

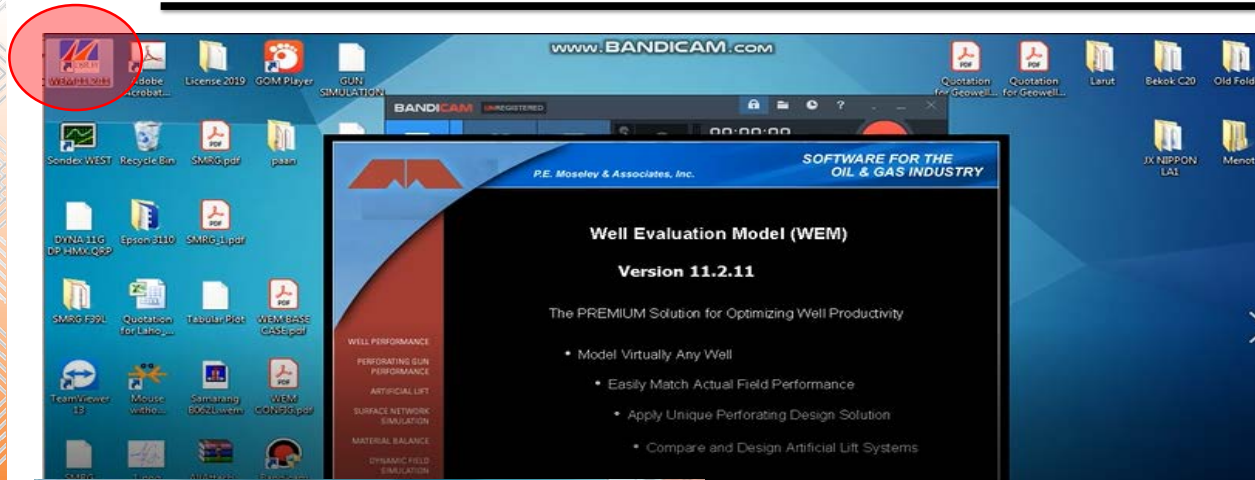
WEM SIMULATION TUTORIAL

Well Evaluation Model for Perforating Design

Prepared by: Baby Cintami Massaugee Abdullah

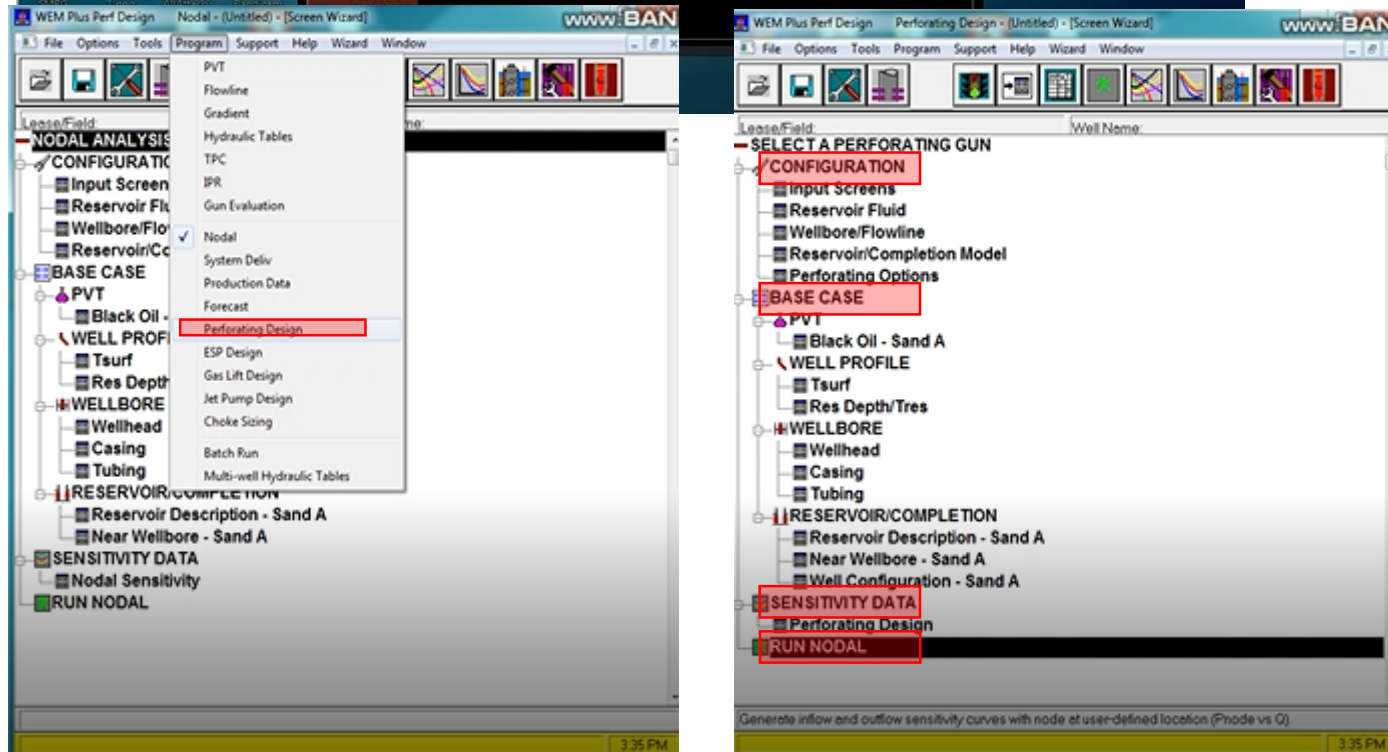
Date: January 2020

CONFIGURATIONS - SELECT WELL PROGRAM



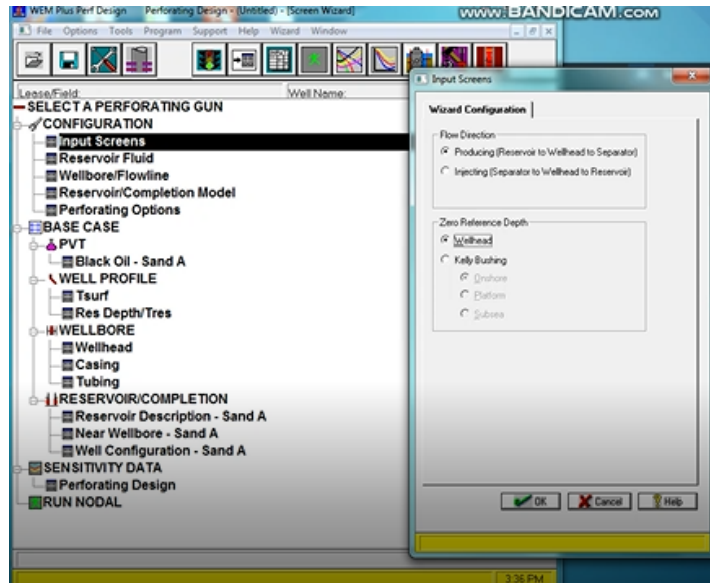
1. Open WEM 11.2.11
2. Click **Screen Wizard** > OK
