

Profile Help

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Profile

Production Profile Generation and Analysis

by Petroleum Solutions Ltd

Profile Help

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Printed: May 2010

Table of Contents

	Foreword	0
Part I	Welcome to Profile	7
1	Introduction	7
Part II	Field Schedule	11
1	Defining Field Input	11
Part III	Well Schedule	17
1	Defining Wells	17
2	Defining Schedule	20
Part IV	Associated Production	22
1	Secondary Hydrocarbons	22
2	Water Production	24
Part V	Injectors / Gaslift	28
Part VI	Facilities Contraints	31
Part VII	Table / Charts	34
Part VIII	Chart Operations	37
Part IX	Main Results Panel	41
Part X	Change Chart Settings	43
Part XI	Create Reports	45
Part XII	Tools Menu Items	50
1	Well Scheduler	50
2	Analyse Actual Profile	53
3	Backcalculate Decline Exponents	62
4	Well PI Calculations	63
5	Calculate Depletion GOR Profile	67
6	PVT Calculations	73
7	Recovery Factor Estimate	76
8	Quicklook Oil VLP/IPR	77
Part XIII	Worked Example	87

Contents	5

1 Arkle Discovery	87
Oil Production Profile	
Gas Production Profile	
Water Production Profile	
Water Injection Profile	
Facilities Sizing	
Results	
Index	97





7

1 Welcome to Profile

1.1 Introduction



Profile is an easy to use application intended for Petroleum Reservoir Engineers to :

Quickly prepare and analyse primary and associated production profiles.

Compare to analogue fields for well spacing, recovery/well, plateau offtake rates, decline rates,

Quicklook sizing for facilities throughput capacity for all production and injection streams.

The assumptions behind *Profile* are based on the various phases of production life of an oil or gas field, ie,. a buildup period, a plateau period and a decline period.

Two different approaches for generating primary hydrocarbon phase production profiles are provided within this application.

Either :

- The ability to generate a field production profile by defining the field production buildup, plateau and decline rates and recoverable reserves. The application solves for the required number of development wells; producers and injectors, that fit with the timing of the field production profile, or
- The ability to generate a field production profile by specifying different well types and the schedule for drilling these wells. This approach permits the modelling of different well recoveries and workovers, etc. The field profile is simply the sum of all the wells specified in the well schedule

The ability to quickly model associated hydrocarbon phases (either gas for an oilfield or condensate for a gas field), and water production for an oilfield is provided, together with the ability to quickly model water injection, gas injection, requirements for gas fuel and flare and schedule workovers.

License.dat File

The "License.dat" file is located in the Application Startup folder (eg C:\Program Files\Petroleum Solutions\Profile\)

The contents of this ASCII license file needs to contain the following license information.

[License Settings] LicensedTO = Company = ProductID = LicenseID =

If any of the above License key information is incorrect or absent, or if the License.dat file is missing then the application will fail to startup.

.NET Framework

This application requires the presence or installation of Microsoft .Net Framework version 2.

.NET Framework version 2 is a component of the Microsoft Windows® operating system used to build and run Windows-based applications.

Should .NET Framework version 2 not be installed on the destination PC then a link is provided below to download this system software. The user should download and install .NET Framework version 2 before attempting to install this application.

Inttp://www.petroleumsolutions.co.uk/downloads.html

The installation of .Net Framework also requires a minimum software and hardware requirement. Details of which are shown below. Specifically, note that you cannot install the .NET Framework on a computer running the Microsoft Windows 95 operating system.

Minimum requirements

To install .NET Framework [Dotnetfx.exe], you must have one of the following operating systems, with Microsoft Internet Explorer 5.01 or later installed on your computer:

Microsoft® Windows® 98

- Microsoft® Windows® 98 Second Edition
- Microsoft® Windows® Millennium Edition (Windows Me)
- Microsoft® Windows NT® 4 (Workstation or Server) with Service Pack 6a
- Microsoft® Windows® 2000 (Professional, Server, or Advanced Server) with the latest Windows service pack and critical updates available from the Microsoft Security Web site (www.microsoft. com/security).
- Microsoft® Windows® XP (Home or Professional)

Recommended hardware

CPU Recommended	RAM Recommended
Pentium 90 MHz or faster	96 MB or higher





2 Field Schedule

2.1 Defining Field Input

The user can choose between working with a *Field Profile* approach or a *Well Profile* approach by choosing the dropdown box in the main toolbar menu, as shown below.

	💕 🖬 🔣 🕫	Profile [Field Test ver	ion2.ppd]	
Н	ome			🛞 😒 About
Profile Type Frequency	Field Profile	Report Font Tahoma v 9 v Style Blue v	PDF Report	⊙ Scheduler AB ⁴ Exponents 🔒 GOR 📗 RF
Units	Well Profile	Presult Boxes Colour → State Global Qa/Qi ratio Decimals 2	Kcel Report	🕅 Analyse 🔚 Well PI 🚸 PVT 🏭 VLP/IPR
Pi	rofile Setup	Global Settings	Output	Other Tools

Once the Field Profile approach is chosen the application main tab bar should change to the following.

	F 🔝 🖬			Profile				<u> </u>
Н	lome							🙆 😒 About
Profile Type	Field Profile	ler AB ¹ Exponents 📕 GOR 🧱 RF						
Frequency	Annual 👻				PDF Report			
Units	Oilfield 👻	Result Boxes Cold	ur 🍸 👶 Global Qa/Qi ratio 🛛 Decimal	s 2 ‡	📓 Excel Report	Ar Analyse	🔙 Well PI 🍣 PVT 🏩 🛛 VLP/IPR	
P	Profile Setup		Global Settings		Output		Other Tools	
			Field Details				Main Results	
Fie	eld Name / Description	01		L .: [30]	10		Buildup Production	
	Hydrocarbon Type ?	01	Month of First p	roduction Jan 20			Plateau offtake rate	
			Fi	eld Area	km²	•	Year of final Plateau	
Field Sche	dule Associated Produ	ction Injectors / Gaslift	Facilities Constraints Tables / Charts				Production to end of Plateau	
							Prod'n to end of Plateau [%]	
F	Recoverable Oil [mmstb	0]			Swing Factor		Decline duration [Years]	
	Buildup to Plateau	[in Mstb/d]	Plateau duration [years]				Total Field Life [Years]	
	Year 2010	<u>^</u>	Decline Rate [fraction]		'n' Factor		Total Production [mmstb]	
	Year 2011 Year 2012	E	Decline Type	Exponential 💽			Abandonment rate [mstb/d]	
	Year 2013		Abandonment, Qa/Qi	0.025]			
	Year 2014 Year 2015			Back Solve	Decline Rate		Acres/Production well No. of Production Wells	

Under the same main toolbar menu, the user can also select between *Oilfield Units* and *Metric Units*, which determines the units preference applied throughout all the panels and forms within the application.

Again under the same main toolbar menu, the user can also choose between *Annual* or *Semi-Annual* or *Monthly* periods for reporting purposes. All internal calculations are done on a monthly basis and reported in Annual, Semi-Annual or Monthly periods.

Once the user selects the Field Profile approach and selects the Field Schedule button in the main toolbar the following Main Panel should become visible.

Recoverable Oil [mmst	b]				Swing Factor
——— Buildup to Plateau	[in Mstb/d]	Plateau d	luration [years]		
Year 2010	*	Decline	Rate [fraction]		'n' Factor
Year 2011	=		Deelles Tores		
Year 2012			Decline Type	Exponential	
Year 2013		Aband	onment, Qa/Qi	0.025	
Year 2014					
Year 2015				Back Solve I	Decline Rate
Year 2016					
Year 2017		🔽 Cal	lculate required n	umber of Production	Wells ?
Year 2018				— Well Details —	
Year 2019					
Year 2020		Use	e field decline rat	e?	
Year 2021					
Year 2023				First Year	Final Year
Year 2023		10	/ell Qi[msth/d]		
Year 2025			ion di [mata/d]		
Year 2026		Yea	ars at Qifor well		
Year 2027		Decli	ine Rate (fraction)	1	
Year 2028					
Year 2029	T	Abar	ndonment, Qa/Qi	0.025	

The User should attempt to type in as much data as possible.

A Fieldname / Description [OPTIONAL] is only used for reporting purposes.

The Hydocarbon Type [REQUIRED] determines the primary & secondary hydrocarbon phases, and also determines the applicability of water production and water injection.

First Month of production [REQUIRED] is the month in which first oil or gas production is achieved. Once a month has been input and validated for errors the labels will change to reflect the actual years or months in the Buildup to plateau panel. See below.

The Field Area [OPTIONAL] is used to determine the Area / Production Well calculated and displayed in the Main Results Panel located on the right of the main application screen.

Recoverable Oil (or Gas) [REQUIRED] is the target ultimate recovery for the field or prospect being analysed.

Year 2010	*
Year 2011	=
Year 2012	-
Year 2013	
Year 2014	
Year 2015	
Year 2016	
Year 2017	
Year 2018	
Year 2019	
Year 2020	
Year 2021	
Year 2022	
Year 2023	
Year 2024	
Year 2025	
Year 2026	
Year 2027	
Year 2028	
Year 2029	-

Buildup to Plateau [REQUIRED] is the primary hydrocarbon phase production rates building up to a final rate, which is assumed to be the plateau production rate.

Plateau duration [REQUIRED] is simply the number of years that the field remains on it's plateau production.

Swing Factor [OPTIONAL] is a well deliverability check provided for gas fields that operate on a summer/ winter swing basis. ie if a number of 1.25 is entered, then the application will check that the well deliverability can achieve 1.25 x the field production levels, otherwise the application will add additional wells to ensure that this deliverability can be met.

Decline Type [REQUIRED]. The user is given the option of either exponential or hyperbolic decline type

The exponential decline curve, or constant rate decline [since the decline rate does not change with time], equation is shown below.

$$q = q_i e^{-at}$$

Where,

- q = Production rate at time = t
- qi = Initial production rate
- a = Constant decline rate fraction, between 0 and 1
- t = time, typically measured in months or years.

The hyperbolic decline curve equation is shown below.

$$q = q_i (1 + na_i t)^{-1/n}$$

Where,

n = additional constant decline exponent, between 0 and 1

Special cases for the hyperbolic decline equation occur at n=0 [exponential decline] and n=1 [harmonic

decline].

The following text is taken from "Petroleum Engineering Handbook" published by the Society of Petroleum Engineers, page 40-26.

"An analysis of a large number of actual production-decline curves assembled by Cutler indicates that most decline curves normally encountered are of the hyperbolic type, with values for the exponent n between 0 and 0.7, while the majority fall between 0 and 0.4."

Decline Rate [REQUIRED] is the constant decline rate fraction, between 0 and 1, in the exponential [a] or hyperbolic [a_i] decline equation.

'n' Factor [REQUIRED if decline type = Hyperbolic] is the additional constant decline exponent, between 0 and 1, in the hyperbolic decline equation.

A simple tool is provided via the main menu item 'Tools\Backcalculate Decline Exponents' to quickly calculate values for decline rate parameters 'a' and 'n'. See help topic <u>Backcalculate Decline Exponents</u>.

Abandonment, Qa/Qi [REQUIRED] determines the year of field abandonment and is simply defined as the ratio of the final rate divided by the initial rate. Typical values are 0.1 or 0.05.

The Abandonment, Qa/Qi value is required in several places across the application, therefore the user can choose to select to change the global value by selecting the relevant inputbox, accessed via the menu option Options/Set Global Qa/Qi, shown below.

ſ		6 1 1	Ŧ							Profile
	Ho	me								
	Profile Type	Field Profile	•	Report Font Tahoma		9	+	Style B	lue	-
	Frequency	Annual	-			-				
	Units	Oilfield	-	Presult Boxes Colour	÷.0 Global (Qa/Qi rati		Decimals	2	÷
	Pn	ofile Setup			Global S	ettings				
					Set Global C	Qa/Qi				

Back Solve Decline Rate button

Assuming the user has entered sufficient buildup rates, plateau duration and the target ultimate recovery, then the user can press the Back Solve Decline Rate button to quickly back calculate the appropriate decline rate to equal the target ultimate recovery.

Well Details panel

Well Details								
☑ Use field decline rate ?								
	First Year	Final Year						
Well Qi [mstb/d]								
Years at Qi for well								
Decline Rate [fraction]								
Abandonment, Qa/Qi	0.025							
		J						

The above panel determines how to calculate the number of production wells required to meet the field

production profile, assuming these have already been defined by the buildup, plateau and decline periods.

The user is provided with a simple method for modelling the potential for degrading well recoveries versus field life by entering different well rates for the first year and the final year. A simple linear interpolation is done between the first and final year well rates to determine an specific years well rate.

The user can also choose to un-check the Use field decline rate ? check box and enter a more or less aggressive well decline rate in comparison to the field decline rate.





3 Well Schedule

3.1 Defining Wells

The user can choose between working with a *Field Profile* approach or a *Well Profile* approach by choosing the dropdown box in the main toolbar menu, as shown below.

) 💕 🖬 💽 🕫	Profil	e		. - X
	Home				🕢 😒 About
Profile Typ	e Field Profile	Report Font Tahoma • 9 • Style Blue	Screen capture	⊙ Scheduler AB ⁴ Exponents 🚮 GOR 🧾 RF	
Units	Well Profile	Result Boxes Colour v Solobal Qa/Qi ratio Decimals 2	Excel Report	👫 Analyse 🔚 Well PI 😵 PVT 🄃 VLP/IPR	
	Profile Setup	Global Settings	Output	Other Tools	

Once the Well Profile approach is chosen the application main tab bar should change to the following.

	F 🔝 🖬 🝯					Profile				
Н	ome			@ 😒 About						
Profile Type Frequency	Well Profile Annual	Report Font	Schedul	Scheduler AB ⁴ Exponents d GOR RF						
Units	Oilfield -	Nesult Box	kes Colour ▼ .00 G	lobal Qa/Qi ratio	Decimals 2	\$	Excel Report	🕂 Analyse	🔚 Well PI 🗳 PVT 🇓 VLP/IP	R
Pr	rofile Setup		GI	obal Settings			Output		Other Tools	
			Main Results							
Fiel	Field Name / Description Hydrocarbon Type ? Dil Month of First production Jan 2010 Field Area Km ²									
WellSched	ule Associated Produ	iction Injectors /	Gaslift Facilities Co	nstraints Tables	: / Charts				Production to end of Plateau	
Define Wel	Input Well Schedul	e							Prod'n to end of Plateau [%]	
Well Nam	e Well Qi [mstb/d]	Years at Qi for well	Decline Type	Decline [fraction]	'n' factor	Abandonme Qa/Qi	ent Cum.Prod. [mmstb]	Wel ^ [Ye	Decline duration [Years] Total Field Life [Years]	
								E	Total Production [mmstb] Abandonment rate [mstb/d]	

Under the same main toolbar menu, the user can also select between *Oilfield Units* and *Metric Units*, which determines the units preference applied throughout all the panels and forms within the application.

Again under the same main toolbar menu, the user can also choose between *Annual* or *Semi-Annual* or *Monthly* periods for reporting purposes. All internal calculations are done on a monthly basis and reported in Annual, Semi-Annual or Monthly periods.

Once the user selects the Well Profile approach and selects the Well Schedule button in the main toolbar the following Main Panel should become visible.

Jetine Wells Input Well Schedule											
√ell Name	Well Qi [mstb/d]	Years at Qi for well	Decline Type	Decline [fraction]	'n' factor	Abandonment Qa/Qi	Cum.Prod. [mmstb]	We [Ye			

The User should attempt to type in as much data as possible.

