers of coal or sand can be included in a model. The model can then be used to generate a production forecast for each layer or history match the commingled production of a well completed and producing from several zones.

How Many More Wells Should We Drill?

Objectives:

- Forecast future production and reserves update.
- Optimize production of producing wells.
- Identify the infill drilling potential and devise development plan.
- Build a gas gathering model that could be used for field optimization.

Background:

- Large CBM field in the USA, with complex reservoir behavior.
- Large variation in reservoir properties.
- Changing gas composition due to presence of CO2.
- In excess of 25 years of production history.
- Several hundred wells are tied into a complex pipeline network.

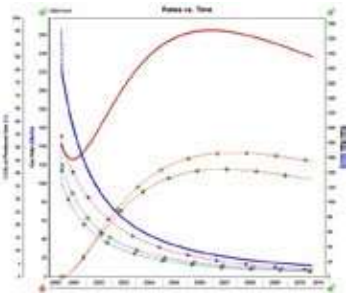
Analysis:

- History matched production data (gas rate, water rate, wellhead pressures) from each well.
- Generated production forecasts for gas, water, and CO2 fraction.
- Accounted for unique CBM characteristics such as binary desorption and matrix shrinkage.
- Built and calibrated a gas gathering model using the history match results.

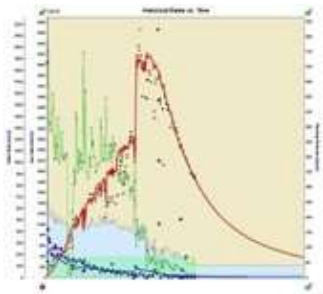
Results:

- The permeabilities obtained from history matching were found to be greater than 30 md in some areas and as low as 0.1 md in other areas.
- Locations where drainage areas were less than the well spacing were identified for potential infill drilling.
- Identified 100+ candidate wells for artificial lift.

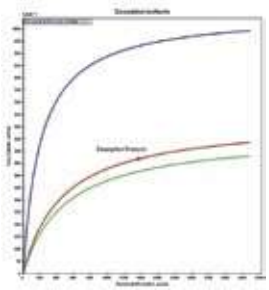
Two-phase production forecast for a multi-layer (2 coal & 1 sand) reservoir.



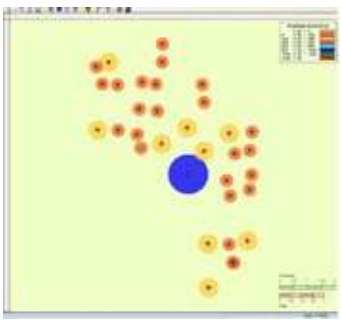
History matching and post-historical data production forecast.



Use binary isotherms when fraction of CO in the produced stream becomes important.

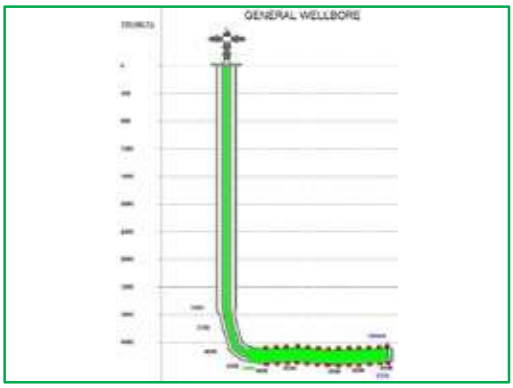


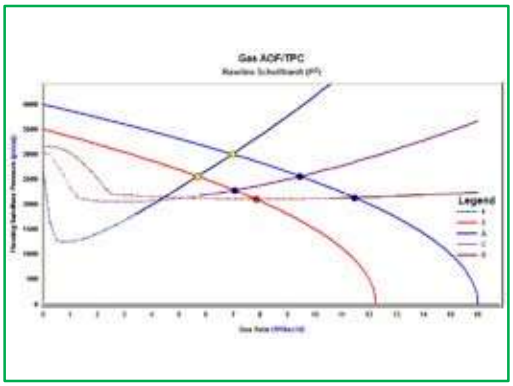
Bubble map displaying well drainage area.

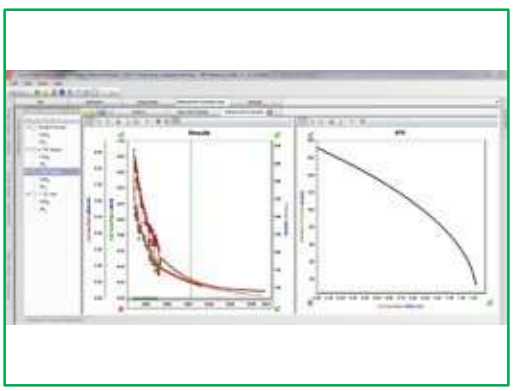


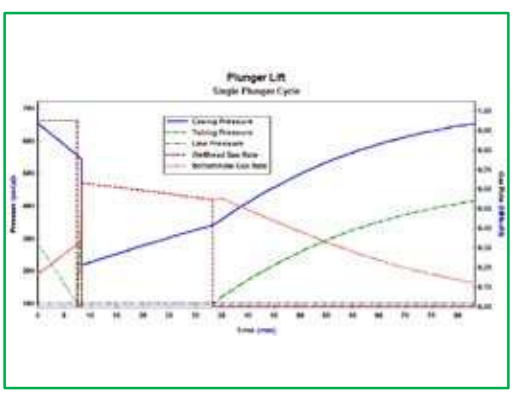
Wellbore Optimization

Efficient Flow from Sandface to Surface









Model Complex Well Completions:

- Create schematics for different well geometries.
- Consider tapered tubing and/or casing completions.
- Include single or multiple perforations.
- Access database of standard casing, tubing, coiled tubing and drill pipe sizes.
- Perform single or multiphase flow (gas, oil and/or water) calculations through tubing, annulus, casing or flowlines.
- Make use of static, production or injection data.

Well Deliverability and Liquid Loading:

- Use various sources to generate past, current and future Inflow Performance Relationship (IPR) curves.
- Create Tubing Performance Curves (TPC) considering different production scenarios:
  - Change of tubing size, use of coiled tubing or velocity strings.
  - Alternate flow paths.
  - Effect of using artificial lift or compression.
- Identify and evaluate conditions such as:
  - Liquid loading.
  - Erosion.
  - Use of soaping agents for liquid removal.

Create IPRs for Unconventional Wells:

Inflow performance in tight reservoirs is not well described by traditional IPR equations.

- IHS VirtuWell solves this problem by allowing the creation of IPRs based on analytical models which model all reservoir flow regimes.
- The IPR can be viewed at any future point in time, allowing production engineers to understand future inflow performance.
- This provides opportunities to investigate any uplift potential.
- Multiple scenario based on hypothetical wellbore improvements (artificial lift, tubing changes, etc.) can be created and analyzed.

This Well is Loaded Up. What Should I Do?

Objectives:

- Identify if the well is liquid loaded.
- Evaluate solutions to improve well performance.

Background:

- Vertical gas well in east Texas.
- Well has now produced for 4 months.
- 2-7/8" Tubing to 11,200 ft.
- 5-1/2" Casing to 11,540 ft.
- Perfs from 11,150 ft to 11,237 ft.
- No bottomhole flowing pressures measured.
- Well history:
  - Initial PR =6,600 psia. Current PR =5,840 psia.
  - Initial production was 1.20 MMscfd at 320 psia WH pressure. WGR =15 bbl/MMscf.
  - Current gas rate is approximately 0.65 MMscfd and intermittent.

Analysis:

SF/WH AOF Module

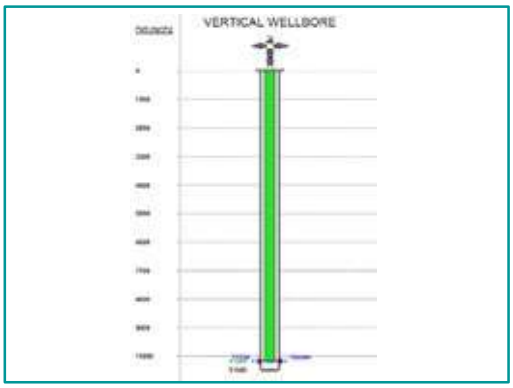
- The initial surface rate and pressure are used to obtain the sandface and wellhead deliverability curves.

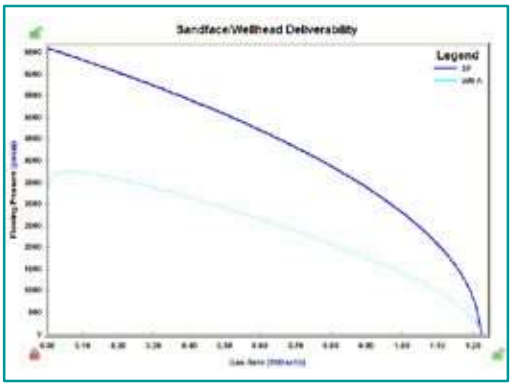
Gas AOF/ TPC Module

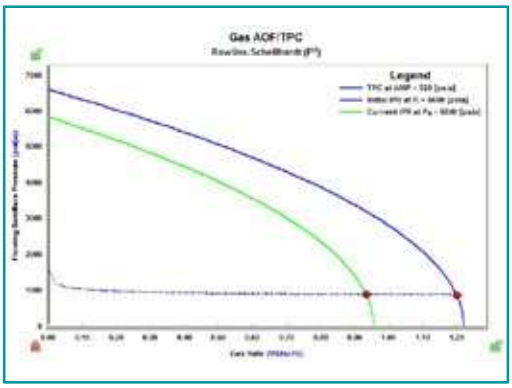
- At a wellhead pressure of 320 psia and 15 bbl/d of water the rate required to lift liquids is 1.09 MMscfd.
- It is confirmed that at the current flowing conditions we have liquid loading problems in the well.
- Solutions to this problem are explored (use of a compressor, coiled tubing and a combination of both).