Note: Screen Wizard represents all input screens required to make a run.
3. Go to Program > Select **Perforating Design**.

Note: There are 3 Group of Program. In the middle section of the dropdown menu, there are 8 programs which consist the Perforating Design.



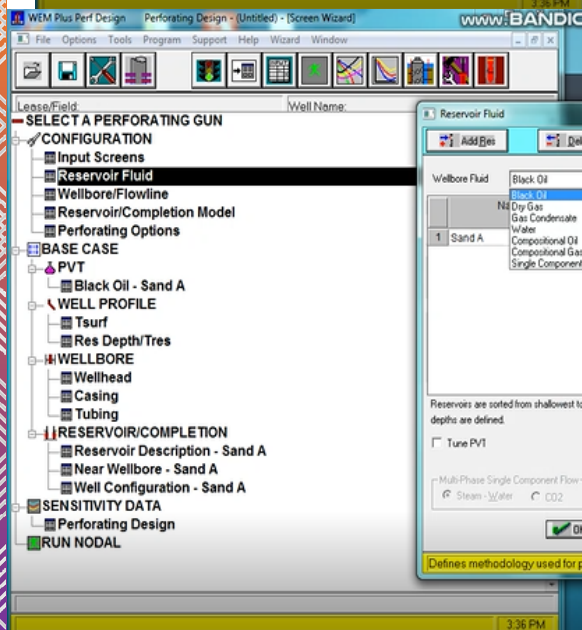
4. The selected program comprised 4 main branches: **CONFIGURATIONS, BASE CASE, SENSITIVITY DATA & RUN NODAL.**