A Fieldname / Description [OPTIONAL] is only used for reporting purposes.

The Hydocarbon Type [REQUIRED] determines the primary & secondary hydrocarbon phases, and also determines the applicability of water production and water injection.

First Month of production [REQUIRED] is the month in which first oil or gas production is achieved. Once a month has been input and validated for errors the labels will change to reflect the actual years or months in the Buildup to plateau panel. See below.

The Field Area [OPTIONAL] is used to determine the Area / Production Well calculated and displayed in the Main Results Panel located on the right of the main application screen.

Well Name [REQUIRED] is a text string intended to briefly describe the type of well to be modelled, eg. Good, Medium, Poor, Long, Short, Horizontal, Vertical, etc.

Well Qi [REQUIRED] is the peak initial well rate

Years at Qi for well [REQUIRED] is the well plateau production period in years

Decline Type [REQUIRED] as with the *Field Profile* approach, the user is given the option of either exponential or hyperbolic decline type.

The exponential decline curve, or constant rate decline [since the decline rate does not change with time], equation is shown below.

$$q = q_i e^{-at}$$

Where,

- q = Production rate at time = t
- qi = Initial production rate
- a = Constant decline rate fraction, between 0 and 1
- t = time, typically measured in months or years.

The hyperbolic decline curve equation is shown below.

$$q = q_i (1 + na_i t)^{-1/n}$$

Where,

• n = additional constant decline exponent, between 0 and 1

Special cases for the hyperbolic decline equation occur at n=0 [exponential decline] and n=1 [harmonic decline].

The following text is taken from "Petroleum Engineering Handbook" published by the Society of Petroleum Engineers, page 40-26.

"An analysis of a large number of actual production-decline curves assembled by Cutler indicates that most decline curves normally encountered are of the hyperbolic type, with values for the exponent n between 0 and 0.7, while the majority fall between 0 and 0.4."

Decline Rate [REQUIRED] is the constant decline rate fraction, between 0 and 1, in the exponential [a] or hyperbolic [a_i] decline equation.

'n' Factor [REQUIRED if decline type = Hyperbolic] is the additional constant decline exponent, between 0 and 1, in the hyperbolic decline equation.

A simple tool is provided via the main menu item 'Tools\Backcalculate Decline Exponents' to quickly calculate values for decline rate parameters 'a' and 'n'. See help topic <u>Backcalculate Decline Exponents</u>.

Abandonment, Qa/Qi [REQUIRED] determines the year of field abandonment and is simply defined as the ratio of the final rate divided by the initial rate. Typical values are 0.1 or 0.05.

The Abandonment, Qa/Qi value is required is several places across the application, therefore the user can choose to select to change the global value by selecting the relevant inputbox, accessed via the menu option Options/Set Global Qa/Qi, shown below.

ſ		F 🔝 🖬 📬		Profile
	Н	ome		
	Profile Type	Field Profile	Report Font Tahoma y 9 y Style Blue	+
	Frequency	Annual 🔹		
	Units	Oilfield -	Result Boxes Colour > Global Qa/Qi ratio	\$
	Pr	ofile Setup	Global Settings	
			Set Global Qa/Qi	

Once all of the above required data has been input for an individual well, then the application will automatically calculate the cumulative production and well life, as shown below.

Define Wells In	put Well Schedu	le						
Well Name	Well Qi [mstb/d]	Years at Qi for well	Decline Type	Decline [fraction]	'n' factor	Abandonment Qa/Qi	Cum.Prod. [mmstb]	Wel ^ [Ye
Good	15	3	Exponential	0.25	0	0.05	15.426	-
Medium	10	2	Exponential	0.3	0	0.05	6.435	-
Poor	7.5	1	Exponential	0.35	0	0.05	3.197	
Very Poor	4	1	Exponential	0.45	0	0.05	0.505	

3.2 Defining Schedule

Once *Define Wells* has been complete then the user can select the second tab [*Input Well Schedule*] to commence scheduling of the predefined wells.



Both the *Date* and *Wellname* input boxes are populated based on the data entered on the previous tab *Define Wells*. The *Date* input boxes contain all the annual or semi-annual dates between the already defined start year and end year.

Check boxes are provided to the left of the *Date*, *Wellname* and *No.Wells* input boxes to quickly enable/ disable the row input in the profile calculation.

The user can display the individual well production profiles they defined in the Define Wells tab by selecting the drop down list box located at the bottom right hand corner of the *Input Well Schedule* tab





4 Associated Production

4.1 Secondary Hydrocarbons

To select *Associated Production* simply press the Associated Production tab located on the main application display, as shown below.

Home		Profile [Field Test versi	ion2.ppd]			🕞 🖻 🗙
Profile Type Field Profile Frequency Annual Units Oilfield	Report Font Tahoma * • ************************	9 * Style Blue * Qa/Qi ratio Decimals 2 \$	Creen capture	C Schedul	er AB ⁴ Exponents 📕 GOR 🧾 F 🥌 Well PI 🏶 PVT 🏹 VLP/IP	R
Profile Setup	Global S	ettings	Output		Other Tools	
Field Name / Description Hydrocarbon Type ?	Test for Field Oil Production	Month of First production Jan 20	10 [Main Results Buildup Production	14.6000
		Field Area 20	km²		Plateau offtake rate Year of final Plateau	2015
Field Schedule Associated Produ	action Injectors / Gaslift Facilities Constrai	nts Tables / Charts			Production to end of Plateau	94.9550
Associated Gas Production Asso	ociated Water Production				Prod'n to end of Plateau [%]	37.98%
13		GOR v's Time Gas Production v's Tin	ne		Decline duration [Years]	26.00
Calculate Associated Hydro	carbon Production ?				Total Field Life (Manual	00.00

The user can choose to calculate an associated gas profile [assuming the main hydrocarbon type is Oil] via either the *Simple Method* or via a *Material Balance Depletion gas/oil ratio (GOR) Method*. If the main hydrocarbon type is Gas/Gas Condensate then the user can only calculate a depletion condensate profile via the *Simple Method*.

The following figure demonstrates the options and the required input.

	GOR v's Time Gas Production v's Time
Calculate Associated Hydrocarbon Production ?	
Associated Gas Production —	2000
Use Simple Method	
Recoverable Oil [mmstb] 259.72	1500-
Recoverable Gas [bcf] 227.13	
Initial GOR [scf/stb] 650	
Final GOR [scf/stb] 1978.5	Astronomic and Astronomic
Curve Type = 4	9 1000- 40 9
© Use Material Balance Depletion GOR	500 -
Calculate Depletion GOR	
	0

Simple Method

Based entirely on a paper presented in the Oil and Gas Journal, 21-Feb-1994, entitled "Program predicts realistic solution-gas-drive GOR" by Neal Teague.

The technique allows the user to select the relationship between the production of the secondary phase in relation to the production of the primary phase by simply iterating with the Curve Numbers, the initial and final gas/oil ratios (GOR) or condensate/gas ratios (CGR) and the secondary reserves.

Curve Numbers can exist between 1 and 10. A Curve Number of 1 assumes a constant GOR or CGR.

The user should iterate with all of these variables until a representative GOR or CGR relationship is obtained for the prospect.

During this iteration process it may become apparent that the technique occasionally calculates negative GOR or CGR versus primary production, wheras in reality this is impossible. In these cases, the user should continue to iterate until a satisfactory relationship is obtained.

Material Balance Depletion GOR Method

The material balance depletion method is provided for oilfields to calculate the primary depletion gas production and is entirely based on the technique outlined by Laurie Dake in "The Practice of Reservoir Engineering", published by Elsevier. [Chapter 3.7 - Volumetric Depletion Fields].

The calculation process is discussed in more detail in the following help topic <u>Calculate Depletion GOR</u> <u>Profile</u>.

It is possible via the Material Balance Depletion GOR Method to calculate the required numbers and curve shape for the Simple Method, an example is included below and is discussed in more detail in the above help topic.

🕌 Calculate Depletion GOR Profile			×
Input Data Setup Calculations			
GOR Calculation Import Field Profile	and Calculate Compa	re to Simple Method	
Recoverable Oil [MMstb]	259.72	Initial GOR [scf/stb]	650.00
Recoverable Gas [Bcf]	230.53	Final GOR [scf/stb]	1978.50
		Curve Type	4
GOR v's Time Gas Production v's Ti	ime		
2000.00 - 1500.00 - 9 1000.00 - 500.00 -			
0.00	/2016 01/01/2022 Material Balance	01/01/2028 01/01/203	34 01/01/2040
		ОК	Cancel

4.2 Water Production

The user can choose to calculate an associated water production profile for both Oil fields and Gas / Gas Condensate fields.

) 💕 🖬 🐼 🕫		Profile [Field Test vers	ion2.ppd]			- 0 X
	Home						🔞 😒 About
Profile Typ Frequency Units	e Field Profile Annual Oilfield	Report Font Tahoma	9 v Style Blue v a/Qi ratio Decimals 2 \$	Screen capture Screen capture PDF Report Screen Report	Schedul	er AB ⁴ Exponents 🔒 GOR 🧾 RF 🔙 Well PI 🚸 PVT 🏹 VLP/IPR	
	Profile Setup	Global Se	attings	Output		Other Tools	
		Field De	tails			Main Results	
Fi	eld Name / Description Hydrocarbon Type ?	Test for Field Oil Production	Month of First production Jan 20	10		Buildup Production Plateau offtake rate	14.6000 8.03%
			Field Area 20	km²	-	Year of final Plateau	2015
Field Sche	dule Associated Prod	uction Injectors / Gaslift Facilities Constrain	ts Tables / Charts			Production to end of Plateau	94.9550
Associated	d Gas Production Asso	ciated Water Production				Prod'n to end of Plateau [%]	37.98%
		3				Decline duration [Years]	26.00
Calc	ulate Associated Water	Production ?	1.0 T	/		Total Field Life [Years]	32.00

To calculate a water production profile select the tab *Associated Water Production* located in the *Associated Production* panels (as shown above). The following will be displayed.



The user has two options for calculating a water production profile for either a Oil field or a Gas / Gas Condensate.

For Oil Fields the following can be input :

- 1. Use Predefined Watercut (fw) v's Recovery Factor (Np/N), where Np is the cumulative oil produced and N is the stock tank oil originally in place or STOOIP, and
- 2. Use User defined fw v's Np/N.

For Gas or Gas Condensate Fields the following can be input :

- 1. Use Predefined Water Gas Ratio (WGR) v's Recovery Factor (Np/N), where Np is the cumulative gas produced and N is the Gas initially in place or GIIP, and
- 2. Use User defined WGR v's Np/N.

Depending on the Field Type, and assuming the first option is selected, the user can select between Favourable, Moderate or Aggressive watercut development trends, from the Predefined fw (or WGR for gas fields) vs Np/N dropdown box.

The ultimate field recovery factor and field abandonment watercut (or WGR for gas fields) level are also required. The solution then simply looks up, for each calculation period, the production rate and current recovery factor and applies the appropriate watercut/WGR for that period to calculate a water production rate.

The user also has the ability to modify both the early and late curvature of the selected predefined watercut/WGR development trend by toggling the up/down arrows in the *Customise Predefined* group box

Assuming the user wishes to use a specific watercut/WGR development trend then the user can select the second option, *Use User defined fw (or WGR) v's Np/N*. The user should toggle on this option and

either manually type in values of ascending order, of recovery and watercut/WGR, or choose to import a comma delimited ASCII file, via the Import CSV button.

This file can be generated in Microsoft Excel and saved as a CSV filetype. An example of what the file should look like is provided below.

	A	В	С
1	0	0	
2	0.0254	0.006	
3	0.0509	0.0182	
4	0.0763	0.0357	
5	0.1018	0.0588	
6	0.1272	0.0878	
7	0.1527	0.123	
8	0.1781	0.165	
9	0.2035	0.2139	
10	0.229	0.2701	
11	0.2544	0.3333	
12	0.2799	0.4032	
13	0.3053	0.4788	
14	0.3308	0.5586	
15	0.3562	0.6406	
16	0.3816	0.7221	
17	0.4071	0.8	
18	0.4325	0.8709	
19	0.458	0.931	
20	0.4834	0.9764	
21	0.5089	1	
22			
23			

The solution then assumes that the final figures represent the abandonment recovery factor and watercut/WGR (ie., last calculation period), then for each calculation period the current recovery factor is worked out and a watercut/WGR value is interpolated, and therefore for the current oil production rate, an appropriate water production rate is calculated.





5 Injectors / Gaslift

To select *Injectors / Gaslift* simply press the Injectors / Gaslift tab located on the main application display, as shown below.

- 🔊 🖬 🖬 🕄 🕫	Profile [Field Test vers	ion2.ppd]			
Home					🕖 🍤 About
Profile Type Field Profile * Frequency Annual * Units Oilfield *	Report Font Tahoma • 9 • Style Blue •	Creen capture	 Schedule Analyse 	er AB ⁴ Exponents 📕 GOR 🧾 R 🔄 Well PI 😵 PVT 🏹 VLP/IPI	F
Profile Setup	Global Settings	Output		Other Tools	
	Field Details			Main Results	
Field Name / Description	Test for Field Oil Production			Buildup Production	14.6000
Hydrocarbon Type?	UII Month of First production Jan 20	10 (Plateau offtake rate	8.03%
	Field Area 20	km²	-	Year of final Plateau	2015
Field Schedule Associated Product	tion Injectors / Gaslift Facilities Constraints Tables / Charts			Production to end of Plateau	94.9550
	2			Prod'n to end of Plateau [%]	37.98%
Water Injection ?	as Injection ?			Decline duration [Years]	26.00

Then the following panel will be displayed.

Water Injection	Well Workovers
Voidage Replacement O Constant Rate	[Years]
Well Water Injection Rate [mbbls/d] 25	Production Wells 5
Voidage Replacement [%] 100	Water Injection Wells 10
Bo [rb/stb] 1.35 Bw [rb/stb] 1	Gas Injection Wells
Field Injection Rate [mbbls/d]	Gaslift Requirement [mmscf/d]
Gas Injection	Total Field Gaslift Requirement
Well Gas Injection Rate [mmscf/d]	or, Individual Well Requirement 2.5
Field Gas Injection (as % of Prod'n)	Fuel Gas and Flare
	Fuel Gas and Flare [mmscf/d]

Assuming the user wishes to model water injection then they should toggle on the *Water Injection* ? check box and the Water Injection group box should become active.

The user can choose to either model a constant field injection rate or model a voidage replacement ratio. Assuming Voidage Replacement is selected then the user should enter the desired voidage replacement percentage and the oil and water formation volume factors.

The Well Water Injection Rate [REQUIRED] is an individual well's water injection rate. The application

will calculate when to drill additional water injectors based on the field water injection profile.

Gas injection works in a similar fashion to water injection. Should the user wish to model gas injection then they should toggle on the *Gas Injection*? check box and the Gas Injection group box should become active.

The user can choose to either model a constant gas injection rate or model gas injection rate as a percentage of total production.

The Well Gas Injection Rate [REQUIRED] is an individual well's gas injection rate. The application will calculate when to drill additional gas injectors based on the field gas injection profile.

The ability to schedule Well Workovers is provided by simply entering their relative frequency in years, ie., a value of 5 years results in a well being workover every 5 years. The application keeps a tally of the cumulative wells drilled [production wells / water injection and gas injection wells] and their frequency of workovers and presents a workover schedule in the main field results table. Cumulative number of workovers, and Reserves per total production wells plus production well workovers are also presented in the Main Results Panel.