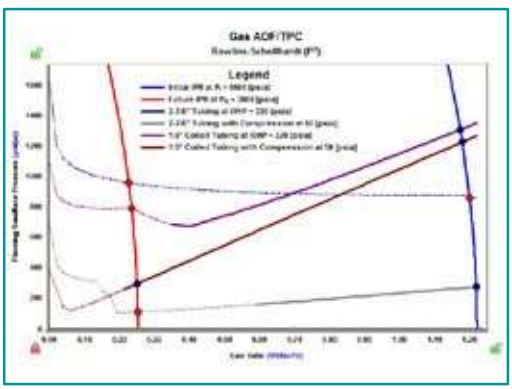
Results:

- 1-1/2" coiled tubing was installed and the well unloaded as expected. New wells in the area have since been completed with 1-1/2" coiled tubing from initial production.



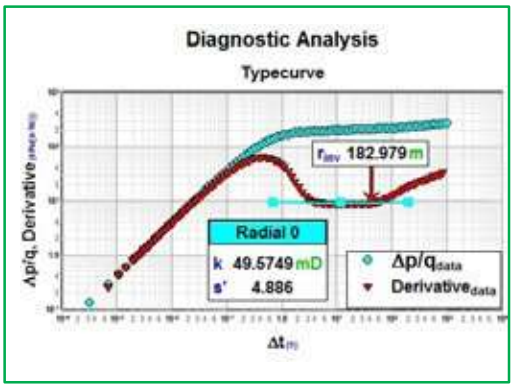


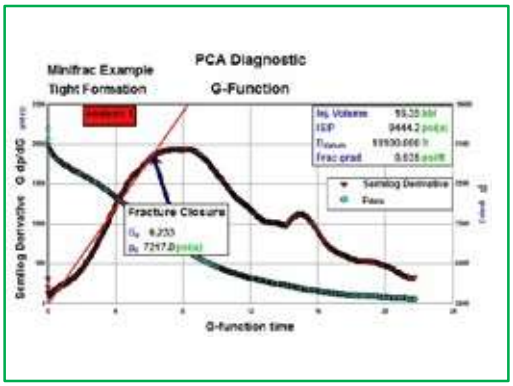


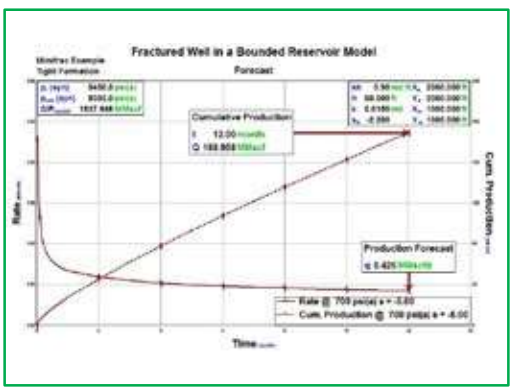


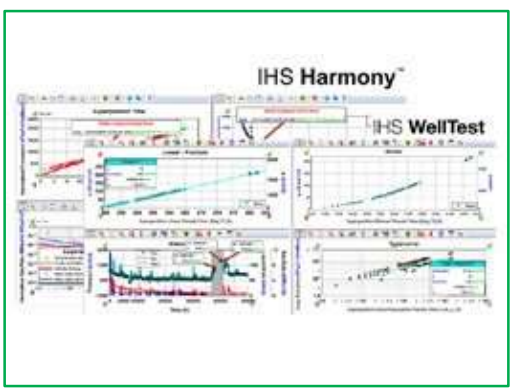
Advanced Pressure Transient Analysis

Everyday Well Test Data Interpretation Tool









Analyze Build-Up and Drawdown Data:

Load and plot data with easy-to-use import and filtering tools. Built-in wizards guide the user from data input through analysis, modeling and forecasting. Data from "controlled" tests or "un-planned" build-ups on producing wells are easily prepared for analysis using the flexible data management feature.

Analyze Mini-Frac Tests to Estimate Reservoir Pressure and Permeability in Tight Formations:

Pressure fall-off data from mini-frac tests can be analyzed using pre-closure and after-closure analysis techniques to identify fracture closure, quantify leakoff coefficients and estimate reservoir pressure and permeability.

IHS WellTest has the ability to advance after-closure analysis beyond diagnostics and straight line analysis to include modeling capability. The models are consistent with the work of M.Y. Soliman and D. Craig and show good agreement with K.G. Nolte's solutions when radial flow is achieved.

Predict Deliverability Performance:

Using results determined from pre-frac tests, predict the deliverability performance for different frac properties to establish optimum frac design.

Leverage Well Test Results in Field Development and Planning:

Greater insights are often achieved by combining different analysis results together. A direct link between IHS WellTest and IHS Harmony makes this possible. Bring well test modeling results directly into IHS Harmony. Leverage Harmony's production data analysis and field level visualization capabilities in order to paint the whole picture.

Mini-Frac Analysis: Estimating Closure, Permeability, and Pore Pressure in Tight Formations

Objectives:

- To identify closure, establish reservoir flow characteristics and estimate initial pressure.

Background:

Vertical well. MPP =10,000 ft.

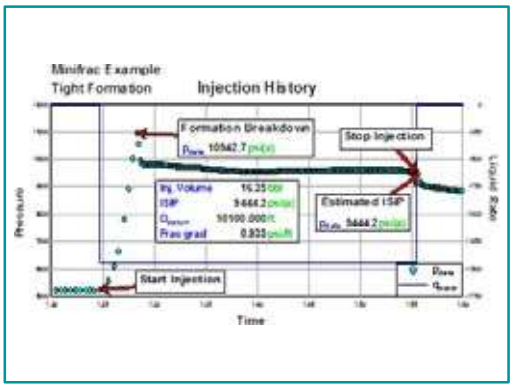
- Pressures monitored at wellhead, converted to bottomhole for analysis.
- 18-minute injection at 1 bpm followed by 24 hour shut-in.

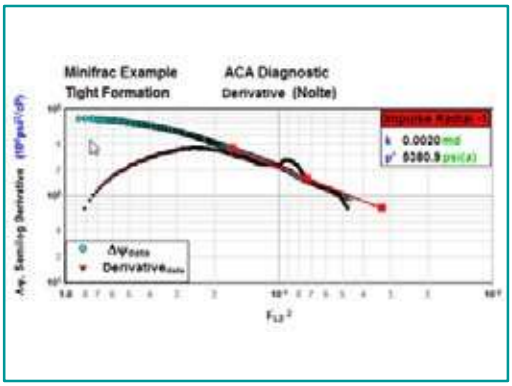
Analysis:

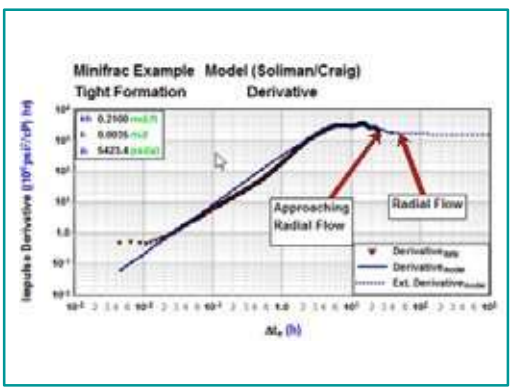
- Fracture closure is identified within the initial 3-hours of the falloff period.
- The semilog derivative, calculated with respect to
- shut-in time, exhibits a slope of -1 shortly after-closure, suggesting that radial flow has developed.
- The semilog derivative developed by K.G. Nolte, exhibits a slope of -1 shortly after-closure, suggesting that radial flow has developed.
- The model suggests radial flow was not quite achieved during the test period, and would likely develop after about 49 hours of falloff.

Results:

- The transition to radial flow is sufficiently developed to yield reliable estimates of formation pressure (5423 psi) and permeability (3.5 µd).

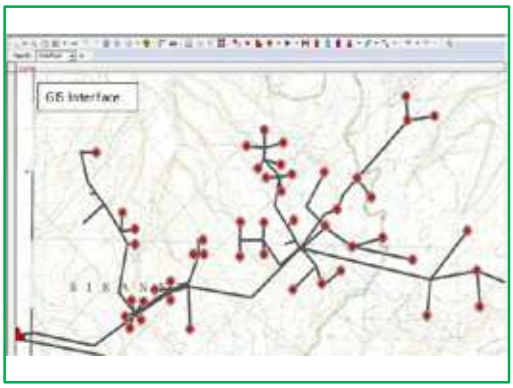


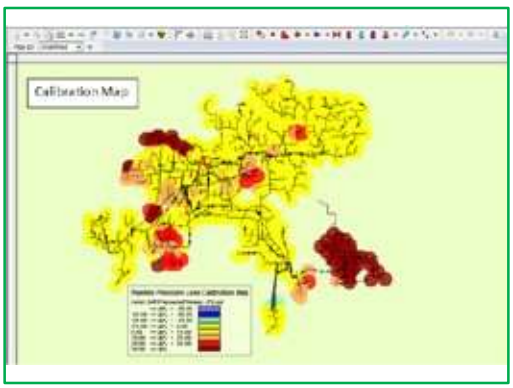


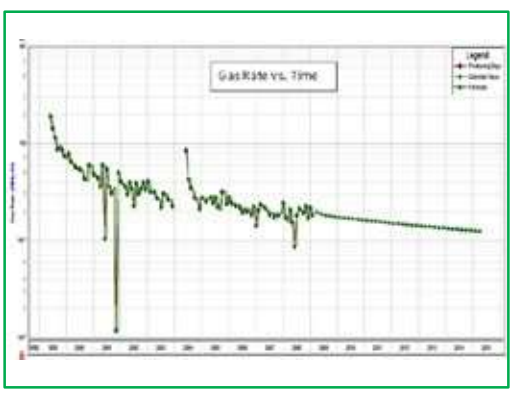


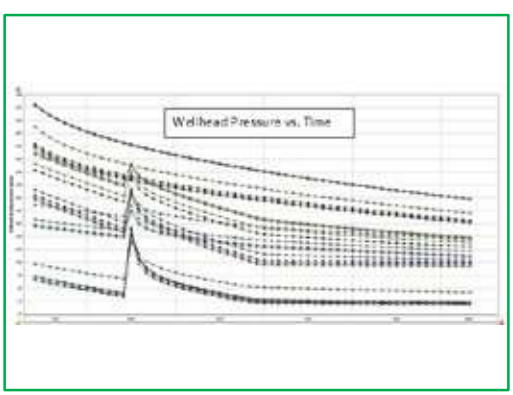
Integrated Asset Management

Flow Modeling from the Reservoir to the Delivery Point









Field Development Planning from Reservoir to Delivery Point Using:

- Geographical referencing.
- On-screen editing.
- Shape files.
- Image files.
- Oil and gas analytical reservoir models.
- Compression or pump modeling.
- Phase change relationships.
- Proposed development forecasting.
- Economic forecasting.