INPUT SCREEN / RES FLUID



1. Flow Direction > **Producing (Reservoir to Wellhead to Separator)**
2. Zero reference depth > **Wellhead**

Note: reference datum as either the wellhead or the Kelly rig bushing. If Kelly bushing option is selected, all actual lengths in the well are corrected back to the wellhead for calculation purposes. The reference depth has no influence on the Flowline profile.



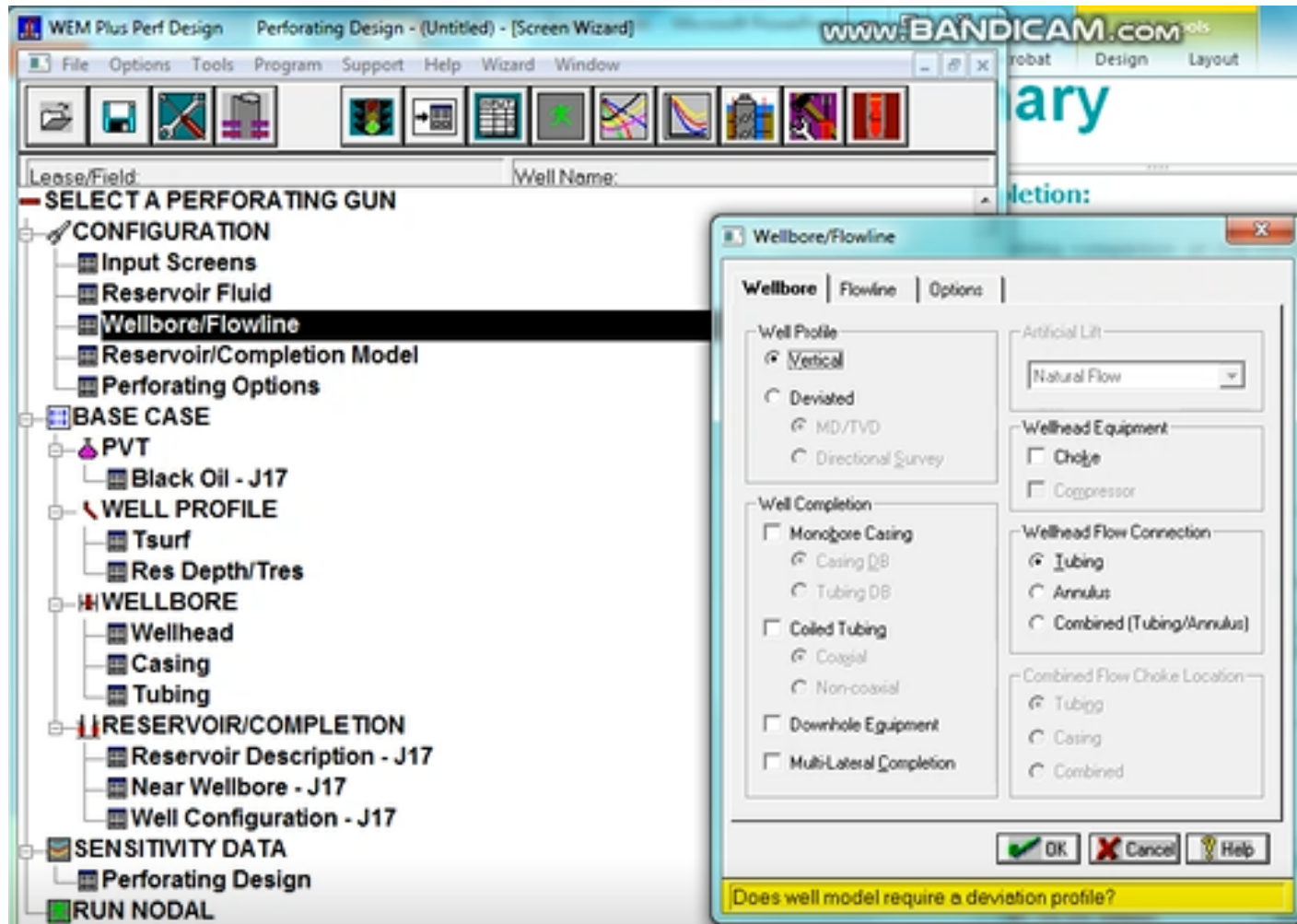
Executive Summary

Location: Bekok-B, Offshore Peninsular, PM9E PSC		Completion: Single string completion at J18/19/20 Zone		
Well Status: Active well.		Latest Production Test: (Latest Well Test from J18/19/20 - Dec 2007)		Cum Production: 8.1 MMstb (Sep 2018)
Diagnosis:				