Both gaslift requirement and fuel gas and flare effect the required gas compression levels and ultimate gas sales profile.

The user can choose to either model the gaslift requirement as a constant field requirement or on an individual production well requirement.





6 Facilities Contraints

To select *Facilities Constraints* simply press the Facilities Constraints tab located on the main application display, as shown below.

) 💕 🖬 🐼)	Ŧ	Profile [Field Test version2	2.ppd]			- 0 X
	Home						🔞 📎 About
Profile Typ	e Field Profile	-	Report Font Tahoma	Screen capture	C Schedule	ar AB ⁴ Evolutionante 📕 GOB 🚟 BE	
Frequency	Annual	-		PDF Report			
Units	Oilfield	•	Result Boxes Colour V Global Qa/Qi ratio Decimals 2	Excel Report	A Analyse	Well PI 🎖 PVT 👷 VLP/IPR	
	Profile Setup		Global Settings	Output		Other Tools	
			Field Details			Main Results	
Fi	eld Name / Descri	ption	Test for Field Oil Production			Buildup Production	14.6000
	Hydrocarbon Ty	ype?	Oil Month of First production Jan 2010]▼	Plateau offtake rate	8.03%
			Field Area 20	km²		Year of final Plateau	2015
Field Sche	dule Associated I	Produc	ion Injectors / Gaslift Facilities Constraints Tables / Charts			Production to end of Plateau	94.9550
				C		Prod'n to end of Plateau [%]	37.98%

Then the following panel will be displayed.

Year [yyyy]	System Uptime [%]	Oil Separation [mstb/d]	Total Liquids [mstb/d]	Water Production [mstb/d]	Water Injection [mstb/d]	Gas Injection [mmscf/d]	Gas Compression [mmscf/d]
2005	90	75	75	75	75	50	50
	System Uptin	ne Oil Separa	— Quick Calcula ation Total Liqu	ite Facilities Con	straints ————————————————————————————————————	ection Gas Inie	ction Gas
	[%]	[mstb/c	l] [mstb/d] [mstb/	tion [mstb/	d] [mmsci	[/d] Compression [mmscf/d]

With a quick look facilities sizing tool located towards the bottom of the panel, as follows.

The intent with these calculation routines are to provide a simple tool to roughly size the facilities constraints.

Should the user enter numbers in the first set of input boxes above, then the application will check whether all the of capacity constraints are met by the various production and injection profiles, and a traffic light system displayed in the Main Results panel located towards the bottom right of the main

application panel, as shown below.



Green indicates that the specific facility constraint, for a given system uptime, is not exceeded by the production & injection profiles. Red indicates that the specific facility constraint has been exceeded.





7 Table / Charts

To select *Tables / Charts* simply press the Tables / Charts tab located on the main application display, as shown below.

		Ŧ	Profile [Field Test version2.ppd]								
Home @ S About											
Profile Type	Field Profile	-	Report Font Tahoma	O Scheduler AP Exponente - GOP - PE							
Frequency	Annual	-	PDF Report								
Units	Oilfield	*	Pesult Boxes Colour * 400 Global Qa/Qi ratio Decimals 2 C Keel Report	Analyse	Well PI 😵 PVT 🛕 VLP/IPI	3					
Pi	rofile Setup	Other Tools									
		Main Results									
Fiel	ld Name / Descrij	Buildup Production	14.6000								
	Hydrocarbon Ty	pe?		Plateau offtake rate	8.03%						
		Year of final Plateau	2015								
Field Sched	ule Associated F	Production to end of Plateau	94.9550								
Field Produc	tion Well Produ	Prod'n to end of Plateau [%]	37.98%								
		Desting denting Name1	00.00								

Then the following panel will be displayed.

Year	Producers	Injectors	Workovers	Average Oil Production [mstb/d]	Cumulative Oil [mmstb]	Average Gas Production [mmscf/d]	Cumulative Gas [bcf]	Av Water f [m:
2010	1	1WI		15.00	5.48	9.75	3.56	
2011	1	1WI		25.00	14.60	16.25	9.49	
2012	2	2WI		55.00	34.73	35.72	22.56	
2013	1			55.00	54.81	35.62	35.56	
2014				55.00	74.88	35.51	48.53	
2015			1P	55.00	94.96	35.54	61.50	
2016			1P	51.69	113.87	33.76	73.85	
2017			2P	46.06	130.69	30.88	85.12	
2018			1P	41.04	145.67	28.69	95.60	
2019				36.58	159.02	27.04	105.46	
2020			1P 1WI	32.60	170.95	25.75	114.89	
2021			1P 1WI	29.04	181.55	24.68	123.90	
2022			2P 2WI	25.88	191.00	23.71	132.55	
2023			1P	23.06	199.42	22.78	140.86	
2024				20.56	206.94	21.83	148.86	
2025			1P	18.32	213.62	20.84	156.46	
2026			1P	16.32	219.58	19.81	163.69	
2027			2P	14.54	224.89	18.73	170.53	
2028			1P	12.96	229.63	17.63	176.98	
2029				11.55	233.85	16.51	183.01	
2030			1P 1WI	10.29	237.61	15.39	188.63	
2031			1P 1WI	9.17	240.95	14.28	193.84	
2022			ווירי סר	017	242.05	10.00	100 07	

The field production and injection profiles are shown in the first tab *Field Production*. Individual well production profiles are shown in the following tab *Well Production* (see below), and the charts are shown in the third tab *Charts* (see below).

Field Production	Well Production	Charts						
Date	Average Field Rate [mstb/d]	Average Wells Rate [mstb/d]	Jan-2010 1 well(s)	Jan-2011 1 well(s)	Jan-2012 2 well(s)	Jun-2013 1 well(s)	Dec-2037 1 well(s)	ŕ
2010	15.00	15.00	15.00					
2011	25.00	29.62	15.00	14.62				
2012	55.00	57.22	14.10	14.62	28.50			
2013	55.00	62.84	12.56	13.74	28.50	8.04		
2014	EE 00	CO 04	11.10	10.05	20,70	10.70		



To select between charts, simply select the required chart via the drop down list box shown above.




8 Chart Operations

Chart tooltips

Chart tooltips are provided to allow the user to quickly analyse the displayed production for other calculated profiles. The tooltips will automatically be displayed by simply holding the mouse over the required series point or year.



Zooming / Unzooming

The ability to zoom with a chart is provided the allow the user to better analyse the data.

To zoom in simply hold down the left mouse button and drag the mouse over the required zoom area, as shown below.



The resultant zoomed in area should look like the following.



The user can select the scroll bar located at the bottom of the chart to quickly scroll along the production profile.

To unzoom simply select the small Reset Button located on the left of the scroll bar, as shown above.

Chart Context Menu

The context menu associated with the main chart display can be accessed by a single right mouse button click over the main chart, as shown below.



The user can choose to save a copy of any of the charts to the clipboard, or as a graphic file (either PNG, BMP or JPG format).



Production Profile Generation and Analysis



9 Main Results Panel

Once all the appropriate data has been entered to perform a calculation, and the user has pressed the large Calculate button located towards the bottom right of the application, the Main Results panel will be populated with results. See below.



If either the *Chart Properties* or *Tools* menu items are displayed in the navigation bar on the right, to return to the *Main Results* section simply press the *Main Results* navigation bar, as shown above.

The intent with displaying these results throughout the application is to help guide the user in designing the appropriate production and injection profiles, given the user's knowledge of analogue fields for well spacing, recovery/well, plateau offtake rates, decline rates, etc.



Production Profile Generation and Analysis



10 Change Chart Settings

The user can change individual series appearance by selecting the chart icon located at the bottom right-hand corner of the application, as shown below.

This will display the Chart Properties grid which allows the user to change any aspect of the chart appearance.

					, ο <mark>- Σ</mark>	٢
	🙆 🕥 About				🔞 🚫 Ab	out
er AB ¹ Exponents 🚮 GOR 🧾 RF		er AB ¹ Exp	onents 📕 GC	DR 🧾 RF		
🔙 Well PI 😵 PVT 🏭 VLP/IPR		🔙 Well F	PVT 🚦	VLP/IPR		
Other Tools		Othe	r Tools			
Main Results		Chart P	roperties			
	14 6000	▲ Series	Colour			
Buildup Production	14.0000	Oil Col	our	LimeGr	een 💌	
Plateau offtake rate	8.03%	Gas Co	Dour 145	255, 51 Dive	. 0	
Year of final Plateau	2015	Total	roduction Col	153 0	153	
	2010	Water	niection Colou	0 204	255	
Production to end of Plateau	94.9550	Gas In	ection Colour	255, 20	4, 204	
Prod'n to end of Plateau [%]	37.98%	Gas Co	ompression Co	255, 15	3, 51	
		Gas Sa	ales Colour	Yellow		
Decline duration [Years]	26.00	▲ Series	Appearance			
Total Field Life [Years]	32.00	Gradie	nt Style	TopBottom		
		Gradie	nt End Colour	WhiteS	moke	
Total Production [mmstb]	259.7202	Series	Border Colour	Black		
Abandonment rate [mstb/d]	2,7465	Series	Shadow Depth	8		
		Show 1	2 Cumulative	I rue		
Acres/Production well	000.000	- Series	Cabler Format:	S True		_
Acres/11000ction/weil	823.68	D Label F	ont	Microsoft Sa	ns Serif 8	
No. of Production Wells	6	Series	Font Colour	Yellow		
No. of Injection Wells	4.14/1	Label F	Position	Bottom		
	4 \VI	Label A	Angle	-90		
Reserves/Production well	43.2867	Decima	al Places	0		
No. of Workovers	270 1004/		je Legend			
	27P 10001	Legend	Font	Microsoft Sa	ins Serif, 8	
Reserves/(Prod's+WO's)	7.8703	Туре		Table		
		Positio	n	Тор		
Facilities Constraints Ch	iecks	Alignm	ent	Center		
		4 Chapp	ent Avie Format	Outside		
Oil Separation Water	Injection	D Axis Fo	ont	Microsoft Sa	ns Serif 9	
Total Liquida	ningtion	Decima	al Places	1		
rutai triguitus	njection	Axis La	abel Colour	102, 0,	51	
Water Production Gas Co	mpression	X Axis	Colour	Black		
		X Avie	Style 🔍	Solid 🚽		-
	1	Oil Colou Select col	r lour for the Oil	Production Se	eries	
Main Results		Main	Results			
	Sh					14
	2	۰ <u>۱</u>				
)				



Production Profile Generation and Analysis



11 Create Reports

Profile Reports can either be created in Adobe Acrobat format ("PDF") or Microsoft Excel format ("XLS").

To access the Create Report option, select the Create Report menu item located under the Main File menu item, as shown below.

) 💕 🖬 🐼) =	Profile [Field Test versi	ion2.ppd]	
	Home			🔞 😒 About
Profile Typ	e Field Profile	Report Font Tahoma + 9 + Style Blue +	Screen capture	Scheduler AB ⁴ Exponents 4 GOR 📓 RF
Frequency	Annual		PDF Report	
Units	Oilfield	Result Boxes Colour	Kcel Report	
	Profile Setup	Global Settings	Output	Other Tools
		Field Details	Create Adobe PDF F	Report Chart Properties

Assuming the Create Abode PDF Report is selected the user will be prompted for a report PDF filename, and a file similar to the following should be created.



Assuming the Create Microsoft Excel Report is selected the user will be prompted for a report XLS filename, and a file similar to the following should be created.

	А	В	С	D	Е	F	G	Н		J	K	F
1		1										f
2												í.
3			Field Name / Description	Test for Field Oil Prod	uctio	n						
4												
5			Hydrocarbon Type :	Oil								
6			Field Area [km ²]	20								
7												
8			Field Input			Buildup	to Plateau [in Mstb/d]		Main Results			í.
9												
10			Recoverable Oil [mmstb] :	250		Year 2010	15		Buildup Production :	14.6000		
11			Month of First production :	Jan-2010		Year 2011	25		Plateau offtake rate :	8.03%		
12			Plateau duration [years] :	4		Year 2012	55		Year of final Plateau :	2015		í.
13			Swing Factor :	1.0					Production to end of Plateau :	94.9550		
14			Decline Type :	Exponential					Prod'n to end of Plateau [%] :	37.98%		
15			Decline Rate [fraction] :	0.11527					Decline duration [Years] :	26.00		í.
16			'n' Factor :						Total Field Life [Years] :	32.00		
17			Abandonment, Qa/Qi :	0.05					Total Production [mmstb] :	259.7202		
18									Abandonment rate [mstb/d] :	2.7465		L
19			Well Input Details						Acres/Production well :	823.68		
20									No. of Production Wells :	6		
21			Use field decline rate ? :	Yes					No. of Injection Wells :	4 WI		L
22			First Year Well Qi [mstb/d] :	15					Reserves/Production well :	43.2867		
23			Final Year Well Qi [mstb/d] :	3					No. of Workovers :	27P 10WI		
24			Abandonment, Qa/Qi :	0.05					Reserves/(Prod's+WO's) :	7.8703		i
25												Ĺ
26												
27												
28						,						1

	A	В	C	D	E	F	G	Н		J	K	L
1												
2												
3	Product	ion 8	Injection Profiles									
4												
							Average Oil		Average Gas		Average Water	
							Production	Cumulative Oil	Production	Cumulative Gas	Production	Cumulative
5			Year	Producers	Injectors	Workovers	[mstb/d]	[mmstb]	[mmscf/d]	[bcf]	[mstb/d]	Water [mmstb]
6			2010	1	1WI		15	5.48	9.75	3.56	0.02	0.01
7			2011	1	1WI		25	14.6	16.25	9.49	0.11	0.05
8			2012	2	2WI		55	34.73	35.72	22.56	0.91	0.38
9			2013	1			55	54.81	35.62	35.56	2.38	1.25
10			2014	0			55	74.88	35.51	48.53	4.65	2.95
11			2015	0		1P	55	94.96	35.54	61.5	8.01	5.87
12			2016	0		1P	51.69	113.87	33.76	73.85	11.91	10.23
13			2017	0		2P	46.06	130.69	30.88	85.12	15.69	15.96
14			2018	0		1P	41.04	145.67	28.69	95.6	19.57	23.1
15			2019	0			36.58	159.02	27.04	105.46	23.51	31.68
16			2020	0		1P 1WI	32.6	170.95	25.75	114.89	27.47	41.74
17			2021	0		1P 1WI	29.04	181.55	24.68	123.9	31.38	53.19
18			2022	0		2P 2WI	25.88	191	23.71	132.55	35.17	66.03
19			2023	0		1P	23.06	199.42	22.78	140.86	38.86	80.21
20			2024	0			20.56	206.94	21.83	148.86	42.37	95.72
21			2025	0		1P	18.32	213.62	20.84	156.46	45.72	112.41
22			2026	0		1P	16.32	219.58	19.81	163.69	48.72	130.19
23			2027	0		2P	14.54	224.89	18.73	170.53	51.54	149
24			2028	0		1P	12.96	229.63	17.63	176.98	54.1	168.8
25			2029	0			11.55	233.85	16.51	183.01	56.03	189.26
26			2030	0		1P 1WI	10.29	237.61	15.39	188.63	57.85	210.37
14		As	sociated Production	Workovers-Ir	niectors-Gaslift	Facilities Contraint	s Results and	Profiles 4				► I



48	Profile	Help
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Production Profile Generation and Analysis



12 Tools Menu Items

Numerous tools are provided to aid the user with production profile generation.

To access these tools, simply select any of Tools in the **Other Tools** menu bar, as shown below.