Production Optimization:

Diagnostics for easy identification of:

- Additional system losses.
- Liquid loading.
- Data errors.
- Bottlenecks.
- Uplift potential.

Production Forecasting and Development Justification:

Use IHS Piper to determine:

- Pipeline, compression, pump gas lift, and wellbore requirements.
- Impact of proposed development (i.e. infill wells, compression, pipeline expansion).
- If proposed development is economic.

Import IHS RTA and IHS CBM Models:

- Quantify flush production on a daily or monthly basis.
- Identify production back-out.
- Identify potential problems due to liquid loading.
- Evaluate impact of re-completion.

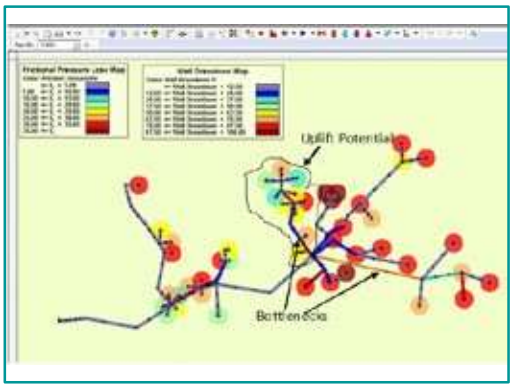
Evaluate Upside Potential in Debottlenecking

Objectives:

Determine if there is potential for system optimization and quantify the potential revenue.

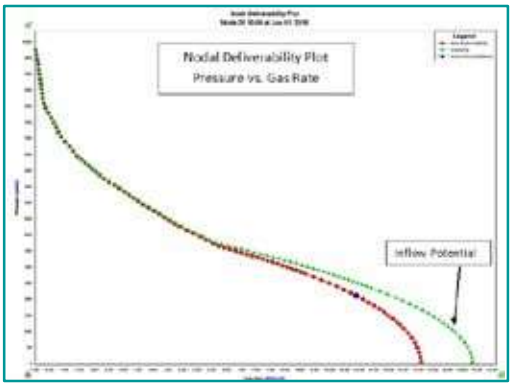
Background:

- 44 wells.
- Average operating pressure of 230 psia.
- Total gas rate of 39 MMscfd.
- Compression is currently utilized.
- Bottlenecks upstream of compressors.
- Uplift curve reveals potential by lowering suction pressure and reducing frictional pressure losses.



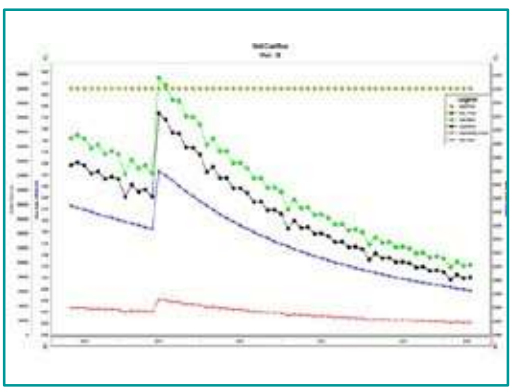
Analysis:

- Add two miles of 6" pipe.
- Account for additional gas volumes through compressors; increase compressor capacity curves to reflect full load conditions.
- Input economic parameters.



Results:

- Reduced wellhead pressure by 50 – 100 psi.
- 1.9 MMscfd incremental rates.
- Cumulative incremental production of 1 Bcf over five years.
- NPV =$2,114,300 over 5 years.

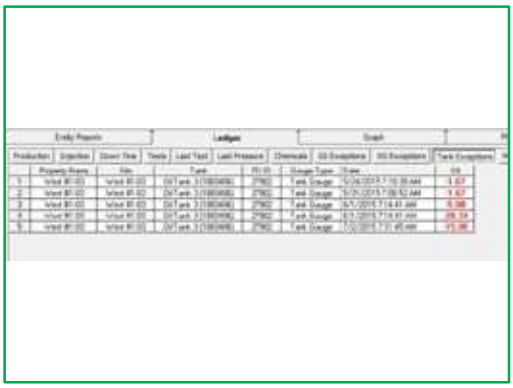


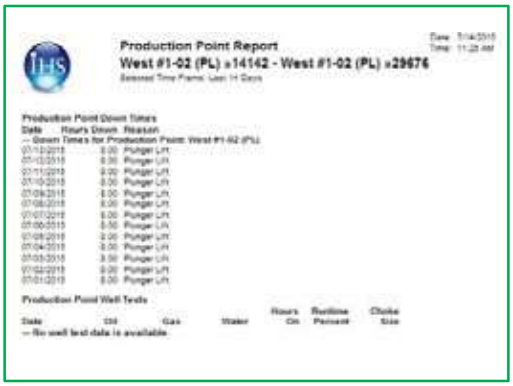
Other Studies:

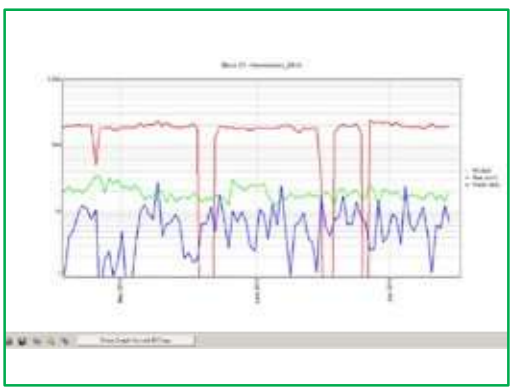
IHS Piper is currently being used to model:

- 7,000 wells over 30 years.
- Shale gas developments in the Barnett, Marcellous, Montney and Woodford.
- San Juan CBM field development and monitoring.
- Gathering systems in tight gas basins such as Picenace, Washakie.

Real-time Oil & Gas Daily Production Data Collection and Monitoring Software Solution







Bolster Production and Operations with on-demand Field Data Analysis:

Optimize Production:

- Real-time access to production data enables production optimization through faster identification of problem spots and trends.
- Original Production data is captured and stored immediately.
- Reduce data entry errors.
- Make faster, more precise decisions.

Quick Startup:

- Transitions from existing systems are fast and easy.
- Minimal hardware required.
- Easily configured to your individual business needs for all oilfield equipment.

Lower Operating Costs:

- Spend less time collecting and organizing your data and more time analyzing.
- Our customers report lowered costs just because IHS FieldDIRECT makes it that much easier to spot equipment failures and other problem spots.
- Streamlining the flow of production information throughout your organization increases efficiency tremendously.

Enhance Field Data Analysis to Optimize Well Production and Streamline Operations

Objectives:

- Enhance decision-making capabilities.
- Improve comprehensiveness and accuracy of field data.
- Increase efficiency, optimize production and reduce costs.
- Promote continuous improvement, compliance and operational excellence to mitigate risk.

Background:

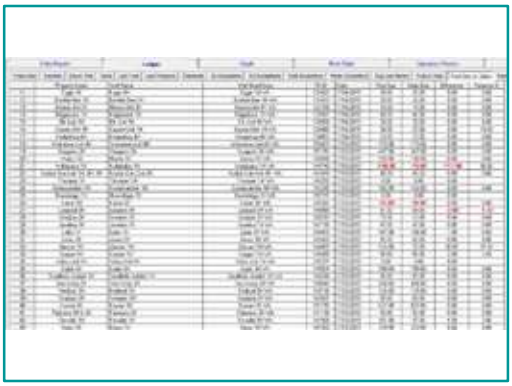
- Leading Independent E&P Company.
- Engineering Tech spending approximately 40-60 hours each month.
- Approximately 50 different worksheets with data from different Fields/Well Sites.
- No consistency.

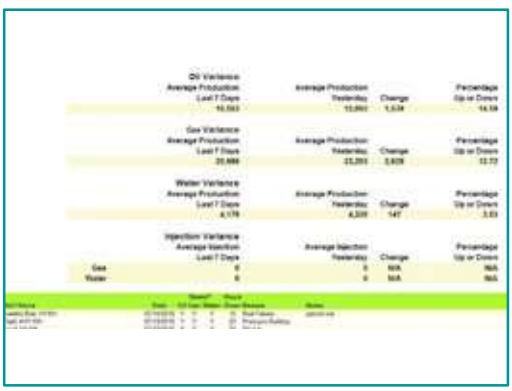
Solution:

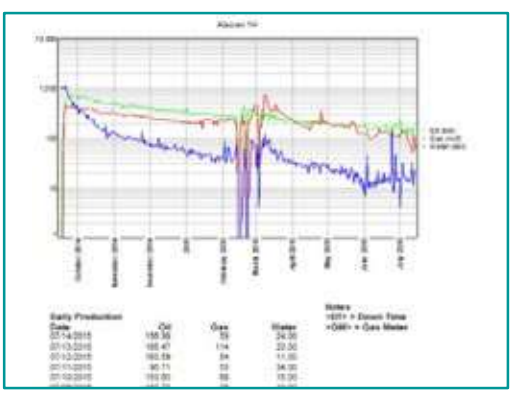
- Implement IHS FieldDIRECT across all operations.