<ul style="list-style-type: none"> BeB02 well is a single oil producer, completed in J18/19/20 reservoir. It started production in April 1990 with initial rate of 2500.00 bbl/d of oil and zero Water Cut (WC). BeB02 was shut in since 1998 due to 100% WC. Well was re-tested on 2007 and was confirmed 100% WC. Based on BeB02 log, there is an opportunity to perforate J17 sand as a pilot for J17 sand which is as Low-Resistivity and Low-Contrast Candidate. 				
Job Proposed:				
To shut off J18/19/20 zone and perforate J17 zone.				
Gain: 325 bbl/d of oil (instantaneous)	Cost: RM 0.99 Million	NPV@9%: RM 56.99 Million	IRR: High	Payout: 0

3. Choose Reservoir Fluid that is expected to be produced – this will define the PVT model used. You may refer to the job proposal.

4. Rename sand accordingly.

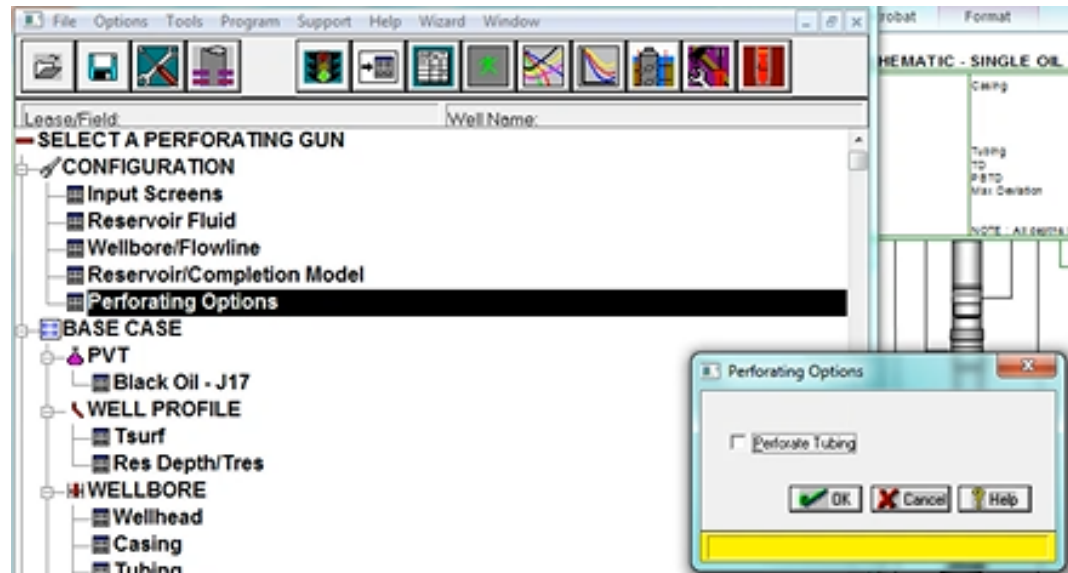
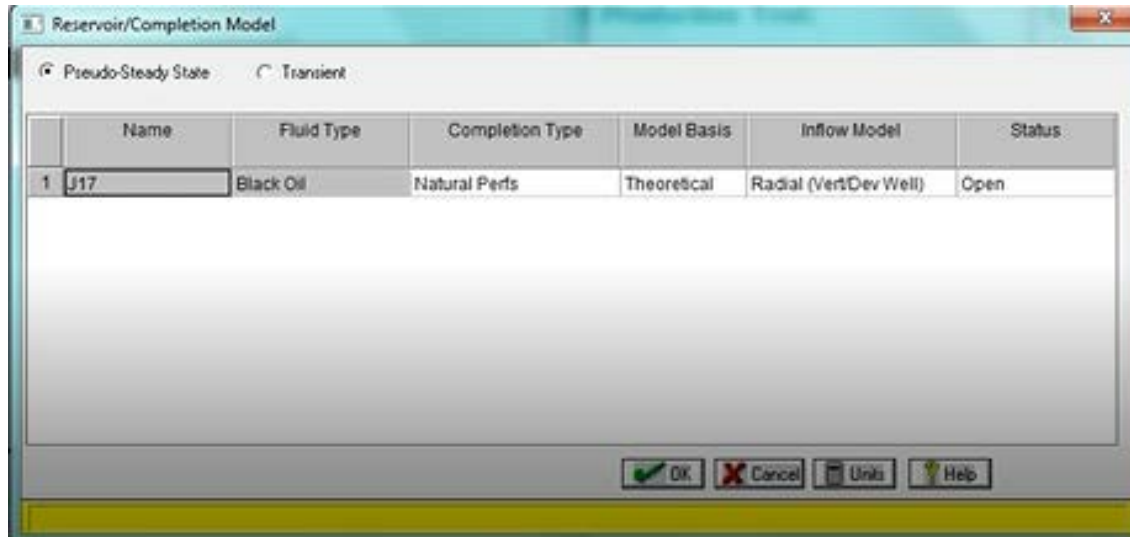
WELLBORE/FLOWLINE