		12	Ŧ	Profile		
	Ho	me				@ 😒 About
Profile	Туре	Field Profile	•	Report Font Tahoma • 9 • Style Blue •	🖵 Screen capture	Scheduler AB ⁴ Exponents 4 GOR BE
Frequ	ency	Annual	-		PDF Report	
Units		Oilfield	*	Result Boxes Colour V Store Global Qa/Qi ratio Decimals 2	📧 Excel Report	Analyse 🔚 Well PI 🌑 PVT 🕺 VLP/IPR
	Pr	ofile Setup		Global Settings	Output	Other Tools

12.1 Well Scheduler

This tool is provided to allow the user to quickly schedule the first production dates for a series of production wells given a knowledge of their drilling and completion durations and improvement performance.

) 💕 🖌 🐼) =	Profile [Well Test - ver	sion2.ppd]							
	Home				@ 😡 Abo						
Profile 1	vpe Well Profile	-	Report Font Tahoma Y 9 Y Style Blue Y	🖵 Screen capture	GOR BE						
Frequer	cy Annual	-		A-PDF Report							
Units	Oilfield	*	Result Boxes Colour V Stor Global Qa/Qi ratio Decimals 2	🔀 Excel Report	N Analyse Well PI S PVT 🔋 VLP/IPR						
	Profile Setup Global Settings Output Other Tools										
	Field Details Well Scheduler ain Results										

Once the tool is selected, the following input form should be displayed. Once the user enters data for the required number of wells and the drilling and/or completion performance (first well & last well duration and selects a performance), the performance chart will be displayed.





The user can select to save the chart to a file or the clipboard by selecting the context menu [single right mouse click] on either chart or calculation table, as shown below.

Well Scheduler Required Number of We Drilling Performance	lls 20 mpletion Performance (Results	
Input Completion Per First Well, days Final Well, days	formance 30 Performance 10	Average
35 30 5 25 15 10 10 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0	how Chart Series Labels Save Drilling Chart Save Completion Chart Copy Drilling Chart Copy Completion Chart Copy Table Data to Clipboard Vell Number	
		Calculate Well Schedule

Once the user is happy with the drilling and completion performance then they should press the Calculate button in the toolbar, as shown below, to calculate the well schedule.

Required Number of Wells 20 Drilling Performance Completion Performance Results
Input Completion Performance First Well, days 30 Final Well, days 10
$\begin{bmatrix} 35 \\ 30 \\ 25 \\ 20 \\ 10 \\ 5 \\ 0 \\ 0 \\ 5 \\ 0 \\ 0 \\ 5 \\ 0 \\ 0 \\ $
Calculate Well Schedule

Then the following results should be displayed in the third tab *Results*.

Date Online 1-Jan-2005 10-May-2005 2-Sep-2005
1-Jan-2005 10-May-2005 2-Sep-2005
10-May-2005 2-Sep-2005
2-Sep-2005
10.0 0005
18-Dec-2005
29-Mar-2006
5-Jul-2006
8-0 ct-2006
9-Jan-2007
11-Apr-2007
12-Jul-2007
11-0ct-2007
10-Jan-2008
9-Apr-2008
9-Jul-2008
7-0ct-2008
5-Jan-2009
5-Apr-2009

To transfer the results back to the Well Schedule / Input Well Schedule section of the main application select the OK button, otherwise select the Cancel button to return to the main application without the results of the Well Scheduler calculation.

12.2 Analyse Actual Profile

The following tool is provided to allow the user to quickly analyse the buildup, plateau and decline characteristics of a known well or field.

	F 🔝 🖬 📬	Profile [Well Test - ver	rersion2.ppd]
Н	ome		@ 😒 Abou
Profile Type	Well Profile -	Report Font Tahoma v 9 v Style Blue v	Screen capture
Frequency	Annual -	ab 2 Decembra College at 100 Clobel Op (0) ettal	A PDF Report
Units	Oilfield •	Result Boxes Colour + A,0 Global Qa/Qi ratio Decimais 2	
Pr	rofile Setup	Global Settings	Output Other Tools
		Field Details	Analyse Actual Profile Results

Once the tool is selected, the following input form should be displayed.

💼 Analyse Actua	al Profile							
🗁 🛃 🗎 🚍	Oil	✓ Oilfield	-	Calendar Mon	:hly -]		
Input Data Calcu	lated Data Charts	5						
Month	Producing Days	0il Volume	Gas Volume	Water Volume				▲ □
					-			
					-			
					-			
					-			
					-			
								-
STO	DOIP [mmstb]		Recoverab	le Oil [mmstb]				Import CSV
							Calculate	Cancel

The User can import a comma delimited ASCII production history file, via the *Import CSV* button. An example is shown below of the required input format, in both a text editor or Microsoft Excel format.

The intent with the production history file is to have the input data frequency as MONTHLY. The user can choose to calculate and display the history data as either Monthly, semi-annually or annually later after successfully pressing the *Calculate* button.

Month, Producing Days, Oil volume (bbl), Gas Volume (MMCF), Water volume (bbl)	
Sep-1975,30,236735.8688,85.24961338,0	
Oct-1975,31,1104081.798,388.779202,0	
Nov-1975,30,1480055.191,496.2064282,0	
Dec-1975,31,1883502.474,637.1119615,0	
Jan-1976,31,2272835.423,776.7814813,0	
Feb-1976,29,2260218.064,756.4402314,0	
Mar-1976,31,2608107.455,897.5929674,0	
Apr-1976,30,3123054.2,1081.723657,0	
May-1976,31,3881510.939,1266.172178,0	
Jun-1976,30,4992436.051,1618.400697,0	
Jul-1976,31,4263170.32,1373.528775,29021.18334	
Aug-1976,31,6014523.886,1957.774675,21781.61203	
Sep-1976,30,6432425.152,2067.567984,12472.69323	
Oct-1976,31,9079170.91,2931.082295,9126.51431	
Nov-1976,30,8656608.895,2790.141447,6057.08703	
Dec-1976,31,10540991.94,3398.012862,5195.38306	
Jan-1977,31,10851928.7,3496.187645,4654.4594	
Feb-1977,28,10610054.06,3396.423702,4126.11536	
Mar-1977,31,12511935.35,3998.503511,4685.90845	
Apr-1977,30,10656674.13,3370.961825,2616.56096	
May-1977,31,13402572.45,4264.317032,3195.22348	
Jun-1977,30,13182642.95,4137.396108,21391.64381	
Tml_1977 31 12019348 88 3771 18298 40386 87001	

	А	В	С	D	E	F	G
1	Month	Producing Days	Oil Volume [bbls]	Gas Volume [Mcf]	Water Volume [bbls]		
2	Sep-75	30	236735.90	85249.60	0.00		Ľ
3	Oct-75	31	1104081.90	388779.20	0.00		
4	Nov-75	30	1480055.30	496206.40	0.00		
5	Dec-75	31	1883502.60	637111.90	0.00		
6	Jan-76	31	2272835.60	776781.40	0.00		
7	Feb-76	29	2260218.20	756440.20	0.00		
8	Mar-76	31	2608107.60	897592.90	0.00		
9	Apr-76	30	3123054.40	1081723.60	0.00		
10	May-76	31	3881511.20	1266172.10	0.00		
11	Jun-76	30	4992436.40	1618400.50	0.00		
12	Jul-76	31	4263170.60	1373528.60	29021.20		
13	Aug-76	31	6014524.30	1957774.50	21781.60		
14	Sep-76	30	6432425.60	2067567.80	12472.70		
15	Oct-76	31	9079171.50	2931082.00	9126.50		
16	Nov-76	30	8656609.50	2790141.20	6057.10		
17	Dec-76	31	10540992.60	3398012.50	5195.40		
18	Jan-77	31	10851929.40	3496187.30	4654.50		
19	Feb-77	28	10610054.80	3396423.40	4126.10		
20	Mar-77	31	12511936.20	3998503.10	4685.90		
21	Apr-77	30	10656674.80	3370961.50	2616.60		
22	May-77	31	13402573.30	4264316.60	3195.20		
23	Jun-77	30	13182643.80	4137395.70	21391.60		
24		ortios 🕅	100100/0 70	2771102 60			

Once a ASCII CSV file has been successfully imported, the User should input approximate values for Originally-In-Place and Ultimate Recovery volumes. These numbers are used to calculate the production offtake rates and for the Watercut Vs Oil Recovery plot, see picture below.

💼 Analyse Actua	I Profile				
🗁 🔒 🗎 🖵	Oil	👻 Oilfield	-	Calendar Month	thly -
Input Data Calcul	lated Data Charts				
Month	Producing Days	0il Volume	Gas Volume	Water Volume	
Sep-1975	30.00	236735.90	85249.60	0.00	
Oct-1975	31.00	1104081.90	388779.20	0.00	1
Nov-1975	30.00	1480055.30	496206.40	0.00)
Dec-1975	31.00	1883502.60	637111.90	0.00)
Jan-1976	31.00	2272835.60	776781.40	0.00	3
Feb-1976	29.00	2260218.20	756440.20	0.00	1
Mar-1976	31.00	2608107.60	897592.90	0.00)
Apr-1976	30.00	3123054.40	1081723.60	0.00)
May-1976	31.00	3881511.20	1266172.10	0.00)
Jun-1976	30.00	4992436.40	1618400.50	0.00)
Jul-1976	31.00	4263170.60	1373528.60	29021.20)
Aug-1976	31.00	6014524.30	1957774.50	21781.60)
Sep-1976	30.00	6432425.60	2067567.80	12472.70	1
Oct-1976	31.00	9079171.50	2931082.00	9126.50	1
Nov-1976	30.00	8656609.50	2790141.20	6057.10)
Dec-1976	31.00	10540992.60	3398012.50	5195.40)
Jan-1977	31.00	10851929.40	3496187.30	4654.50)
Feb-1977	28.00	10610054.80	3396423.40	4126.10	1
Mar-1977	31.00	12511936.20	3998503.10	4685.90	1
Apr-1977	30.00	10656674.80	3370961.50	2616.60)
May-1977	31.00	13402573.30	4264316.60	3195.20)
Jun-1977	30.00	13182643.80	4137395.70	21391.60	-
STC	OOIP [mmstb] 42	00	Recoverabl	e Oil [mmstb] 2	2700 Import CSV
					Calculate Cancel

The User should then press the *Calculate* button located at towards the bottom right of the input panel, then *Calculated Data* and *Charts* Panels should become populated with data.

As with all tables within the application, the user has the ability to copy both tables to the clipboard via the standard windows shortcut key, CTRL+C.

Within the Charts panel, the user can select between chart frequency by selecting the *Calculation Frequency* dropdown menu item, as shown below.

Normalised Semi-Annual and Normalised Annual options are provided to normalise the production profile relative to the start date, ie., A normalised Semi-Annual profile beginning in Sep-1975 will have reporting periods of September and March of each year (6 monthly intervals) and a normalised Annual profile beginning in Sep-1975 will have reporting periods of September of each year (12 monthly intervals). The purpose for adding these two options are to more accurately calculate the offtake rate and cumulative offtake for the plateau and end of plateau periods.



The User has the ability to quickly scan the profile for whatever Frequency period and tooltips are provided to quickly analyse the various production rates, ratios and offtake percentages, see below.



In particular the offtake rate and cumulative offtake figures can be used when designing the required production profile back in the main application.



The User can also change the Y Axis Type between Linear and Logarithmic, via the context menu associated with the chart. The context menu is accessed via a single right mouse click while the mouse is located over the chart. See picture above.

Provision is also made to do decline curve analysis. Should the User want to calculate the decline exponents for either Exponential, Harmonic or Hyperbolic declines, select the *Select Points* context menu item, as shown above, to toggle on the points selection. The user should then select points on the chart to conduct the regression analysis. Once the User is happy with the selection of points, access the context menu again by a single right mouse button click while the mouse is located over the axis areas (not in the display chart area - as this may continue to add regression points), then select the *End Selection* menu item. See picture below.



The following task pane will then be populated with decline exponents, see below. The user can toggle between decline types and whether or not to fix the initial selected rate in the regression analysis. The user should manually iterate between these options until the RMS error is minimised.

Decline Fit Water Pro	duction	Decline Fit Water Pro	duction
Exponential Harmonic Hyperbolic Fix Selected (Qi ?	 Exponential Harmonic Hyperbolic Fix Selected (2i ?
	0.000321		0.000321
n	0.000000	n	0.000000
☑ Include on Ch Qa	nart ? 13933.56	☑ Include on Cf Qa	nart ? 13933.56
Pre	dict	Pre	dict 💦
Npa		Npa	2764.14
Ta		Та	20-Sep-2014

Should the User wish to extrapolate an ultimate recovery and abandonment date, simply enter an abandonment rate in the above text box "Qa" and press the *Predict* button.

The user can also manually regress a watercut vs oil recovery relationship, by selecting the "Watercut vs Oil Recovery" chart and expanding the *Water Production* navigation bar category.



Once the user has entered approximate numbers for *Recovery Factor* and *Abandonment Watercut (fw)*, the User can iterate the Early and Late curvature values, as shown below, until a satisfactory fit is achieved.



For completeness, the ultimate recovery and abandonment date equations are included below.

Where,

- qa = Abandonment production rate
- qi = Initial production rate
- a = Constant decline rate fraction, between 0 and 1
- n = additional constant decline exponent, between 0 and 1
- Npa = Cumulative Production between qi and qa
- Ta = Time (in days) between qi and qa

Exponential Decline
$$N_{pa} = \frac{1}{a} \times (q_i - q_a)$$
 $T_a = \frac{ln\left(\frac{q_a}{q_i}\right)}{-a}$

Harmonic Decline
$$N_{pa} = \frac{q_i}{a} \times \ln\left(\frac{q_i}{q_a}\right)$$
 $T_a = \frac{\left(\frac{q_a}{q_i} - 1\right)}{a}$



12.3 Backcalculate Decline Exponents

The following tool is provided to allow the user to quickly calculate the decline curve exponents having minimal knowledge of the production history.

	- 🔝 🖬 📬	Profi	e	
	Home			🔞 🗞 About
Profile Frequ	e Type Well Profile vency Annual v	Report Font Tahoma • 9 • Style Blue	Creen capture	Scheduler AB ⁴ Exponents d GOR GR RF Krankver Well PL PVT VI P/IPR
Units	Oilfield	Global Settings	Excel Report Output	Other Tools
		Field Details		Backcalculate Decline Exponents

Once the tool is selected, the following input form should be displayed.

Input Production Data		Decline Type = Hyperbolic	-
Exponential Decline		The number of roots are : 3	
Harmonic Decline			
Ø Hyperbolic Decline		Root: 1 Decline Constant [a] : 0.000662/day Decline Constant [a] : 0.24163/year	
Initial Production Rate [Mstb/d]	65.48	Decline Constant [n] : 0.000000	Ε
Final Production Rate [Mstb/d]	6.38	Root: 2 Decline Constant [a]: 0.001094/day	
Cumulative Production [MMstb]	75.10847	Decline Constant [a] : 0.39931/year Decline Constant [a] : 0.400661	
Time [days]	3517	Boot : 3	
		Decline Constant [a] : 0.002634/day Decline Constant [a] : 0.96141/year Decline Constant [n] : 1.000000	-

Both the exponential and harmonic decline curve equations are special cases of the hyperbolic decline curve equation. The exponential equation has a value of 'n'=0, and harmonic equation has a value of 'n'=1, in the hyperbolic decline curve equation.