Results:

- Eliminated 40-60 hours per month preparing 60 worksheets for several properties reports.
- Cut report preparation time from several days to about 5 minutes- or the click of a button.
- Strengthened company-wide transparency and accountability with detailed, annotated data.
- Enabled confident decisions and production optimization by making data available to staff and stakeholders from one reliable source.
- Contributed to the sale of 2 major assets by giving interest owners access to the history and real-time production data for each well.

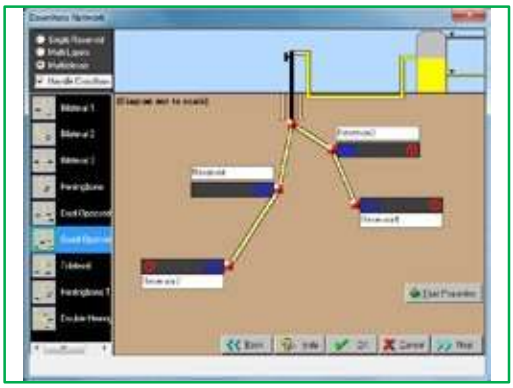


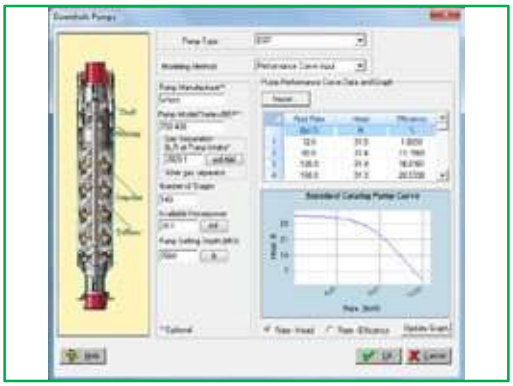


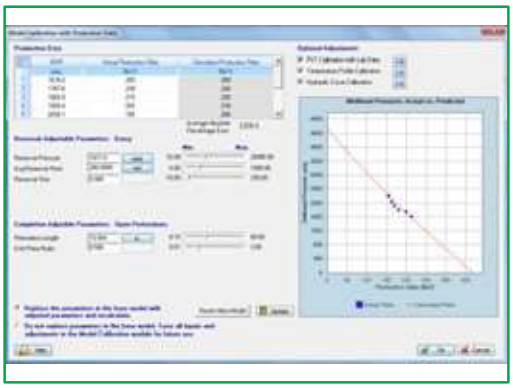


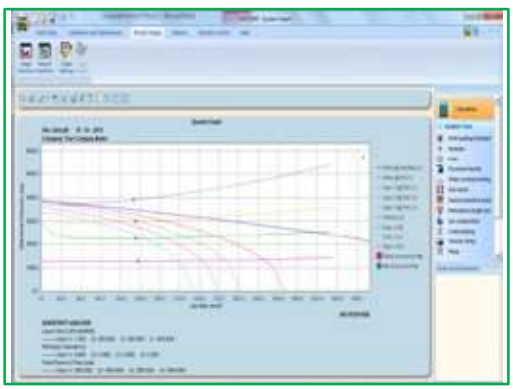
Production Optimization

Maximize Well Deliverability with Artificial Lift Optimization









Complete Well System Modeling and Well Deliverability Evaluation:

- 40+ IPR models for vertical and horizontal, oil and gas wells.
- Completion modeling, perforation gun databank and Skin factor estimation.
- 20+ multiphase flow correlation and choke modeling for wellbore and flowline simulation.
- Downhole network modeling including multilateral and multilayer wells.
- Scale, Hydrate, Erosion and Sand Production prediction.

Gas Well Deliquification, Artificial Lift Modeling and Optimization:

- Gas Lift system design and optimization.
- Downhole pump simulation including ESP, PCP and User Defined Pumps.
- Velocity String and Coiled Tubing modeling.
- Liquid loading estimation and gas well deliquification.

Model Calibration and Productivity Optimization:

- Calibrate well system model using production data.
- Sensitivity Analysis and Maximization module to simulate the optimum production strategy.
- Lab PVT data, Temperature Survey, Heat Transfer Correlation & Coefficient calculation and Hydraulic Curve Calibration as optional input to improve model accuracy.

Is Gas Lift Suited for My Well?

Objectives:

- Analyze well deliverability potential.
- Design Gas Lift system to achieve target production rate.

Background:

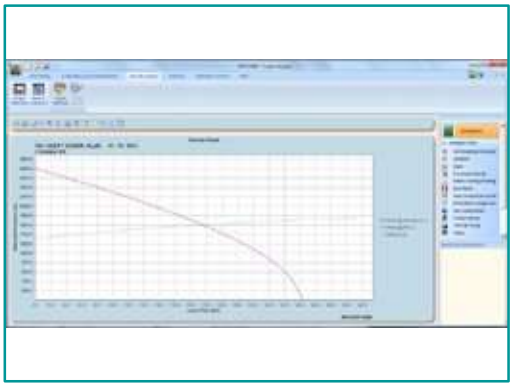
- Onshore oil production well with lateral section of 8500ft.
- 7-3/4" Casing to 16500ft.
- 4-1/2" tubing to 7500ft.
- Estimated reservoir pressure of 2820psig, with 28% water cut and 400scf/bbl GOR.
- Majority of wells in the area are on gas lift.

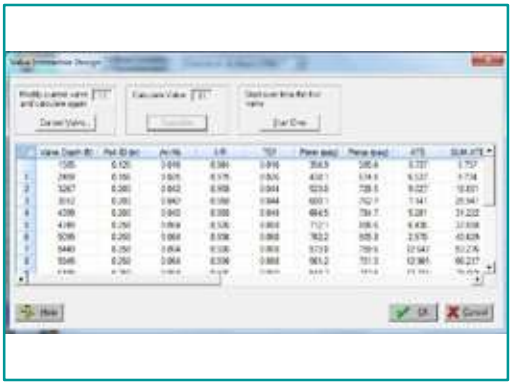
Analysis:

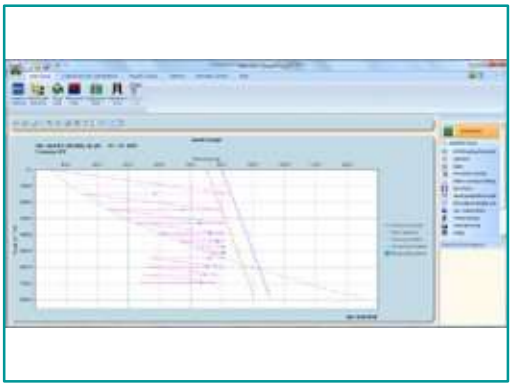
- Vogel Corrected For Water Cut IPR was used for reservoir deliverability estimation, and a potential of 200+ bbl/D liquid production is available from reservoir.
- Nodal Analysis indicated artificial lift is required to reach well production potential.
- Simplified gas injection model indicated 400Mscf/D injection with injection pressure of 800psig can deliver around 200bbl/D liquid production.

Results:

- Gas Lift system designed for the well with 10 valves installed and minimum spacing of 500ft.
- System designed to produce at 800psig injection pressure with 400Mscf/D to reach 200bbl/D liquid production.
- Kick off condition with 1000psig injection pressure was considered.

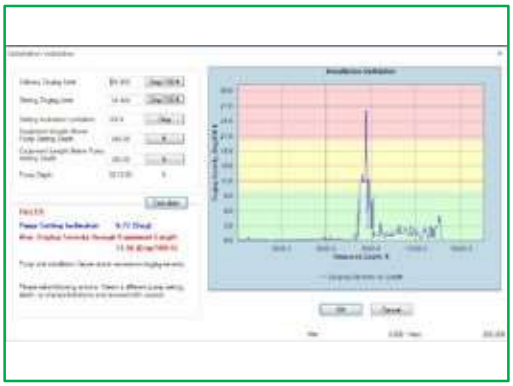


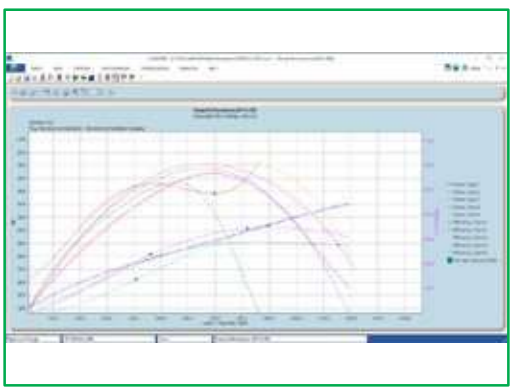


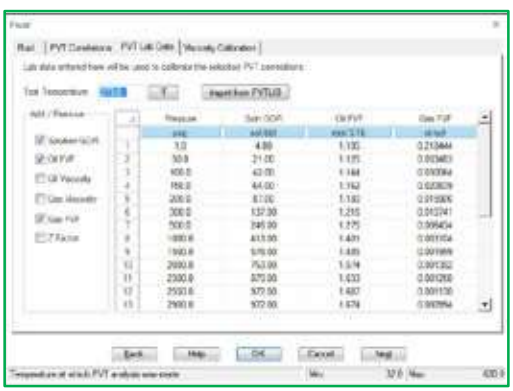


Electronic Submersible Pump Design and Optimization

World's Only Vendor Neutral ESP System Design and Analysis Tool







Solving for Well and ESP System Theoretical Performance:

- Estimate well deliverability.
- Solve for Pump Intake Condition, Total Fluid Rate or Pump Depth.
- Free gas and gas separation calculation.
- Multiphase flow and choke correlation for wellbore and flowline calculation.
- Equipment installation validation, motor slip and motor heat rise calculation.

Equipment Selection and Comparison:

- Databank includes performance data for Pump, Motor, Seal, Housing, Cable, Gas Separator VSDs and more, from all major ESP equipment manufactures.
- Excel template and inventory file for equipment import.
- Compare equipment performance and suitability across different vendors and models.

System Calibration and Optimization:

- PVT lab data and viscosity calibration.
- Stage by stage pump viscosity correction based on Fluid, Water, Oil or Emulsion.
- Non-Linear temperature correlation.
- Derating and Gas Interference.
- Optimization and Diagnostic module.

What Pump and Motor Should I Choose for My Well?

Objectives:

- Design ESP system for oil production well.
- Select and compare equipment from different vendors and models.

Background:

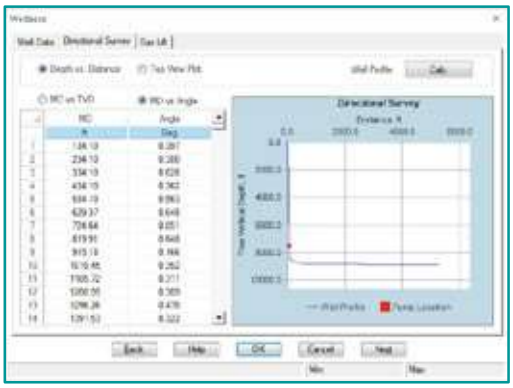
- Onshore oil production well with lateral section of 5800ft with detailed directional survey data.
- 7-5/8" Casing to 13782ft.
- High reservoir deliverability with desired production rate 2500bbl/D.

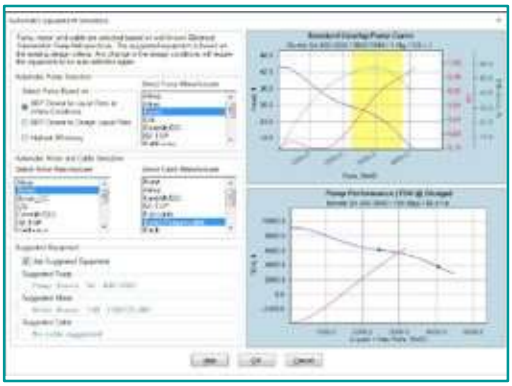
Analysis:

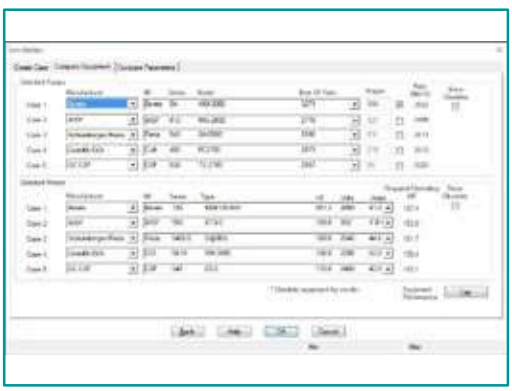
- Reservoir deliverability estimated with simple PI method using available well test data.
- Pump intake condition requirement calculated with desired rate for 794psig pump intake pressure and 5708ft required TDH, if pump were to be set at 7500ft.

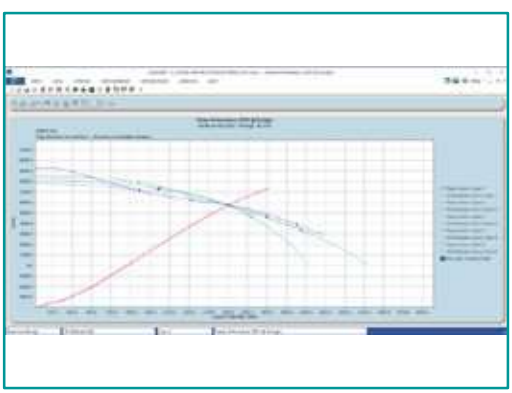
Results:

- Use Auto Select Equipment to select Pump, Motor and Cable candidate.
- Borets, GE ESP, WSP, Schlumberger/REDA and Baker Hughes Centrilift equipment were selected for comparison.
- Borets 5A 400-3000 pump and Borets 130 EDB125- INV motor were selected for this specific well in consideration of efficiency at current and future production rate.



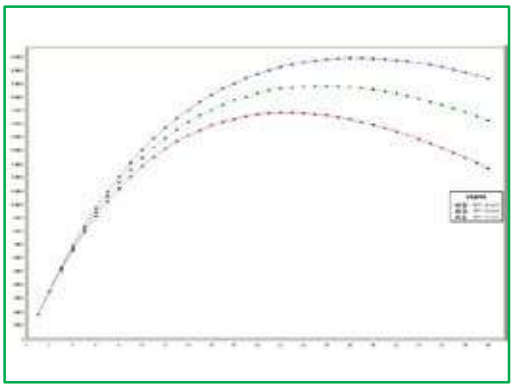


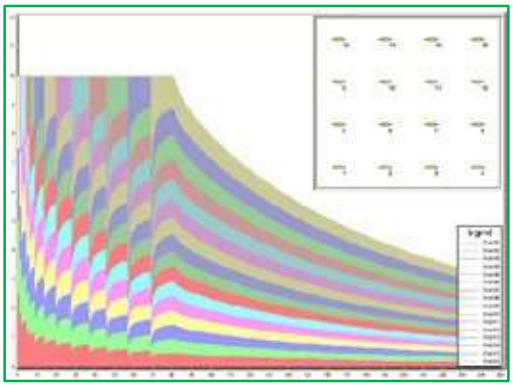


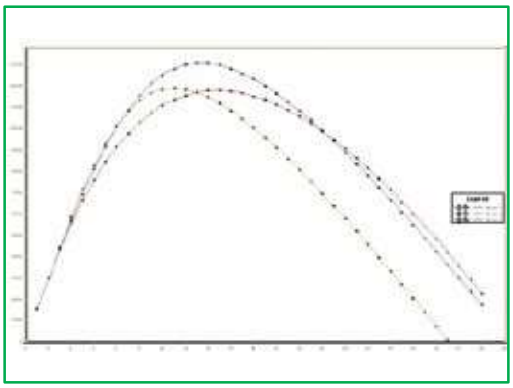


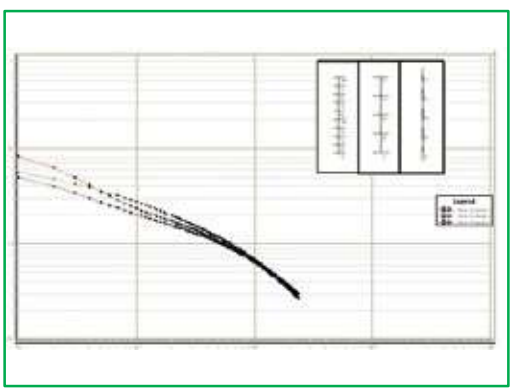
Tight and Shale Gas Development Planning

Make Better, Faster Field Planning Decisions









Determine Optimum Well Spacing:

Answer the question "How many wells do Ineed to optimally produce this field?" by comparing and evaluating a wide range of development scenarios based on both recovery and profitability indicators. Test the sensitivity of results to uncertainty in various reservoir and economic input parameters.

Schedule On-stream Dates for New Wells:

Determine when new wells need to come on-stream to maintain a predetermined maximum field production rate. IHS Evolution's sophisticated analytical reservoir model predicts performance of new wells, properly accounting for depletion and well placement.

Optimize Surface Capacity:

Use IHS Evolution to determine the most efficient usage of gathering system facilities in a "green field" development. Run multiple scenarios using different maximum field rates to find the most profitable results.

Evaluate Optimum Fracture Spacing in Horizontal Wells:

Use IHS Evolution to generate production and cash-flow forecasts for different complex completions, including multi-laterals and multi-stage fractures.

New Tight Gas Field Development Study

Objectives:

To Determine:

- How many wells should be drilled to achieve a total field recovery factor of at least 70%, over 20 years?
- What is the most profitable well spacing scenario?
- What is the optimum field production rate, given that infrastructure will be expensive (letting the wells flow unrestricted will be cost prohibitive)?
- What is the optimum drilling schedule to achieve the desired field production rate?

Background:

- Operator X has acquired new acreage offsetting a large tight gas development.

Analysis:

- We began by populating the reservoir model and running field forecasts.
- Figure 1 shows that 18 wells are required to recover 70% of the original-gas-in-place (OGIP) over 20 years.
- Figure 2 shows a clear maximum value at 12 wells drilled, rather than 18.
- Figure 3 suggests that the optimum field development scenario consists of drilling 13 wells with a maximum rate limitation of 5 MMscfd for the field.
- Figure 4 shows the resulting well schedule.

Results:

- Operator X began with some basic reservoir, well and economic data, but little or no direction. Using IHS Evolution we were able to quickly and systematically find a theoretically optimum development strategy for their undrilled acreage.