For both the exponential and harmonic decline curves, the exponent 'a' can be solved by re-arranging their decline curve equations to the following :

Exponential Equation

Harmonic Equation

$$a = \frac{\ln\left(\frac{q_i}{q}\right)}{t} \qquad \qquad a = \frac{\left(\frac{q_i}{q} - 1\right)}{t}$$

From the above equations, the user should note that only a knowledge of the initial production rate, final production rate and time interval are required to calculate the decline exponent 'a'.

The solution of the hyperbolic parameters are based on the technique described in the following Society of Petroleum Engineers paper, where an additional parameter Cumulative production, Np, is required.

"A Numerical Solution to Two-Parameter Representation of Production Decline Curve Analysis", SPE16505, B. Agbi and M Ng, 1987

The solution of the hyperbolic decline curve equation for values of 'a' and 'n' displays all roots of the equation, including values of 'a' at n=0 (exponential decline) and n=1 (harmonic decline).

12.4 Well PI Calculations

The following tool is provided to allow the user to quickly, but approximately, estimate the well productivity index (PI) of a vertical or horizontal oil well.

		F 🔊 🖬 🛃		Profile		x
	Ho	ome			@ \$	About
F	rofile Type	Well Profile -	Report Foot Taboma	- Screen capture		
F	requency	Annual 🔹		PDF Report		
ι	Inits	Oilfield -	Pecimals 2	Excel Report	Analyse 🚾 WelkPt 😵 PVT 🏹 VLP/IPR	
	Pn	ofile Setup	Global Settings	Output	Other Tools	
			Field Details		Well PI Calculations	

Once the tool is selected, the following input form should be displayed.

III Well PI Calculations					×
🗁 🛃 🗎 🖵 🔟	≫ Convert				
Vertical Oil Well Horizo	ntal Oil Well				
Permeability, mD	50		Thickness, ft	50	
Oil FVF Bo, rb/stb	1.35		Area	320	Acres 🔽
Oil Viscosity, cP	0.6		Skin factor		
			Well Radius, ft	0.365	
Dietz Shape Factor					
			•		
Dietz Shape Factor	Θ	-0			4.5132
				PI, stb/d/psi	2.6247
					Close

The user can easily change the Dietz shape factor contained within the semi/pseudo steady- state vertical PI equation, by using the track bar located in the Dietz Shape Factor group box. A graphical image of individual shapes and their respective shape factor values are displayed simultaneously as the user slides the track bar.

Once the user has input all the necessary input, select the Calculate button to calculate the vertical semi/pseudo steady state PI.

Horizontal and slanted oil well PI can be calculated in the second tab Horizontal Oil Well.

Method	Pseudo Stead	y State [1996] - Economides	
kx, mD	50	Well Radius, ft	0.365
ky, mD	50	Well X Midpoint [xo], ft	
kz, mD	50	Well Y Midpoint [yo], ft	
Oil FVF Bo, rb/stb	1.35	Well Length [L], ft	2000
Oil Viscosity, cP	0.6	Well Height above Base [zw], ft	25
Major Length [xe], ft	3733	Well Inclination, degrees	75
Minor Length [ye], ft	3733		
Thickness, ft	50	Show Well Schematic	
ikin Factor			
Calculate Skin ()) Input Skin	PI, stb/d/psi	19.6179
k (skin), mD			
Skin factor	0.0000		Calculate

The user can select from numerous published techniques, listed below :

Pseudo Steady State [1996] - Economides
Pseudo Steady State [1996] - Economides
Pseudo Steady State [1990] - Kuchuk & Goode
Pseudo Steady State [1989] - Babu & Odeh
Pseudo Steady State [1988] - Joshi
Steady State [1991] - Economides
Steady State [1990] - Renard & Dupuy
Steady State [1988] - Joshi
Steady State [1984] - Giger
Steady State [1984] - Borisov
Slant Well [1975] - Cinco-Ley, Ramey, Miller

A well schematic is included within the application (and accessed by selecting the Show Well Schematic button) to clarify the various nomenclature requested. The schematic is shown for completeness below.



Another tool is provided to allow the user to quickly convert between area, equivalent radius and length, to better permit comparison with vertical and horizontal PI solutions. To convert between area, radius and length simply type a number into one of the text boxes and then leave the text box (select tab or mouse click to go to another text box).

💼 c	🚻 Convert Between Area, Radius and Length								
	Area	50	Acres						
	Equivalent Radius	832.633732266€	ft 🔹						
	Equivalent Length	1475.804865145	ft 🔹						
			OK						

The user can generate a Microsoft Excel report by selecting Excel icon in the toolbar located towards the top of the dialog form. The user will be prompted for an Excel filename, and a file similar to one the following should be created.

	А	В	С	D	E	F	G	Н		5
1										Π
2										
3			Vertical Oil Well PI Calculations							
4										
5			Permeability, mD	50						
6			Thickness, ft	50						
1			Area	320	Acres					
8			Skin factor	0.005						
9			Well Radius, ft	0.365						
10			Oil FVF Bo, rb/stb	1.35						
11			Oil Viscosity, cP	0.6						
12			Dietz Shape Factor	4.5132						
13										
14			PI, stb/d/psi	2.6247						
15										
16			Horizontal Oil Well Calculations							
17										
18			Method	Pseudo S	Steady St	ate [1996]	 Econon 	nides		≡
19			kx, mD	50						
20			ky, mD	50						
21			kz, mD	50						
22			Oil FVF Bo, rb/stb	1.35						
23			Oil Viscosity, cP	0.6						
24			Major Length [xe], ft	3733						
25			Minor Length [ye], ft	3733						
26			Thickness, ft	50						
27			Well Radius, ft	0.365						
28			Well X Midpoint [xo], ft							
29			Well Y Midpoint [yo], ft							
30			Well Length [L], ft	2000						
31			Well Height above Base [zw], ft	25						
32			Well Inclination, degrees							
33			k (skin), mD							
34			Skin factor	0.0000						1
35									-	
36			Pl, stb/d/psi	19.6179						
37										
38										Y
14 4	► H W	ell PI Ca	lculations	Ī	4					

12.5 Calculate Depletion GOR Profile

The material balance depletion method tool is provided for oilfields to calculate the primary depletion gas production, and is entirely based on the technique outlined by Laurie Dake in "The Practice of Reservoir Engineering", published by Elsevier. [Chapter 3.7 - Volumetric Depletion Fields].

Calculate Depletion	GOR Profile				
nput Data Setup Calc	ulations				
Reservoir Pi [psi]	4500	Cw, [1/psi]	3.3E-06	Swc, fraction	0.25
Reservoir T [deg F]	175	Cf, [1/psi]	3E-06	Sor, fraction	0.25
		krg', fraction	0.25	Sgc, fraction	0.03
PVT Input (PVT Charts					
API Gravity	35				
Gas Gravity	0.65	Gas Ci (Mole	Percent)		
Separator Pi [psi]		N2			
Separator T [deg F]	CO2			
GOR at Pb [scf/stb] 650	H2S		Calculated	d Values
Pb Correlation	McCain [D	atabank 1991]	•	2938.13	
Bo Correlation	McCain [D	atabank 1991]	•	Boi = 1.3016E	3ob = 1.3344
Oil Viscosity	McCain [D	McCain [Databank 1991]		0.6775	
				[Calculate
			- Und	dersaturated Recov 3.2378%	very Factor Calculate
			(OK	Cancel

The tool has two main sections accessed from the toolbar; Input Data Setup and Calculations.

Input Data Setup Panel

Within the *Input Data Setup* tab (shown above), the user is asked to input the initial reservoir pressure, reservoir temperature, water and formation compressibility, endpoint gas relative permeability, initial water, residual oil and critical gas saturation values.

The user is also asked to input Fluid PVT values of API gravity, gas gravity, GOR at bubblepoint pressure and any CO2 and H2S content in the gas composition.

Once the PVT data has been input the user can press the *Calculate* button in the PVT Input tab and values for bubblepoint pressure (Pb), oil formation volume factor (Bo) and oil viscosity, will be displayed for the selected correlation.

To view the calculated values of Oil GOR, Bo and viscosity versus pressure and Gas Bg, Viscosity and Z Factor versus pressure select the PVT Charts tab, as shown below.



Once the user is happy with the input data and PVT calculations, to calculate the Undersaturated recovery factor simply press the Calculate button in the Undersaturated Recovery Factor Group box, located at the bottom of the *Input Data Setup* Panel.

Calculations Panel

Once the user presses the *Calculations* tab, the following panel is displayed.

d	Calculate Depl	etion GOR Profile					×
5	0						
(Ir	put Data Setup	Calculations					
		Import Field Profile	and Coloulate	Compare to Simp	la Mathad		
	on calculaton		e al lu Calculate	Compare to Simp			
	alculation Resul	Chart Pressure	and GOR				
Ш,		13					
	Pressure 🖌	Rs	Bo	0il Viscosity	Bg	Gas Viscosity	Â
	2938.13	650.00	1.3344	0.5770	0.00536	0.01991	
	2929.37	647.69	1.3333	0.5782	0.00538	0.01988	
	2920.61	645.37	1.3322	0.5794	0.00539	0.01984	=
	2911.84	643.06	1.3311	0.5806	0.00541	0.01981	
	2903.08	640.75	1.3300	0.5819	0.00542	0.01978	
	2894.32	638.44	1.3289	0.5831	0.00544	0.01975	
	2885.56	636.13	1.3278	0.5843	0.00545	0.01972	
	2876.79	633.83	1.3267	0.5855	0.00547	0.01969	
	2868.03	631.52	1.3256	0.5868	0.00548	0.01966	
	2859.27	629.22	1.3245	0.5880	0.00550	0.01963	
	2850.51	626.92	1.3234	0.5893	0.00551	0.01960	
	2841.74	624.61	1.3223	0.5905	0.00553	0.01957	
	2832.98	622.32	1.3212	0.5918	0.00555	0.01954	
	2824.22	620.02	1.3201	0.5930	0.00556	0.01951	
	2815.46	617.72	1.3190	0.5943	0.00558	0.01947	
	2806.69	615.43	1.3179	0.5956	0.00560	0.01944	
	2797.93	613.13	1.3169	0.5969	0.00561	0.01941	
	2789.17	610.84	1.3158	0.5982	0.00563	0.01938	Ψ.
	•						F.
			Abandonm	nent Pressure (psi)	2500	Calcula	ate
					ОК	Cance	

Once the user enters a valid abandonment pressure and presses the Calculate button, the Muskat technique (as outlined by Dake) for calculating depletion below the bubblepoint is performed.

A chart showing the pressure and GOR behaviour is shown in the Chart Pressure and GOR tab, and an

example is shown below.



Once the user is happy with the pressure and GOR behaviour, they can proceed by pressing the *Import Field Profile and Calculate* button located towards the top of the *Calculations* panel, and the following will be displayed.

out Data Setup	alculations				
DR Calculation	nport Field Prof	ile and Calculate	Compare to Simple	Method	
alculate Field De	pletion Profile	Calculate Field Depl	etion Profile		
Year ⊿	Oil Rate	Cumulative Oil	Np/N	GOR	Gas Rate
01/01/2010	15.00	0.5	0.0004	650.00	9.75
01/02/2010	15.00	0.9	0.0007	650.00	9.75
01/03/2010	15.00	1.4	0.0011	650.00	9.75
01/04/2010	15.00	1.8	0.0014	650.00	9.75
01/05/2010	15.00	2.3	0.0018	650.00	9.75
01/06/2010	15.00	2.7	0.0022	650.00	9.75
01/07/2010	15.00	3.2	0.0026	650.00	9.75
01/08/2010	15.00	3.6	0.0029	650.00	9.75
01/09/2010	15.00	4.1	0.0033	650.00	9.75
01/10/2010	15.00	4.6	0.0037	650.00	9.75
01/11/2010	15.00	5.0	0.0040	650.00	9.75
01/12/2010	15.00	5.5	0.0044	650.00	9.75
01/01/2011	25.00	6.3	0.0050	650.00	16.25
01/02/2011	25.00	7.0	0.0056	650.00	16.25
01/03/2011	25.00	7.7	0.0062	650.00	16.25
01/04/2011	25.00	8.5	0.0068	650.00	16.25
01/05/2011	25.00	9.3	0.0074	650.00	16.25
01/06/2011	25.00	10.0	0.0080	650.00	16.25
•		III			•

The user should press the *Import Field Profile and Calculate* button to import the primary oil production profile and calculate the gas profile based on the Muskat calculated GOR profile.

Calculate Field Depletion Profile Calculate Field Depletion Profile

The Gas production rate and GOR profile can be viewed by selecting the Chart Pressure and GOR tab, as shown below.

To compare the Material Balance calculated profile with the Simple Method Profile, select the *Compare* to Simple Method button, located towards the top of the *Calculations* panel.

The following will be displayed.



All numbers are fixed in this panel with the exception of the *Curve Type*. The user can toggle the value of Curve Type [between 1 and 10] by selecting the up and down arrows in the Curve Type value box.

To view the Gas Production profile comparison simply select the Gas Production √s Time tab, as shown below.


To transfer the calculated material balance values back into the main application's Associated Production Use Simple Method technique, the user should press the *OK* button. To return to the main application without transferring any values, the User should press the *Cancel* button.

12.6 PVT Calculations

The following tool is provided to allow the user to quickly calculate values for Gas, oil and water fluid properties.

		🞽 🖬 🐼)	Ŧ	Pr	ofile		
	Н	me					🛞 😒 About
F	rofile Type	Field Profile	-	Report Font Tahoma • 9 • Style Blue	•	🖵 Screen capture	Scheduler AB ⁴ Exponents d GOR RF
F	requency	Annual	*			PDF Report	
ι	nits	Oilfield	*	Result Boxes Colour * 5.6 Global Qa/Qi ratio Decimals 2	•	📧 Excel Report	
	Pr	ofile Setup		Global Settings		Output	Other Tools
				Field Details			Main Re PVT Calculations

Once the tool is selected, the following input form should be displayed.

Composition (10)	in ads and	anda.	Input Pressure and Temperature	
		Composition (Mole Percent)	Pressure	psi 💌
Methane	C1		Temperature	deg. F
Ethane	C2			
Propane	C3		Calculations	
Butane	C4		Pseudo Reduced P	
lso Butane	iC4		Paguda Paduaad T	
Pentane	C5		Fseudo Neduceu T	
Iso Pentane	iC5		Z Factor	
Hexane	C6		Expansion Factor [scf/rcf]	
Heptanes +	C7+		Gas FVF [rcf/scf]	
Nitrogen	N2		Gas Gravity	
Carbon Dioxide	CO2		Gas Viscosity [cP]	
Hydrogen Sulphide	H2S		Gas Compressibility [1/psi]	
			Gas gradient [psi/ft]	
Total Mole	Percent			
Re	emainder			Calculate

The user can select between Gas, Oil and Water calculations by pressing the icons in the toolbar, as shown below.

PVT Calculations	X
🗣 Gas 🌢 Oil 🍐 Water 🖵 📓	
From Composition From Gas Gravity Display Gas Calculations	Input Pressure and Temperature

Within the Gas PVT Calculations panel, the user can choose to calculate the relevant PVT properties based on a knowledge of the gas composition or the gas gravity.

The Oil PVT Calculations panel is shown below and consists of numerous published correlations for solution GOR, bubblepoint, formation volume factor, viscosity and compressibility.

Once all the required data has been input and the user presses the Calculate button, the list of correlation results are displayed. To enable or disable a correlation value from the average and standard deviation results at the bottom, simply un-check the correlation and re-press the Calculate button.