Figure 1: Recovery Factor Versus Number of Wells Drilled

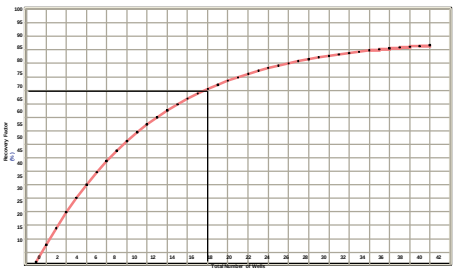


Figure 2: NPV Versus Number of Wells Drilled

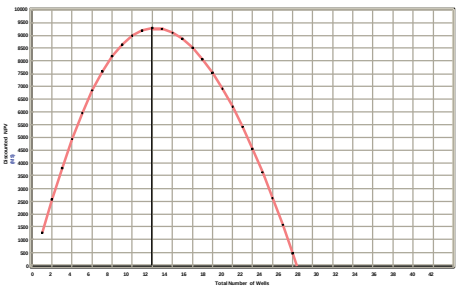


Figure 3: NPV Plot Comparing Three qmax Scenarios

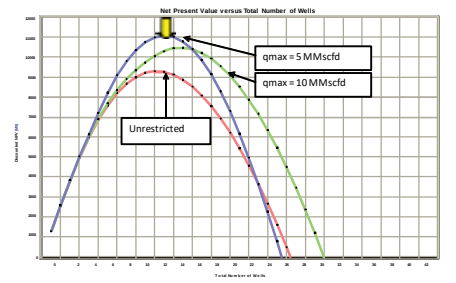
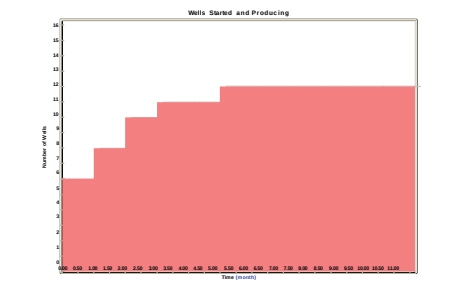
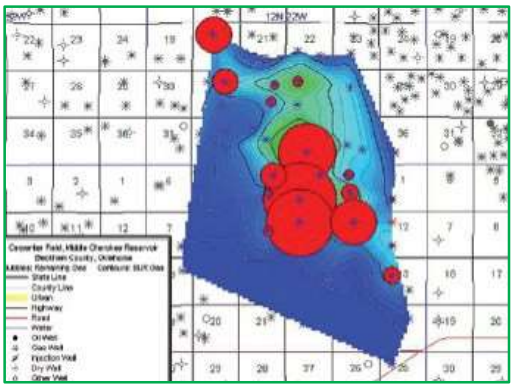
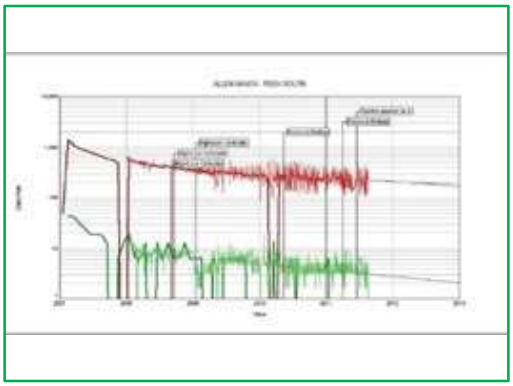


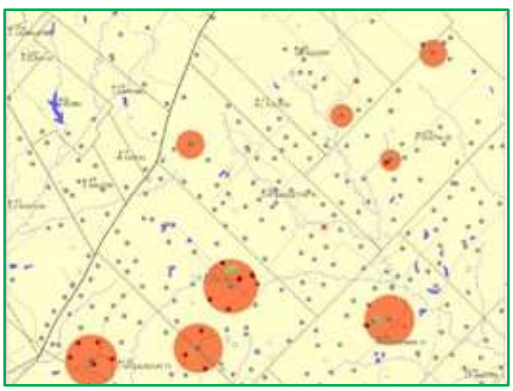
Figure 4: Calculated Well Schedule for qmax = 5 MMscfd

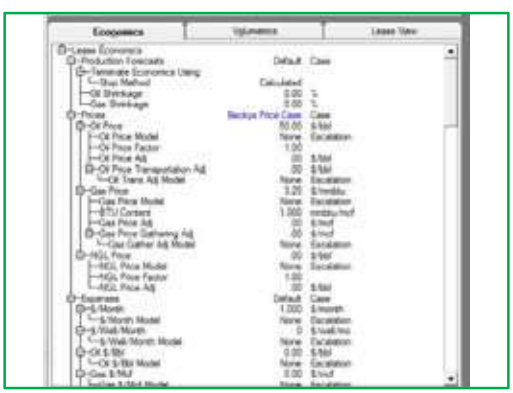


Maximize Well Production with Reservoir and Economic Analysis









Model and Map Multiple Scenarios:

- Set up cases for decline curve forecasts, prices, expenses, taxes, investments, and interests.
- Easily switch between different cases.
- Economics includes ROI, ROR, payout and NPV calculations.
- Click and drag and automatic decline curve fit lets you refine declines on your own evaluations.
- Unparalleled fast and simple modeling capabilities.

Evaluate Reserves Potential Quickly:

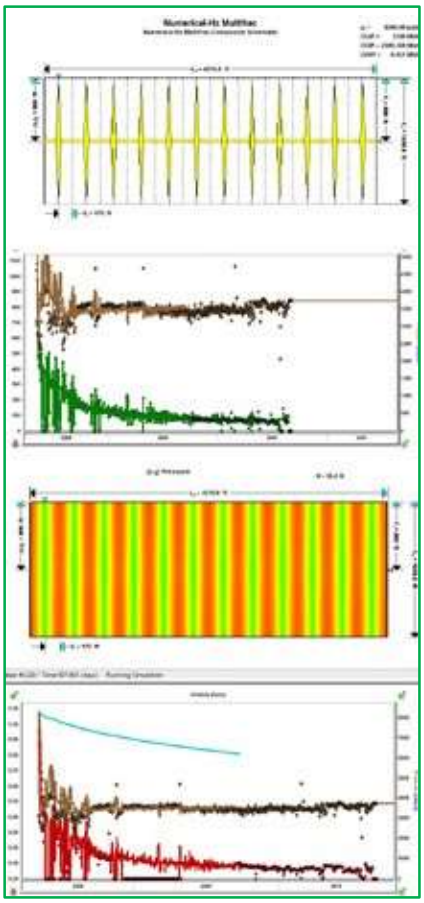
- Evaluate Net Income associated with remaining reserves and undeveloped reserve potential.
- View EUR simultaneously three ways in one window- decline curve analysis, gas pressure analysis, and oil, gas and CBM volumetric calculations all at once.

Powerful Reporting:

- 65 Standard Reports.
- Easy and quick custom report generation.
- Report Books- reports that automatically create well, subtotal and grand total level reports.

Seamless Integrations:

- PowerTools is integrated with a variety of IHS Data Sources and applications including Enerdeq, Production Data on CD, IHS Petra, and IHS FieldDIRECT.



The Challenge of Unconventional Resource Development

As an industry, we have gained knowledge through direct experience. With rig counts down the best approach to building knowledge is through sharing experience. Changes in the development environment bring new questions and challenges. Change could be driven by many factors such as economic or technological.

The Community of Best Practice works with Exploration and Production companies to create a strong foundation of knowledge that address these challenges. Based on well performance data an objective analysis and perspective can be gained to provide a meaningful well to well comparison. This helps to reduce risk, reduce cost, and improve results.

IHS' Stewardship of Knowledge

IHS is a trusted leader in the evaluation of well performance data. In addition to over 40 years of experience in well analysis IHS has analyzed thousands of shale oil and gas wells across the globe with the intent of determining reservoir characteristics, optimizing production and developing reliable forecasts. As we analyze new wells this collection provides a valuable source of analogs. Our clients benefit from having access to Community experts that expedite the transfer of knowledge.

Each Community member derives unique benefits that improve well performance depending on their unique position in a play.

Immediate Value

The current Eagle Ford and Duvernay Communities contain analyses performed by IHS' experienced engineering team with additional supporting material conveying Insights. IHS has made an enormous investment in engineering research, software solutions, and analysis methodologies specifically aimed at the unique challenges inherent in unconventional assets.

Also available is the Bakken Community Database. While not an active Community, it is a valuable database available to IHS clients. Our professional rigor is applied to each well submitted to a Community; all wells are analyzed with a consistent methodology ensuring a meaningful well to well comparison.

Continuing Value and Ongoing Dialogue

Every Community evolves as an expanding source of information. New members join communities, and every well is updated regularly as new production data comes available, with each member contributing new wells annually.

The Community program grows in value year over year, providing a framework for capturing and sharing what works and what does not. IHS engineers are available to discuss the reservoir, completion strategies, and well performance, while Community gatherings facilitate intercompany discussion on the play.

Current Communities

Existing Communities include the Eagle Ford and Duvernay

We are founding new communities in the Permian and Utica formations and a ReFrac Community open to operators able to contribute ReFrac data from unconventional assets. The Bakken/Three Forks Database includes analyses and insights and is available for a one-time purchase.

The strength of our expertise lies in the interdisciplinary cooperation between our geophysical, geological, petrophysical, and reservoir engineering staff. The integration of these disciplines produces a practical and technically rigorous reservoir interpretation.

The geoscience team's interpretation of oil and gas reservoirs incorporates all pertinent:

Seismic, stratigraphic, structural and petrophysical analyses.

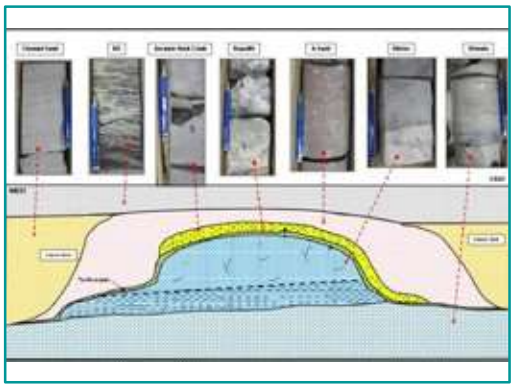
Gross and net pay analyses and the areal extent of reservoirs are determined through detailed correlations of hydrocarbon zones and surrounding strata.

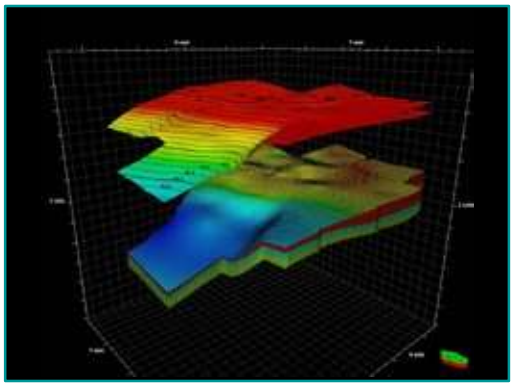
The stratigraphy, lithology, depositional environment, and subsurface structure are assessed.

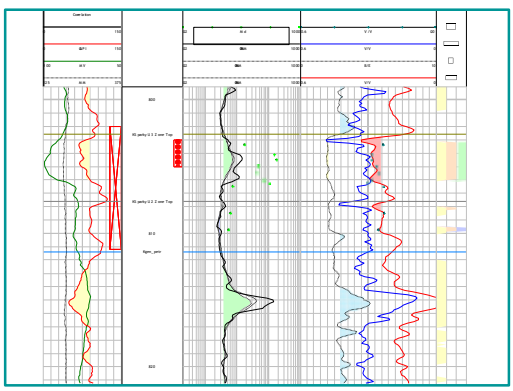
IHS determines reservoir parameters from petrophysical logs, core analyses, drillstem tests, well completion, and test information.

Mapping and modeling of reservoirs is completed utilizing all available information for a study area. Geophysical expertise is incorporated as required.

Software: IHS AccuMap®, IHS AccuLogs®, IHS Petra®, IHS Kingdom®, GeoGraphix, Petrel, IHS EDIN, IHS Enerdeq® Browser, Performance Evaluator, and IHS Reservoir Engineering applications.

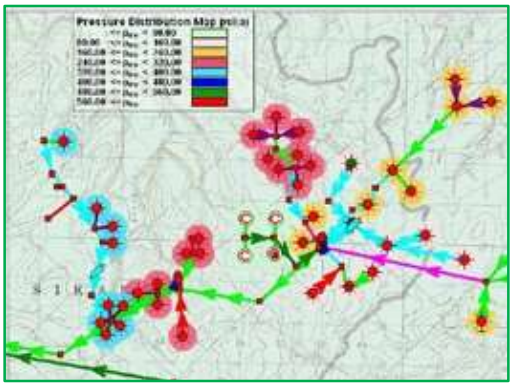






Our project list includes:

- Geophysics
- Petrophysical evaluation
- Sequence stratigraphy
- Sedimentology
- Geochemistry
- Static reservoir characterization - 2D and 3D
- Probablistic and deterministic resource assessment
- Expert witness



Using our IHS Piper software, IHS engineers build an integrated model of downhole and surface assets including:

- Reservoirs, including conventional reservoirs, tight and shale reservoirs, and coal seam gas.
- Wellbores, including the ability to view inflow curves with outflow curves and predict when liquid loading will occur.
- Surface gathering system, including all pipelines with elevation changes, displayed on a scale.

GIS map capable of layering additional shape or image files

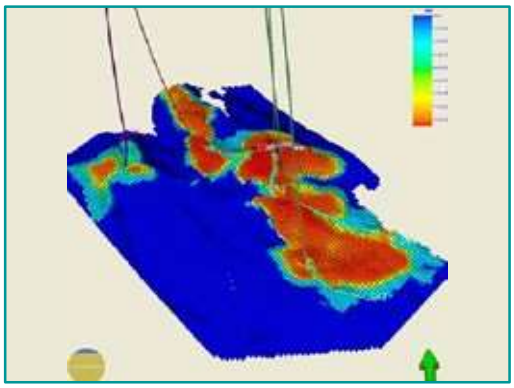
- Facilities, including compression, separation, dehydration and refrigeration.

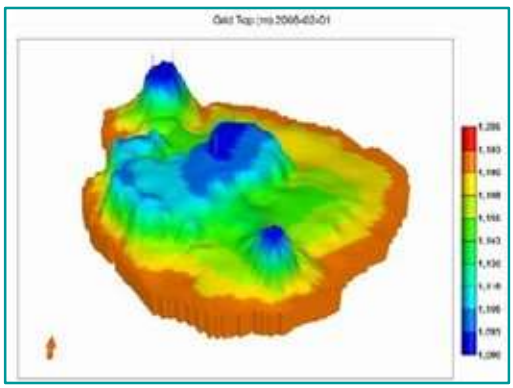
The model is tuned to existing conditions and then used to forecast production from individual wells or at any node in the system. Multiple production scenarios are evaluated to answer such questions as:

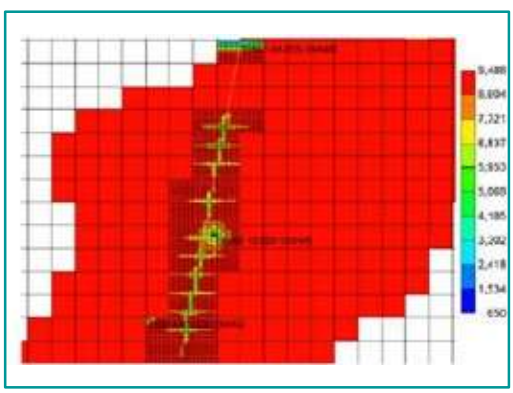
- How are bottlenecks in my gathering system impacting bottom line production?
- Where is pipeline capacity available for new well production?
- What is the impact of additional compression at my sales point?
- How much compression is needed?
- When will each well be subject to liquid loading?
- How much production can be hedged?
- What area of my field has the greatest uplift potential from system optimization?

IHS has worldwide Integrated Asset Management experience including multizone systems in Alberta, CBM in Wyoming, high pressure gas in Pakistan and tight gas in Australia and the USA (Piceance Basin).

Some clients choose to use specific IHS services to augment their reservoir understanding. Alternatively, we are hired to combine and coordinate all of IHS's expertise in conducting integrated reservoir studies leading to master development plans for Greenfield or Brownfield developments.







Static 3D Model

- Geophysics
- Petrophysics
- Sedimentology
- Stratigraphy
- Wells, deviation survey, completions and stimulations

Dynamic Model

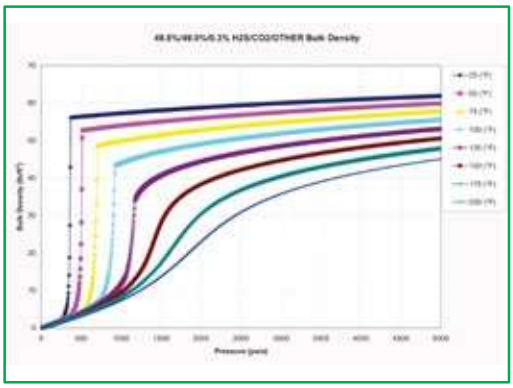
- Geophysics
- Petrophysics
- Sedimentology
- Stratigraphy
- Fluid properties
- PVT
- Rock-fluid properties
- Static reservoir pressure
- Production data analysis
- Reservoir drive
- Material balance
- Populate 3D model

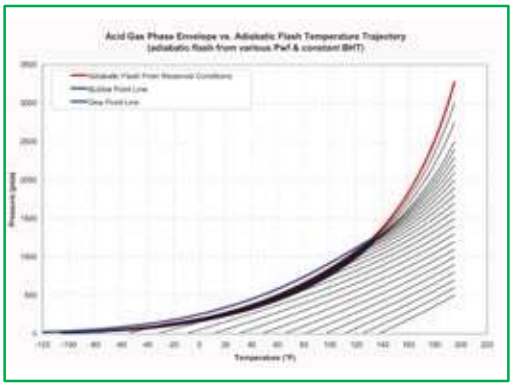
Numerical Simulation

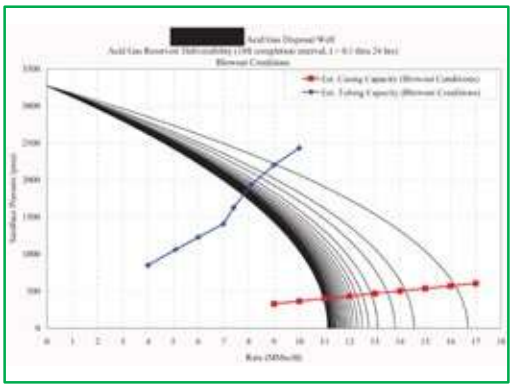
- Experimental design
- Gas, black oil, thermal, compositional simulation
- Stochastic modeling and production forecasting

Economic Analysis

- Economic evaluation
- Risk assessment
- Decision tree analysis







Our Production Engineering services complement geological and reservoir engineering studies by incorporating the practical aspects of field operations.

Our services include:

- Wellbore nodal analysis
- Artificial lift; rod pump, plunger lift, gas lift
- By-passed pay evaluation
- Workover recommendations and programming
- Fracture stimulation optimization
- Waterflood surveillance
- Water disposal
- Acid gas disposal

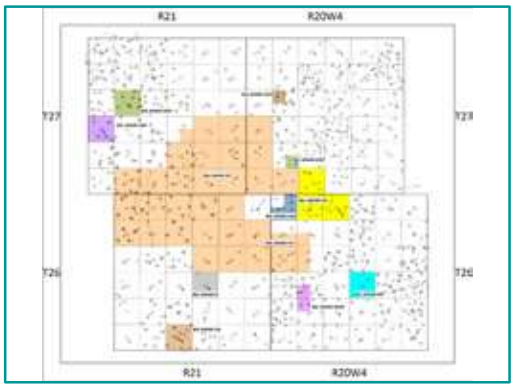
IHS' qualified reserves evaluators use our considerable in-house experience and specialized expertise to truly understand your reservoirs, to accurately model and forecast production, and to provide reserves estimates with confidence. We prepare professional NI 51-101 documents, SEC and PRMS compliant reserves reports for Canadian, United States and international regulators.