API Gravity	35					_		
Gas Gravity	0.65		Calculate	Author	Area	Date	Value	
				Standing	California	1947	1.3629	
Separator P		psi		Vasquez-Beggs	Databank	1980	1.3929	
Separator T		deg. F	V	Glaso	North Sea	1980	1.3210	
			v	Al-Marhoun	Middle East	1988	1.3626	
Deservoir P	4500	Dei D		McCain	Databank	1991	1.3490	
	205			Dokla-Osman	UAE	1992	1.3842	
Reservoir I	220	deg. F		Farshad	Colombia	1992	1.4412	
				DeGhetto	Databank	1994	1.3929	
GOR at Pb	650	scf/stb	· V	Almehaideb	UAE	1997	1.3915	
Undersatur	rated ?			Hanafy-Macary	Egypt	1997	1.5181	
				Petrosky	Gulf of Mexico	1998	1.3433	
Pb	3536	psi		Al-Shammasi	Databank	1999	1.3715	
			v	Dindoruk-Christman	Gulf of Mexico	2001	1.3260	
						Average	1.	3813 rb/stb
					Sta	ndard Devi	iation 0.	0522

The Water PVT Calculations panel is shown below

nout Data		Calculations		
Pressure	psi 🔽	Formation Volume Factor [rb/stb]		
Temperature	deg.F 🖃	Viscosity [cP]		
Salinity [ppm]		Compressibility [1/psi]		
		Solution Gas Water Ratio [scf/stb]		
		Water Density [bs/ft³]		
			Calculate	
			Calculate	

The user can generate a Microsoft Excel report by selecting the Excel icon in the toolbar, as shown below.

PVT Calculations	X
🗣 Gas 🔺 Oil 💧 Water 🖵	R
Input Data	দেই Create Microsoft Excel Report Jlations

The user will be prompted for a report XLS filename, and a file similar to the following should be created.

	А	В	С	D	E	F	G	Н	1	J	K	L	М	
1														
2														
3														
4														
5			API Gravity	35			Correlation	Location	Year	Bo [rb/stb]			
6			Gas Gravity	0.65			Standing	California	1947	1.3629				
7			Separator P		psi									
8			Separator T		deg. F		Vasquez-Beggs	Databank	1980	1.3929				
9			Reservoir P	4500	psi		Glaso	North Sea	1980	1.3210				
10			Reservoir T	225	deg. F		Al-Marhoun	Middle East	1988	1.3626				
11			GOR at Pb	650	scf/stb		McCain	Databank	1991	1.3490				=
12			Undersaturated ?	True			Dokla-Osman	UAE	1992	1.3842				
13			Pb	3536	psi		Farshad	Colombia	1992	1.4412				
14							DeGhetto	Databank	1994	1.3929				
15							Almehaideb	UAE	1997	1.3915				
16							Hanafy-Macary	Egypt	1997	1.5181				
17							Petrosky	Gulf of Mexico	1998	1.3433				
18							Al-Shammasi	Databank	1999	1.3715				
19							Dindoruk-Christman	Gulf of Mexico	2001	1.3260				
20									Average	1.3813 rb/	stb			
21									Standard Deviation	0.0522				
22														
23														-
14 4	> N	Bu	bblepoint Pressure 🏑	Solution G	DR Oil	Form	ation Volume Factor 🖉 0	il Viscosity					•	Π.

12.7 Recovery Factor Estimate

The following tool is provided to allow the user to quickly calculate a waterdrive recovery factor for potential use with the <u>Associated Water Production</u> ultimate field recovery factor.

The routine for calculation of recovery factor is based on the equation developed by the American Petroleum Institute (API) "A Statistical Study of Recovery Efficiency", 1967.

) 💕 🖬 🐼) ∓		Profile		
	Home				0	💫 About
Profile Typ	e Field Profile	-	Report Fort Tahoma y 9 y Style Blue y	🖵 Screen capture	Scheduler AB ⁴ Exponents	
Frequency	Annual	*		A-PDF Report		
Units	Oilfield	*	Result Boxes Colour 🔪 🖓 Global Qa/Qi ratio	Kcel Report	🚧 Analyse 🚟 Well PI 🌍 PVT 👷 VLP/IPR	
	Profile Setup		Global Settings	Output	Other Tools	
			Field Details		Main Waterdrive Recovery Factor Estima	te

Once the tool is selected, the following input form should be displayed.

Permeability [mD]	350	Oil FVF Bo [rb/stb]	1.35
Porosity [fraction]	0.23	Oil Viscosity [cP]	0.3
Sw [fraction]	0.25	Water Viscosity [cP]	0.4
Initial Pressure [psi]	4500		
Abandonment Pressure [psi]	3500	Recovery Factor [%]	58.529%

The user should enter all the required data, then press the calculate button. To return to main application select the OK button.

12.8 Quicklook Oil VLP/IPR

The following tool is provided to allow the user to quickly calculate, from nodal analysis, the likely initial well oil production rate given a specific tubing design and well trajectory.

		F 🔊 🖬 🛃	Profile [Arkle Analog	ue2.ppd]	
	Н	ome			🔞 🗞 About
Pro	file Type	Field Profile	Report Font Tahoma • 9 • Style Blue •	🖵 Screen capture	Scheduler AB ^t Exponents 4 GOR RE
Fre	quency	Annual 👻		A-PDF Report	
Uni	ts	Oilfield 🔹	Result Boxes Colour V 30 Global Qa/Qi ratio Decimals 2	🔀 Excel Report	W Analyse Well PI SPVI PU VLP/IPR
	Pr	ofile Setup	Global Settings	Output	Other Tools
			Field Details		Main Results Quicklook Oil VLP/IPR

Once the tool is selected, the following input form should be displayed.

Input Tubing Parameters In	nflow Performar	ice		
Data Charts Tables				
Reservoir P [psi]		Separator P [psi]		
Reservoir T [deg F]	Se	parator T [deg F]		
		Select Correlations		
Oil API Gravity	Pb	Standing [California 1947]	-	
GOR at Pb [scf/stb]	Во	Standing [California 1947]		
	Co	Vasquez-Beggs [Databank 1980]	-	
Gas Gravity	μο	Chew-Connally [Databank 1959]	-	
Composition (Mole Percent)			
N2				
C02				
H2S				
Water Salinity [ppm]				
				Calculate

The input data sections are split into three distinct areas and the data and calculations must be input in a sequential manner, as illustrated below.

1. PVT Data Input

Input Tubing Parameters (Inflow Performance Data Charts Tables Reservoir P [psi] 3000 Separator P [psi] 50 Reservoir T [deg F] 140 Separator T [deg F] 80 Select Correlations Oil API Gravity 35 Pb Glaso [North Sea 1980] • GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] • Co Vasquez-Beggs [Databank 1980] • Gas Gravity 0.825 μo Chew-Connally [Databank 1959] • Composition (Mole Percent) N2 1 CO2 2 H2S 3 Water Salinity [ppm] 200000		Olifield units					
Data Charts Tables Reservoir P [psi] 3000 Separator P [psi] 50 Reservoir T [deg F] 140 Separator T [deg F] 80 Oil API Gravity 35 Pb Glaso [North Sea 1980] • OIl API Gravity 35 Pb Glaso [North Sea 1980] • GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] • Co Vasquez-Beggs [Databank 1980] • • Gas Gravity 0.825 µo Chew-Connally [Databank 1959] • N2 1 • • • • N2 1 • • • • Water Salinity [ppm] 200000 • • •	Input Tubing Parar	neters (Inflow P	erforman	ice			
Reservoir P [psi] 3000 Separator P [psi] 50 Reservoir T [deg F] 140 Separator T [deg F] 80 Oil API Gravity 35 Pb Glaso [North Sea 1980] • GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] • GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] • Gas Gravity 0.825 μo Co Vasquez-Beggs [Databank 1980] • Gas Gravity 0.825 μo Chew-Connally [Databank 1959] • • N2 1 • • • • • Mater Salinity [ppm] 200000 • • • •	Data Charts Tab	les					
Reservoir T [deg F] 140 Separator T [deg F] 80 Select Correlations Oil API Gravity 35 Pb Glaso [North Sea 1980] • GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] • Co Vasquez-Beggs [Databank 1980] • Gas Gravity 0.825 µo Chew-Connally [Databank 1959] • Composition (Mole Percent) N2 1 CO 2 H2S 3 Water Salinity [ppm] 200000	Reservoir P [psi]	3000		Separator P [psi]	50		
Oil API Gravity 35 Pb Glaso [North Sea 1980] ▼ GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] ▼ GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] ▼ GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] ▼ Goas Gravity 0.825 µo Chew-Connally [Databank 1959] ▼ Composition (Mole Percent) N2 1 1 CO2 2 1 1 Water Salinity [ppm] 200000	Reservoir T [deg F]	140	Sep	parator T [deg F]	80		
Oil API Gravity 35 Pb Glaso [North Sea 1980] GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] Co Vasquez-Beggs [Databank 1980] • Gas Gravity 0.825 µo Chew-Connally [Databank 1959] • Composition (Mole Percent) N2 1 • • M2 1 • • • Water Salinity [ppm] 200000 • • •				Sele	ect Correlations		
GOR at Pb [scf/stb] 574.7 Bo Glaso [North Sea 1980] Gas Gravity 0.825 Go Vasquez-Beggs [Databank 1980] Gas Gravity 0.825 Go Chew-Connally [Databank 1959] Composition (Mole Percent) N2 1 CO 2 H2S 3 Water Salinity [ppm] 200000	Oil API Gravity	35	Pb	Glaso [North Se	ea 1980]	•	
Co Vasquez-Beggs [Databank 1980] Gas Gravity 0.825 µo Chew-Connally [Databank 1959] Composition (Mole Percent) N2 1 CO2 H2S 3	GOR at Pb [scf/stb]	574.7	Во	Glaso [North Se	ea 1980]	-	
Gas Gravity 0.825 µ0 Chew-Connally [Databank 1959] v Composition (Mole Percent) N2 1 CO2 2 H2S 3 Water Salinity [ppm] 200000			Co	Vasquez-Beggs	: [Databank 1980]	•	
Composition (Mole Percent) N2 CO2 Parameters Water Salinity [ppm]	Gas Gravity	0.825	μο	Chew-Connally	[Databank 1959]	-	
N2 1 C02 2 H2S 3 Water Salinity [ppm] 200000	Composition (Mo	le Percent)	_				
CO2 2 H2S 3 Water Salinity [ppm] 200000	N2	1					
H2S 3 Water Salinity [ppm] 200000	CO2	2					
Water Salinity [ppm] 200000	H2S	3					
Water Salinity [ppm] 200000			_				
	Nater Salinity [ppm]	200000					
							Calculate

Firstly the PVT data has to be input, as shown below.

Once the user has entered all the necessary PVT data, then the user should select the *Calculate* button as shown above. Assuming all the data is correct then the following should be displayed.

Uuicklook VLP/IPR	[WellIPRVLP_Exar	nple.ipr]			
🗁 🛃 📄 🖵 📧	Oilfield units	. 0			
PVT Input Tubing Para	meters (Inflow Per	formance			
PVT Data Charts Tab	les				
Reservoir P [psi]	3000	Separator P [psi]	50		
Reservoir T [deg F]	140	Separator T [deg F]	80		
		Selec	t Correlations		
Oil API Gravity	35	Pb Glaso [North Sea	a 1980]		2521.22
GOR at Pb [scf/stb]	574.7	Bo Glaso [North Sea	a 1980]	▼ E	Boi = 1.2766
		Co Vasquez-Beggs [[Databank 1980]	•	1.216E-05
Gas Gravity	0.825	uo Chew-Connally [[Databank 1959]		0.9616
Composition (Mo	le PVT Calculatio	ns	U		
N2					
CO2	🚺 PI	ease proceed to Tubing	eted successfully. 9 Parameters Data Input.		
H2S	-				
Water Salinity (ppm)			OK	- 1	
			UK		
				_	
				_	
					Salculate
					Close

Charts and tables of PVT results can be inspected in the Charts and Tables section of the PVT input tabs.

Once the user is satisfied with the PVT input and calculations they should proceed to the *Tubing Parameters* Main tab in order to input the required data in this section.

2. Tubing Parameters

In this section, the user should well trajectory and tubing ID as a function of Measured Depth [MD] v/s True Vertical Depth [TVD], as well as other well properties in order to calculate the vertical lift performance via nodal analysis. For information, the method used within this routine is the Modified Hagedorn and Brown multi-phase vertical lift performance relationship.

Input I uping Faraneters Innow Fe	romance			
II Data Charts 19				
Wellhead pressure [psi] 100	Well Details		
Watercut [fraction] 0.3	MD [feet]	TVD [feet]	ID [inches]
Producing GOR [scf/stb] 800	0	0	2.441
Pipe reuchassa linches	1 0.0018	200	200	2.441
Pipe loughness [inches		400	400	2.441
		600	600	2.441
Geothermal gradient [deg E/100ft	1 15	800	800	2.441
Geotriennal gradient [deg 17 four	1 1.0	1000	1000	2.441
Heat Transfer Coefficient [BTU/hr-ft2-F] 15.9	1200	1200	2.441
		1400	1400	2.441
Quick Calculate HT	0	1600	1600	2.441
pout Liquid Rates		1800	1800	2.441
]	2000	2000	2.441
Minimum Liquid Rate [stb/d]	50	2200	2200	2.441
Maximum Liquid Bate [stb/d]	5000	2400	2400	2.441
mannan adara nata [ata a]		2600	2600	2.441
Number of Points	25 💌	2800	2800	2.441
		3000	3000	2.441
		3200	3200	2.441
Set MD Increment		3400	3400	2.441
		3600	3600	2.441
				Import CSV
				Calculate

One of the main uncertainties with any vertical lift performance relationship is what value should the user assume for the heat transfer coefficient [HTC] between the tubing and the rock formation along the total length of the wellbore, assuming no knowledge of producing temperatures from offset wells. As a ready reckoner, the user is provided with a quick HTC calculator, which is shown below.

With this ready reckoner, the user can quickly iterate for given well configurations for likely values of HTC, for use with the vertical lift analysis.

III Quick Calculate Heat Transfer	Coefficient				x
Wellbore Diameter [inches]	8.5]			
Flow Type	Tubing Flow	•	Fluid in Annulus	Gas	-
	OD [inches]	ID [inches]			
Casing Diameter	7	6.241	or, Select Casing Size	7 in OD, 23 lb/ft	-
Tubing Diameter	5.5	4.767	or, Select Tubing Size	5.5 in OD, 17 lb/ft	-
			Heat Transfer Coefficier	nt [BTU/hr-ft2-F]	
			19.9162	Calculate	
				4	-
				Close	

Once the user is satisfied with the input of well tubing parameters, they should press the Calculate

🗩 🛃 📃 💻 🔟 Oilfield units 👒	٢				
VT Input Tubing Parameters Inflow Perfo	ormance				
ell Data Charts					
Wellhead pressure [psi]	100	Well Details			
Watercut [fraction]	0.3	MD [feet]	TVD [feet]	ID [inches]	
Producing GOR [scf/stb]	800	0	0	2.441	
Pine muchness [inches]	0 0018	200	200	2.441	
ripe loughiness [inches]		400	400	2.441	
		600	600	2.441	
Geothermal gradient [deo F/100ft]	1.5	800	800	2.441	
	45.0	1000	1000	2.441	
Heat Transfer Coefficient [BTU/hr-ft2-F]	15.9	1200	1200	2.441	
VLP Calculation	s			2.441	
Qu				2.441	
Input Liquid Rates	Colorian and	- I - I		2.441	
	Calculations com	pieted successfully.	alinnut	2.441	
	ase proceed to inne	wir enformance bat	a input.	2.441	
Maximum Liqu				2.441	
N		_		2.441	
N			OK	2.441	
				2.441	
Set MD Increment		2400	2400	2.441	
Sec MD Increment		3400	3400	2.441	-
		1 3000	5000	2.441	_
				Import CSV	·
			ſ		
			(Calculate	

button as shown below, and the following screen should appear.

Charts of various tubing calculation results can be inspected in the Charts section of the Tubing Parameters input tabs.

Once the user is satisfied with the Tubing Parameters input and calculations they should proceed to the *Inflow Performance* Main tab in order to input the required data in this section.

3. Inflow Performance

Within the Inflow Performance sections there are three methods for inputting and calculating Productivity Index, namely Constant PI, Vogel's or Fetkovich's method.

If the user has a knowledge of production liquids rate versus flowing bottom hole pressure [BHP] then the user can choose to back calculate and best fit any of the above method's input parameters. The example provided below is for the Vogel method. If the user selects the **Yes** button then the calculated values over write the original values in the input areas.



Once the user in satisfied with the input IPR values, they should press the *Calculate* button as shown below.

Quicklook VLP/IPR	[WellIPRVLP_Examp	ple.ipr]		
🔁 🖬 📄 💻 🗷	Oilfield units 🛛 👻	٢		
PVT Input Tubing Parar	meters Inflow Perfo	omance		
IPR Data Chart				
PI Method	Vogel	•	Reservoir pressure [psi]	1934.60
Input Actual Data to	Compare to :		Constant PI Method	
Fluid Rate [bbls/d]	Flowing BHP [psi]	<u>^</u>	PI [bbl/d/psi], J	
684 1836	1800 1400	=	Vogel's Method	
2988 4140	1005 590		Qmax [bbl/d]	4589.77
	IPR Calculations		X	
		alculations complete	ed successfully.	
			OK Point	1,149.23
		_	Liquid Rate [bbl/d]	2,746.66
		•	Back Calculate	Calculate
				Close

The routine will calculate the intersection point of the VLP and IPR relationships to give a resultant nodal analysis production rate and flowing bottom hole pressure.



The user can generate a Microsoft Excel report by selecting the Excel icon in the toolbar, as shown below.

II Quicklook VLP/IPR [WellIPRVLP_Example.ipr]						
🗁 🛃 📄 🖵 🎮 Oilfield units 🕞 🚳						
PVT Input Tubing Para Create Microsoft Excel Report						
IPR Data Chart						

The user will be prompted for a report XLS filename, and a file similar to the following should be created.





Production Profile Generation and Analysis



13 Worked Example

13.1 Arkle Discovery

Given the following reservoir information, calculate oil, gas and water production profiles and water injection, together with the associated facilities sizing (assuming 80% uptime) and schedule for well operations for the following West of the Hebrides discovery. *As is always, you have 1 hour to generate this forecast to then pass on to the economists !*

The preliminary prospect estimates and discovery data are shown below.

Sum mary D	Details							
	Wat dep	ter oth	Field Type	STOOIP	Ultim Recov	ate R <i>i</i> erv	ecovery Factor	
	[ft]]		[mmstb]	[mms	stb]	[%]	
Arkle	150	00	Oil	1200	360)	30%	
Volumetric	and Reserve	oir Proper	ties					
	Reservoir	Reservoi	r Gross	Porosity	Net-to- Gross	Water	Oil Formatio	Permeabilit
	Area	Area	Thickness	i	ratio	Saturation	Volume Factor	,
	[acres]	[km^2]	[feet]	[fraction]	[fraction]	[fraction]	[rb/stb]	[mDarcies]
Arkle	1855	7.51	800	0.27	0.55	0.2	1.14	800
Fluid Prope	rties							
	Reser Dep [ft tvd:	voir th ss]	Initial Pressure [psi]	Temperature [deg F]	API Gravity	/ G [sc	lution OR f/stb]	Bubblepoint Pressure [psi]
Arkle	690	0	3200	140	24	2	220	3100

13.1.1 Oil Production Profile

The following recipe was followed to calculate the primary phase oil production profile.

- 1. Calculate likely individual well production rates.
- 2. From analogues reservoir performance, obtain relationship of plateau offtake rate vs field size and cumulative production offtake prior to field decline.
- 3. Backsolve decline rate for required field reserve level, and compare calculated decline rate to analogue field experience. If the decline rate is greater or less than the expected range, iterate steps 2 and 3, together with a critical review of likely field reserve level or recovery factor.
- 4. Once complete, proceed to calculate the Gas Production Profile

Individual Well Production Rates

Using the reservoir and fluid properties information provided for Arkle

Volumetric	and Reserv	oir Proper	ties					
	Reservoir	Reservo	ir Gross	Porosity	Net-to-	Water	Oil	Permeabilit
	Area	Area	Thickness	;	Gross ratio	Saturation	Formation Volume Factor	n y
	[acres]	[km^2]	[feet]	[fraction]	[fraction]	[fraction]	[rb/stb]	[mDarcies]
Arkle	1855	7.51	800	0.27	0.55	0.2	1.14	800
Fluid Prope	erties Reser Den	∿oir th	Initial Pressure	Temperature	API Gravit	Sol	ution I	Bubblepoint Pressure
	[ft tvd	ss]	[psi]	[deg F]	Claw	, [sc	f/stb]	[psi]
Arkle	690	0	3200	140	24	2	20	3100

The following can be estimated for oil viscosity.

on GUR (B	ubblepoint	nation Volume Facto	VISCOSILY	Lompressibility			
PI Gravity	24		Calculate	Author	Area	Date	Value
as Gravity	0.65			Chour Connollu	Databank	1050	
eparator P		psi 🔽		Beggs-Bobinson	Databank	1905	3 55234
eparator T		deg. F 🔽		Glaso	North Sea	1980	3.62708
				McCain	Databank	1991	3.54589
	2200	noi 🗔		DeGhetto	Databank	1994	4.78144
eservoir P	3200		V	Dindoruk-Christman	Gulf of Mexico	2001	4.78224
	3100	psi 💌					
РЬ							
РЬ						Average	4.05780 cP
РЪ					Sta	Average ndard Devi	4.05780 cP ation 0.66173

From the above the likely range for oil viscosity from low-mid-high values are 3.5 - 4.0 - 4.8 cP. These values can subsequently be used in the estimation of well PI, as shown below, assuming a horizontal wellpath, given the likely low drawdown constraints, and to improve well productivity and reduce well spacing.

tical UII Well Horizontal UI	Well		
Method	Pseudo Stead	y State [1996] - Economides	
kx, mD	800	Well Radius, ft	0.345
ky, mD	800	Well X Midpoint [xo], ft	
kz, mD	240	Well Y Midpoint [yo], ft	
Oil FVF Bo, rb/stb	1.14	Well Length [L], ft	2000
Oil Viscosity, cP	4	Well Height above Base [zw], ft	330
Major Length <mark>[</mark> xe], ft	4427	Well Inclination, degrees	75
Minor Length [ye], ft	4427		
Thickness, ft	400	Show Well Schematic	
Skin Factor			
🔘 Calculate Skin (Input Skin	PI, stb/d/psi	142.1287
k (skin), mD			
Skin factor	5.0000		Calculate

The likely range of well PI is 120 - 142 -160 bopd / psi, and given a prudent 80 psi drawdown, results in an individual well target rate of 11 mstb/d, +/- 2 mstb/d.

Buildup of Production Rate to Plateau

Given a water depth of 1500 ft, and the reservoir depth of almost 7000 ft with a reservoir section of 2000 ft. It was assumed that 6 development producers and 3 injectors wells would be predrilled, prior to the production facility (most likely a FPSO) installation. These would then be tied back and first oil achieved from 6 production wells, resulting in the first years production figure of 60 mstb/d.

Due to likely adverse weather sea conditions, it was assumed that in subsequent years two production wells and one injection well per year would be drilled and tied back.

Plateau Offtake Rate and Onset of field Decline

From analogue fields nearby with similar geological settings and water depth, the following was calculated for plateau offtake rates :

Plateau Production Offtake Rate = 10 - 10.5 - 11% Cumulative Offtake Rate = 40 - 45 - 50%

Given the above set of assumptions the following was put together as an initial pass at a field oil production profile.

🔒 🗋 💕 🖬 🔝 🗧		Pro	ofile [Arkle Analogu	ie2.ppd]			
Home							💿 💊 Abou
Profile Type Field Profile ▼ Frequency Annual ▼ Units Oilfield ▼	Report Font Tahoma	v 9 v Style [ur v] ↓00 Global Qa/Qi ratio Decimals	Blue •	Screen capture PDF Report Excel Report	Schedule Analyse	er AB ⁴ Exponents 🛔 GOR 📑 F 🥌 Well PI 🍣 PVT 🗓 VLP/IF	R
Profile Setup		Global Settings		Output		Other Tools	
		Field Details				Main Results	
Field Name / Description Hydrocarbon Type ?	Arkle Discovery Dil	Month of First p	roduction Jan 201 eld Area 1855	11 [Acres		Buildup Production Plateau offtake rate Year of final Plateau	87.6800 10.65% 2015
ield Schedule Associated Produ	ction Injectors / Gaslift	Facilities Constraints Tables / Charts				Production to end of Plateau	164.3300
Recoverable Oil (mmstb] 360			Swing Factor		Prod'n to end of Plateau [%] Decline duration [Years]	45.65% 16.25
Buildup to Plateau	[in Mstb/d]	Plateau duration [years]	2	1.0		Total Field Life [Years]	21.25
Year 2011 Year 2012 Year 2013 Year 2013 Year 2014 Year 2015 Year 2016 Year 2017 Year 2018 Year 2018 Year 2019 Year 2010 Year 2012 Year 2020 Year 2021 Year 2023 Year 2024 Year 2025 Year 2025 Year 2028 Year 2028 Year 2029 Year 2031	60 A 80 E 100 C	Decline Rate [fraction] Decline Type Abandonment, Qa/Qi Calculate required n Use field decline rat Well Qi [mstb/d] Years at Qi for well Decline Rate [fraction Abandonment, Qa/Qi	0.184814 Exponential Construction Back Solve Back Solve Under Solve Under Solve First Year II 0.184814 0.05	In Factor	e Decline Rate wms (Recover Juidup and PL Jacksolve Req Jate	Total Production (mmstb) Abandonment rate (mstb/d) Acres/Production well No. of Production Wells able serves/Production well No. of Injection Wells ball serves/Production well No. of Workovers Reserves/(Prod's+WO's) Facilities Constraints Oil Separation Vis Total Liquida Gri Water Freduction Hit	360.0004 5.2108 132.50 14 8 WI 25.7143 47P 13WI 5.9016 Checks ex Injection as Injection
				Calculat	2	Main Results	

The offtake rate was iterated to 105 mstb/d in year 2014 to give a similar mid case offtake rate of 10.6 %, and the plateau duration was fixed to 2 years to give a "Production to Plateau end" of 45.6%. See the above Main Results Panel. The decline rate was then backsolved to 0.1848 per annum, which compared favourably to the nearby analogue fields.

13.1.2 Gas Production Profile

The field value for undersaturated gas oil ratio is 220 scf/stb, with the original reservoir pressure of 3200 psi compared with the bubble point pressure of 3100 psi.

The development assumption is for full voidage replacement, provided by water injection, akin to the practice and experience of nearby analogues. However, it is assumed that some local gas breakout would occur near to the end of production plateau. Therefore is was assumed that the GOR would gradually climb to 300 scf/stb, with a resultant field recoverable gas recovery of 87.1 bcf (= 110% of 360 mmstb x 220 scf/stb). The resultant input screen is shown below.

-		Profile [Arkle A	nalogue2.ppd]			
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Profile Type Field Profile	Report Font Tahoma	• 9 • Style Blue	Screen capture	C Schedu	ler AB ⁴ Exponents 🔒 GOR 🧾 RF	
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Field Name / Description	Arkle Discovery				Duildus Destustion	97 6900
Hydrocarbon Type?	Oil	Month of First production	Jan 2011 [-	Buildup Production	10.65%
		Field Area	1855 Acres	-	Year of final Plateau	2015
Field Calendula Associated Dest	ution Injustees / Casility Franklin	a Constrainte Tables / Charte			Production to end of Plateau	164.3300
Associated Gas Production	iciated Water Production	es constraints I ables / Charts			Prod'n to end of Plateau [%]	45.65%
		GOR v's Time Gas Production	n v's Time		Decline duration [Years]	16.25
Calculate Associated Hydrod	carbon Production?				Total Field Life [Years]	21.25
Associated	Gas Production	350			Total Production [mmstb]	360.0004
Line Circula Mathed					Abandonment rate [mstb/d]	5,2108
 Use simple Method 		300-				
Recoverable Oil [m	imstb] 360.00				Acres/Production well	132.50
Recoverable Gas	s [bcf] 87.1	250 -	/		No. of Production Wells	14
Initial GOR [so	cf/stb] 220				No. of Injection Wells	8 WI
Final GOR [so	cf/stb] 300	1 200 -			Reserves/Production well	25.7143
Curve Type = 10 😑 —		S 450			No. of Workovers	47P 13WI
		G 150-			Reserves/(Prod's+WO's)	5.9016
O Use Material Balance De	epletion GOR	100-			Facilities Constraints Ch	ecks
		100				
Calculate E	Depletion GOR	50-			Ull Separation Water	Injection
					Total Liquids Gas I	njection
		0			Water Production Gas Cor	mpression
		01/01/2 01/01/2	01/01/2 01/01/2 01/01/2	01/01/2	L	
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			Calculati			el.

13.1.3 Water Production Profile

From the input assumptions, it can be seen that the assumed ultimate recovery factor is 30%. This ultimate recovery corresponds to an abandonment watercut of approximately 95%, and it is also assumed that the watercut development would be "Moderate".

These assumptions are input as shown below to calculate the water production profile.



13.1.4 Water Injection Profile

As already mentioned, the development assumption is for full voidage replacement, provided by water injection, akin to the practice and experience of nearby analogues.

It is also assumed that the injectors will perform better than the producers, since the water viscosity is lower than the oil viscosity and the likelihood that the injectors will be fractured (either hydraulically or thermally) hence improving injectivity performance. It was assumed that individual injectors would be capable to inject a constant rate of 20 mstb/d.

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Field Name / Description Arkle Discovery				Buildup Production	87.6800			
Hydrocarbon Type? Dil	Month of First production Jan 201	11]-	Plateau offtake rate	10.65%			
	Field Area 1855	Acres	•	Year of final Plateau	2015			
Field Schedule Associated Production Injectors / Gasiit Facilities	eld Schedule Associated Production Injectors / Gasift Facilities Constraints Tables / Charts							
				Prod'n to end of Plateau [%]	45.65%			
Water Injection ? Gas Injection ?				Decline duration [Years]	16.25			
Water Injection	Well Workove	Well Workovers						
Voidage Replacement Oconstant Rate		Frequency [Years]						
Well Water Injection Bate [mbbls/d] 20	Production W	Production Wells 5						
Voidage Beplacement [%] 100	Water Injection W	Water Injection Wells 10						
Bo (rb/stb) 1.14 Bw (rb/stb) 1	Gas Injection W	Gas Injection Wells						
Field Injection Rate [mbbls/d]								
	Gaslift Requirement [mmscf/d]		Reserves/Production wall	8 WI			
Gas Injection	Total Field Gaslift Requirer	nent		No. of Markovern	20./143			
Well Gas Injection Rate [mmscf/d]	or, Individual Well Requiren	nent 3		Reserves/(Prod's+\//O's)	4/F 13WI			
Field Gas Injection (as % of Prod'n)					5.5016			
or [mmscf/d]	Fuel Gas and Fl	are		Facilities Constraints Cl	hecks			
	Fuel Gas and Flare [mms	cf/d] 5		Oil Separation Water	Injection			
				Total Liquids Gas	Injection			
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Workovers were also tentatively modeled to occur every 5 years per producer and every 10 years per injector, to give an approximate idea of when to schedule workover batches.