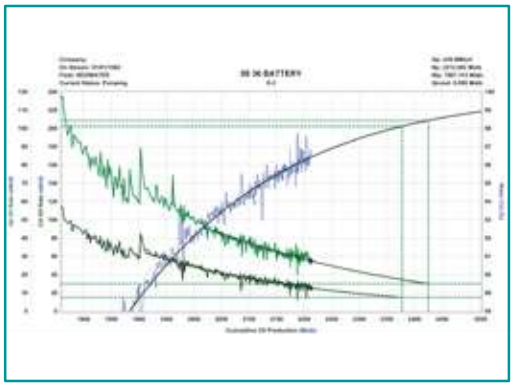
We provide a variety of reports including:

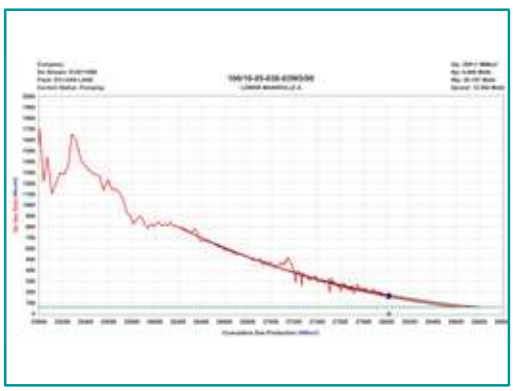
- Annual corporate reserves evaluations
- Individual property reports for acquisition/divestment
- Audit of company reserves to satisfy banking requirements
- Fair market value appraisals/estate valuations
- Submissions to regulatory authorities regarding issues that require economic evaluations
- Assessments of prospective undeveloped lands
- Energy pricing analysis and forecasting

As we conduct our review of your wells and properties, we make recommendations on reservoir management issues which allow you to:

- Increase well density to maximize recovery
- Provide alternative pipeline/compressor routes to alleviate deliverability restrictions
- Enhance recovery techniques
- Conduct a pressure buildup test to determine pool delineation or wellbore damage







IHS provides an integrated team of reservoir engineers, geologists, geophysicists, petrophysicists, production engineers, simulation engineers, and computer specialists. Our results combine static and dynamic modeling into a comprehensive reservoir model that yields additional reserves and successful drilling locations.

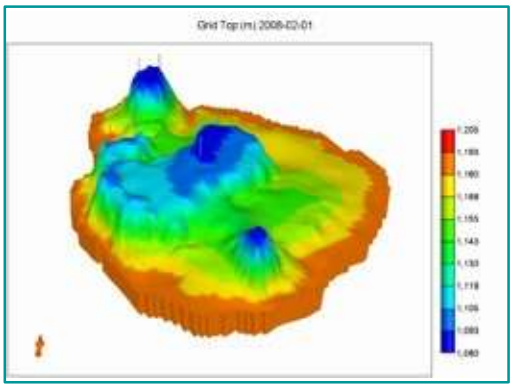
Simulation projects begin with a detailed review of data quality and a scoping analysis of data uncertainty. Simulation proceeds only after the analysis determines that the model is representative of the reservoir, that it will generate dependable results, and that it is economically justified.

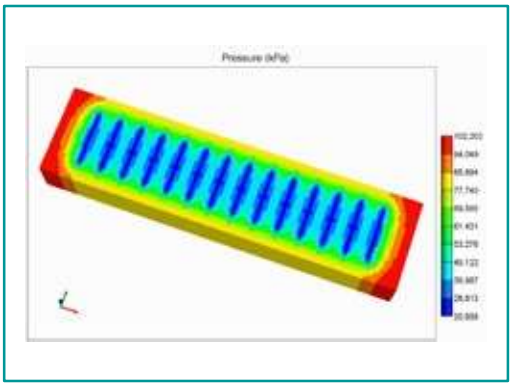
In addition to its specific suite of services, IHS is often engaged to investigate unique reservoir situations for which no precedent exists and the solution path is unclear.

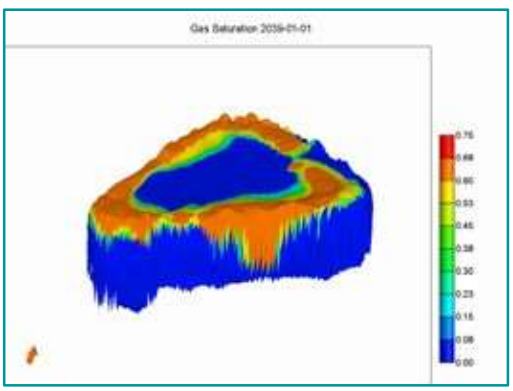
Software: IHS Harmony™, Eclipse (Black Oil and Thermal), CMG (IMEX, GEM, STARS and CMOST).

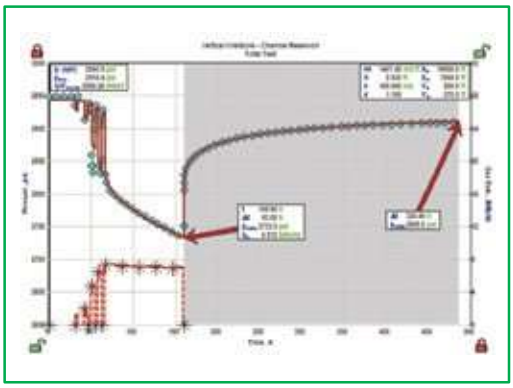
Our project list includes:

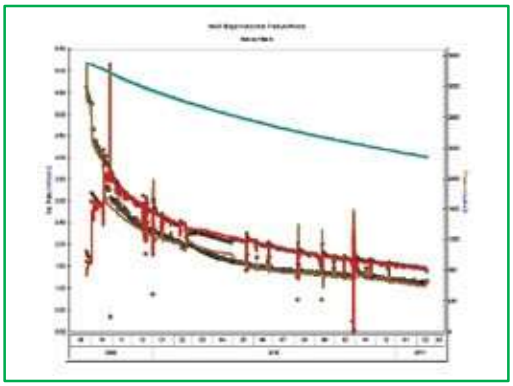
- Waterflood design and optimization
- Thermal oil recovery
- Tertiary EOR schemes
- Infill drilling and pool depletion strategies
- Shale gas/oil development and optimal well spacing
- Coalbed methane
- Gas storage
- Carbon sequestration
- Gas hydrates
- Exploration and development strategies for North American and International clients

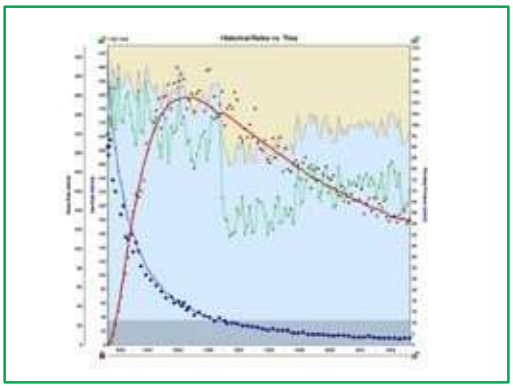


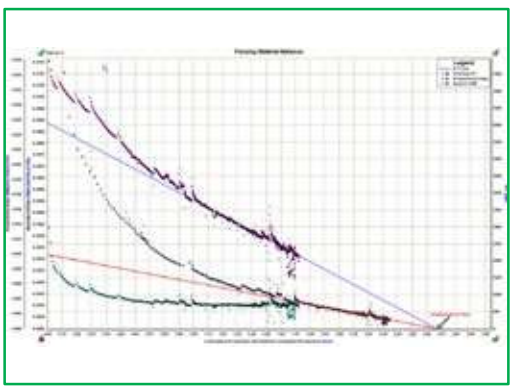












By combining our well test (pressure transient) and advanced decline (rate transient) analysis services, IHS provides a comprehensive understanding of reservoirs, completion efficiency, and optimization potential.

Well Testing (Pressure Transient Analysis)

- Design and analysis of multi/single point flow and buildup for conventional and multi-fractured horizontal wells, injection and falloff (including mini-frac analysis), DST and perforation inflow tests
- Determination of near wellbore reservoir parameters (permeability, skin, fracture parameters)
- Estimation of reservoir pressure, distances to reservoir boundaries and/or heterogeneities
- Prediction of deliverability potential at various flowing conditions
- Recommend potential stimulation (for damaged wells) or optimization candidates (utilizing tubing performance curves and liquid lift calculations)

Rate Transient Analysis

- Reservoir characterization (permeability, skin, fracture half-length)
- Diagnose changing skin or permeability conditions
- Monitor well performance in competitive drainage situations
- Monitor productivity to ensure proper production allocation
- Analytical and numerical production modeling – single zone vertical to multi-frac horizontal wells
- Determination of stimulated reservoir volume, optimal well spacing and EUR/well for unconventional reservoirs
- Proof of "tight gas" for government tax credits

Enhance Your Industry Education

Seeking more accurate analysis? Want to improve reservoir productivity?

With IHS Markit software, you can access a full suite of empirical, analytical and numerical methods. These applications and integrated reservoir management services help our clients optimize production. The engineering training courses for our reservoir engineering products will help you:

- Determine reservoir characteristics
- Improve well performance
- Predict deliverability potential
- Develop reliable forecasts

We offer various types of training covering the following engineering products:

- IHS DeclinePlus
- IHS FieldDIRECT®
- IHS Harmony™
- IHS Harmony™ Forecast (multi-user)
- IHS PERFORM®
- IHS Piper
- IHS PowerTools®
- IHS RTA
- IHS SubPUMP®
- IHS VirtuWell
- IHS WellTest

Getting Started Tutorials:

The introductory software tutorials run 90 minutes in length and are designed to familiarize students with the basic features and functionality within the application. Theory and applied knowledge are beyond the scope of each class.

Comprehensive Courses:

The comprehensive software courses run one to two days in length and are the next step in your learning. The courses incorporate theory, applied knowledge and software workflows giving you the confidence to apply the new techniques in your day to day work.

Customized Training:

In addition to our regularly scheduled courses, we offer custom private software and engineering training to groups. Allow us to customize your training to include use of your data creating a workflow to suit your specific assets. Please contact our Training Coordinator at engineering.training@ihsmarkit.com for more information.

Training Information & Course Registration:

ihs.com\EngTraining

ihs.com\EngRegistration

About IHS Markit

IHS Markit (Nasdaq: INFO) is a world leader in critical information, analytics and solutions for the major industries and markets that drive economies worldwide. The company delivers next-generation information, analytics and solutions to customers in business, finance and government, improving their operational efficiency and providing deep insights that lead to well-informed, confident decisions. IHS Markit has more than 50,000 key business and government customers, including 85 percent of the Fortune Global 500 and the world's leading financial institutions. Headquartered in London, IHS Markit is committed to sustainable, profitable growth.

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