Also, it is assumed that 3 mmscf/d per producer will be available for gaslift to enable lifting these wells at mature watercut levels. This assumption, together with the assumption of 5 mmscf/d for fuel and flare gas, will help size the total gas compression requirement.

13.1.5 Facilities Sizing

Now that we are happy with the oil, gas and water production profiles and water injection assumptions, we input the 80% uptime figure in the "Quick Calculate Facilities Constraints" section, as shown below, then press the *Calculate* button. The routine then searches through each of the production and injection streams, finds each of the maximum values, then multiplies the maximums by the (1 / Uptime).

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Profile S	etup		Gl	obal Settings			Output		Other Tools	
			F	ield Details					Main Results	
Field Nam	ne / Description	Arkle Discovery							Buildup Production	87.6800
Hydro	ocarbon Type?	Oil		 Month 	of First production	Jan 201	1		Plateau offtake rate	10.65%
					Field Area	1855	Acres	•	Year of final Plateau	2015
d Schedule 🗛	ssociated Product	ion Injectors / Ga	slift Eacilities C	onstraints Tables	Charts				Production to end of Plateau	164.3300
2010				10000					Prod'n to end of Plateau [%]	45.65%
Year [uuuu]	System Uptime	Oil Separation [msth/d]	Total Liquids [mstb/d]	Water Production	Water Injection [msth/d]	Gas Inject	ion Gas 11 Compression	Â	Decline duration [Years]	16.25
2011	80	150	200	[mstb/d] 175	200	[" [mmscf/d]		Total Field Life [Years]	21.25
2011		100	200	110	200				Total Production [mmstb]	360.0004
Ť									Abandonment rate [mstb/d]	5.2108
									Aaraa/Production.woll	100 50
									No. of Production Wells	132.50
									No. of Injection Wells	0 \s/l
									Reserves/Production well	25 71/2
									No. of Workovers	47P 13/4/
									Reserves/(Prod's+WO's)	5.9016
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Calculate	80	131.3	183.3	3 159.	7 186.	6	0.0 77	.7		
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The user can then input approximate facilities constraints into the table above, then press the main application *Calculate* button to allow the application to run through the *Facilities Constraints Checks* traffic light system, as also shown above.

13.1.6 Results

Now that we are happy with all the input and calculations with regards to the production and injection profiles, we can inspect the output tables and charts.

For example, the output *Field Production* table below highlights an interesting observation with regards to workover scheduling. There appears to be three logical perdiods in which to conduct batch workover programs, first in 2016 or 2017, then in 2021 and finally in 2026. The workovers proposed for 2028 onwards can probably be ignored, since it is unlikely that there will be any workover operating cost work done when the field is so close to final abandonment.

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Field N	lame / Description	Arkie Discove	ry						Buildup Production	87.6800
Hy	drocarbon Type?	Oil		 Month 	of First production	on Jan 2011			Plateau offtake rate	10.65%
					Field Are	a 1855	Acres	•	Year of final Plateau	2015
	· · · · · · · · · · · · · · · · · · ·								Production to and of Plateau	164 2200
1 Schedule	Associated Produ	ction Injectors /	Gaslift Facilities	Constraints Table	s / Charts				r roduction to end or r lateau	104.5500
d Productio	on Well Production	Charts							Prod'n to end of Plateau [%]	45.65%
3				Average	Current Marco Ol	Average	Cumulative Car	Average	Decline duration [Years]	16.25
Year	Producers	Injectors	Workovers	Oil Production [mstb/d]	[mmstb]	Gas Production [mmscf/d]	[bcf]	Water Produc [mstb/d]	Total Field Life [Years]	21.25
2011	6	4w/i		60.00	21.90	13.2	0 4.82	0	Total Production [mmstb]	360.0004
2012	2	1WI		80.00	51.18	17.6	0 11.26	1		
2013	2	2wl		100.00	87.68	22.0	0 19.29	5	Abandonment rate [mstb/d]	5.2108
2014	1			105.00	126.01	23.10	0 27.72	12		
2015	2	1WI		105.00	164.33	23.13	3 36.17	24	Acres/Production well	132.50
2016			6P	95.11	199.14	21.1	1 43.89	39	No. of Production Molla	
2017			2P	79.05	227.99	17.9	2 50.43	53	No. of Froduction Wens	14
2018			2P	65.71	251.98	15.4	8 56.08	66	No. of Injection Wells	8 WI
2019			1P	54.62	271.91	13.5	8 61.04	79		
2020			2P	45.41	288.53	12.0	0 65.43	91	Reserves/Production well	25.7143
2021			6P 4WI	37.74	302.31	10.5	7 69.29	102	No. of Workovers	47P 13W
2022			2P 1WI	31.37	313.76	9.23	3 72.66	111		
2023			2P 2WI	26.08	323.28	7.9	6 75.56	118	Reserves/(Prod's+WO's)	5.9016
2024			18	21.68	331.22	6.7	9 78.05	124	(7)	
2025			2P 1WI	18.02	337.80	5.72	2 80.13	127	Facilities Constraints	Checks
2026			6P	14.98	343.26	4.7	7 81.88	127		
2027			2P	12.45	347.81	3.9	6 83.32	125	Oil Separation Wa	ter Injection
2028			2P	10.35	351.60	3.2	6 84.51	123	Tatelliquida	na Inication
2029			iP	8.60	354.74	2.6	8 85.49	118		as injection
2030	1		2P	7.15	357.35	2.2	0 86.30	110	Water Production Gas	Compression
2031			6P 4WI	5.95	359.52	1.8	0 86.96	101		
2032			2P 1WI	1.32	360.00	0.4	0 87.10	23		
								+		
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With the following calculations exported as an Adobe 'pdf' file or a Microsoft Excel file, and available to email to the Facilities Design Engineer, and Economists for future cashflow forecasting, the job of generating the field life production and injection profiles is now complete.

Time taken to complete = between 5 minutes and 1 hour, depending on how familiar the Engineer is with representative analogue data.

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1	Year P 2011 2012 2013 2014 2015 2016 2017 2018	froducers	4WI 1WI 2WI 1WI	Workovers A C F [Average Oil Production [[mstb/d] 60.00 80.00 100.00 105.00 105.00	Cumulative Oil [mmstb] 21.90 51.18 87.68 126.01 164.33	Average Gas Production [mmscf/d] 13.20 17.60 22.00 23.10 23.13	Cumulative Gas [bcf] 4.82 11.26 19.29 27.72	Average Water Production [mstb/d] 0.22 1.48 5.36 12.69	Cumulativ Water [mmstb] 0.08 0.62 2.58	e Watercut [percent] 0.0037 0.0182 0.0509 0.1078	Average Liquid Production [mstb/d] 60.22 81.48 105.36	Cumulative Liquid [mmstb] 21.98 51.80 90.26	Average Water Injection [mstb/d] 68.62 92.68 119.36	Cumulative Water Injection [mmbbl] 25.05 58.97 102.53	Average Gas Injection [mmscf/d] 0.00 0.00 0.00	Cumulative Gas Injection [bcf] 0.00 0.00 0.00	e Average Gas Lift [mmscf/d] 18.00 24.00 30.00	Average Gas Compressi on [mmscf/d] 31.20 41.60 52.00	Average Gas Sales [mmscf/d] 8.20 12.60 17.00	Cumulative Gas Sales [bcf] 2.99 7.60
1	2011 2012 2013 2014 2015 2016 2017 2018	6 2 2 1 2	4WI 1WI 2WI 1WI	EP	Coll Coll Production [mstb/d] 60.00 80.00 100.00 105.00 105.00	Oil [mmstb] 21.90 51.18 87.68 126.01 164.33	Gas Production [mmscf/d] 13.20 17.60 22.00 23.10 23.13	Gas [bcf] 4.82 11.26 19.29 27.72	Water Production [mstb/d] 0.22 1.48 5.36 12.69	0.08 0.62 2.58	[percent] 0.0037 0.0182 0.0509 0.1078	Liquid Production [mstb/d] 60.22 81.48 105.36	Liquid [mmstb] 21.98 51.80 90.26	Water Injection [mstb/d] 68.62 92.68 119.36	Water Injection [mmbbl] 25.05 58.97 102.53	Gas Injection [mmscf/d] 0.00 0.00 0.00	Gas Injection [bcf] 0.00 0.00	Gas Lift [mmscf/d] 18.00 24.00 30.00	Gas Compressi on [mmscf/d] 31.20 41.60 52.00	Gas Sales [mmscf/d] 8.20 12.60 17.00	Gas Sales [bcf] 7.60
9	2011 2012 2013 2014 2015 2016 2017 2018	6 2 2 1 2	4WI 1WI 2WI 1WI	EP E	Production [mstb/d] 60.00 80.00 100.00 105.00 105.00	21.90 51.18 87.68 126.01 164.33	Production [mmscf/d] 13.20 17.60 22.00 23.10 23.13	4.82 11.26 19.29 27.72	Production [mstb/d] 0.22 1.48 5.36 12.69	0.08 0.62 2.58	0.0037 0.0182 0.0509 0.1078	Production [mstb/d] 60.22 81.48 105.36	21.98 51.80 90.26	Injection [mstb/d] 68.62 92.68 119.36	Injection [mmbbl] 25.05 58.97 102.53	Injection [mmscf/d] 0.00 0.00 0.00	Injection [bcf] 0.00 0.00 0.00	[mmscf/d] 18.00 24.00 30.00	Compressi on [mmscf/d] 31.20 41.60 52.00	[mmscf/d] 8.20 12.60 17.00	Sales [bcf]
4	2011 2012 2013 2014 2015 2016 2017 2018	6 2 2 1 2	4WI 1WI 2WI 1WI	69	60.00 80.00 100.00 105.00 105.00	21.90 51.18 87.68 126.01 164.33	[mmscf/d] 13.20 17.60 22.00 23.10 23.13	4.82 11.26 19.29 27.72	0.22 1.48 5.36 12,69	0.08	0.0037 0.0182 0.0509 0.1078	60.22 81.48 105.36	21.98 51.80 90.26	[mstb/d] 68.62 92.68 119.36	25.05 58.97 102.53	[mmscf/d] 0.00 0.00 0.00	[bcf] 0.00 0.00 0.00	18.00 24.00 30.00	on [mmscf/d] 31.20 41.60 52.00	8.20 12.60 17.00	2.99 7.60
	2011 2012 2013 2014 2015 2016 2017 2018	6 2 2 1 2	4WI 1WI 2WI 1WI	69	60.00 80.00 100.00 105.00 105.00	21.90 51.18 87.68 126.01 164.33	13.20 17.60 22.00 23.10 23.13	4.82 11.26 19.29 27.72	0.22 1.48 5.36 12.69	0.08	0.0037 0.0182 0.0509 0.1078	60.22 81.48 105.36	21.98 51.80 90.26	68.62 92.68 119.36	25.05 58.97 102.53	0.00	0.00	18.00 24.00 30.00	31.20 41.60 52.00	8.20 12.60 17.00	2.99 7.60
	2012 2013 2014 2015 2016 2017 2018	2 2 1 2	1WI 2WI 1WI	69	80.00 100.00 105.00 105.00	51.18 87.68 126.01 164.33	17.60 22.00 23.10 23.13	11.26 19.29 27.72	1.48 5.36 12.69	0.62	0.0182 0.0509 0.1078	81.48 105.36	51.80 90.26	92.68 119.36	58.97 102.53	0.00	0.00	24.00	41.60	12.60	7.60
	2013 2014 2015 2016 2017 2018	2	2WI 1WI	69	100.00 105.00 105.00	87.68 126.01 164.33	22.00 23.10 23.13	19.29	5.36	2.58	0.0509	105.36	90.26	119.36	102.53	0.00	0.00	30.00	52.00	17.00	13.81
	2014 2015 2016 2017 2018	2	1WI	69	105.00	126.01	23.10	27.72	12.69		0.10/8	11/14									10101
-	2015 2016 2017 2018		1111	6P	105.00	104.35		1 26 17	24.75	16.25	0 1909	120.75	133.22	132.39	202.59	0.00	0.00	32.26	55.36	18.10	20.42
-	2017				95.11	199.14	21.11	43.89	39.66	30.76	0.2943	134,78	229.91	148.09	257.79	0.00	0.00	39.00	60.11	16.11	32,93
-	2018			2P	79.05	227.99	17.92	50.43	53.37	50.24	0.4030	132.42	278.24	143.48	310.16	0.00	0.00	39.00	56.92	12.92	37.65
-	2010			2P	65.71	251.98	15.48	56.08	66.88	74.66	0.5044	132.59	326.63	141.79	361.91	0.00	0.00	39.00	54.48	10.48	41.47
-	2019			10	54.62	271.91	13.58	61.04	79.84	103.80	0.5938	134.46	375.71	142.11	413.78	0.00	0.00	39.00	52.58	8.58	44.61
	2020			6P 4WI	37.74	302.31	12.00	69.29	102.70	174.92	0.7313	140.44	477.23	145.00	519.56	0.00	0.00	39.00	49.57	5.57	49.20
-	2022			2P 1WI	31.37	313.76	9.23	72.66	111.90	215.76	0.7810	143.27	529.53	147.66	573.45	0.00	0.00	39.00	48.23	4.23	50.74
	2023			2P 2WI	26.08	323.28	7.96	75.56	118.98	259.19	0.8202	145.06	582.47	148.71	627.73	0.00	0.00	39.00	46.96	2.96	51.82
	2024			1P	21.68	331.22	6.79	78.05	124.30	304.68	0.8515	145.98	635.90	149.02	682.27	0.00	0.00	39.00	45.79	1.79	52.48
	2025			6P	14.98	343.26	4,77	81,88	127,07	351.28	0.8947	142.25	741.00	146.21	736.37	0.00	0.00	39.00	44.72	0.72	52.75
	2027			2P	12.45	347.81	3.96	83.32	125.76	443.64	0.9099	138.21	791.45	139.95	840.14	0.00	0.00	39.00	42.96	0.00	52.75
	2028			2P	10.35	351.60	3.26	84.51	123.35	488.78	0.9226	133.70	840.38	135.15	889.60	0.00	0.00	39.00	42.26	0.00	52.75
	2029			1P 20	8.60	354.74	2.68	85.49	118.82	532.15	0.9325	127.42	886.89	128.62	936.55	0.00	0.00	39.00	41.68	0.00	52.75
	2030	1		6P 4WI	5.95	359.52	1.80	86.96	101.46	609.48	0.9446	107.41	969,00	108,24	1019.34	0.00	0.00	41.52	43.72	0.00	52.75
	2032			2P 1WI	1.32	360.00	0.40	87.10	23.82	618.20	0.9477	25.14	978.20	25.32	1028.60	0.00	0.00	10.44	10.84	0.00	52.75
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Index	97

Index

- C -

Calculate Depletion GOR Profile 67

- D -

Defining Field Input11Defining Schedule20Defining Wells17

- F -

Facilities Contraints 31

- | -

Injectors / Gaslift 28 Introduction 7

- P -

PVT Calculations 73

- R -

Recovery Factor Estimate 76

- S -

Secondary Hydrocarbons 22

- T -

Table / Charts 34

- W -

Water Production24Well PI Calculations63Well Scheduler50