1. Wellbore/flowline config screen provides choices for configuring the flow system that connects bottom hole to the end of flowline. For this simulation, choke size and flowline will be an option as it can be adjusted during sensitivity (if known or specific request by client). If choke or flowline been chosen, you need to input all the data for both (next tab).
2. For this section, tick only **well profile and wellhead flow connection**.

Note: Downhole equipment is generally for all accessories downhole installed such as SSD, TRSV etc. This will counted later on the pressure losses for Outflow Calculation.

RES/COMPLETION MODEL



1. Completion type describes method used to establish flow communication between reservoir and wellbore.
2. Completion Type – **Natural Perfs**.
3. Model Basis – **Theoretical** (distinguish between formation pressure drop and completion pressure drop with no welltest data available).
4. Inflow Model – **Radial / Horizontal** (based on well trajectory).
5. Status – **Open** (*must set 'Open' otherwise could not run the model*).
6. Perforating Options – tick if perforate through tubing. If perf directly to casing, leave the box unchecked.

The image shows a software interface for configuring a well case. On the left, a tree view shows the configuration hierarchy: Lease/Field, Well Name, SELECT A PERFORATING GUN, CONFIGURATION, Input Screen, Reservoir Flow, Wellbore/Flow, Reservoir/Completion, Perforating, BASE CASE, PVT (selected), Black Oil, WELL PROFILE, Tsurf, Res Depth, WELLBORE, Wellhead, Casing, Tubing, RESERVOIR, Reservoir, Near Well, Well Conf, SENSITIVITY D, Perforating, and RUN NODAL.

The 'Black Oil - J17' dialog box is open, showing the following input fields:

- Stock Tank Oil/Water: Oil Gravity (47.90 deg API), Percent Water (0.0 %), Water Gravity (1.060)
- GOR Input Option: Recombined (selected), Separator, Bubble Point
- Recombined Gas: Recomb GOR (2500.0 scf/stb), Gas Gravity (1.050 air=1), Mole % CO2 (0.870), Mole % N2 (0.410), Mole % H2S (0)

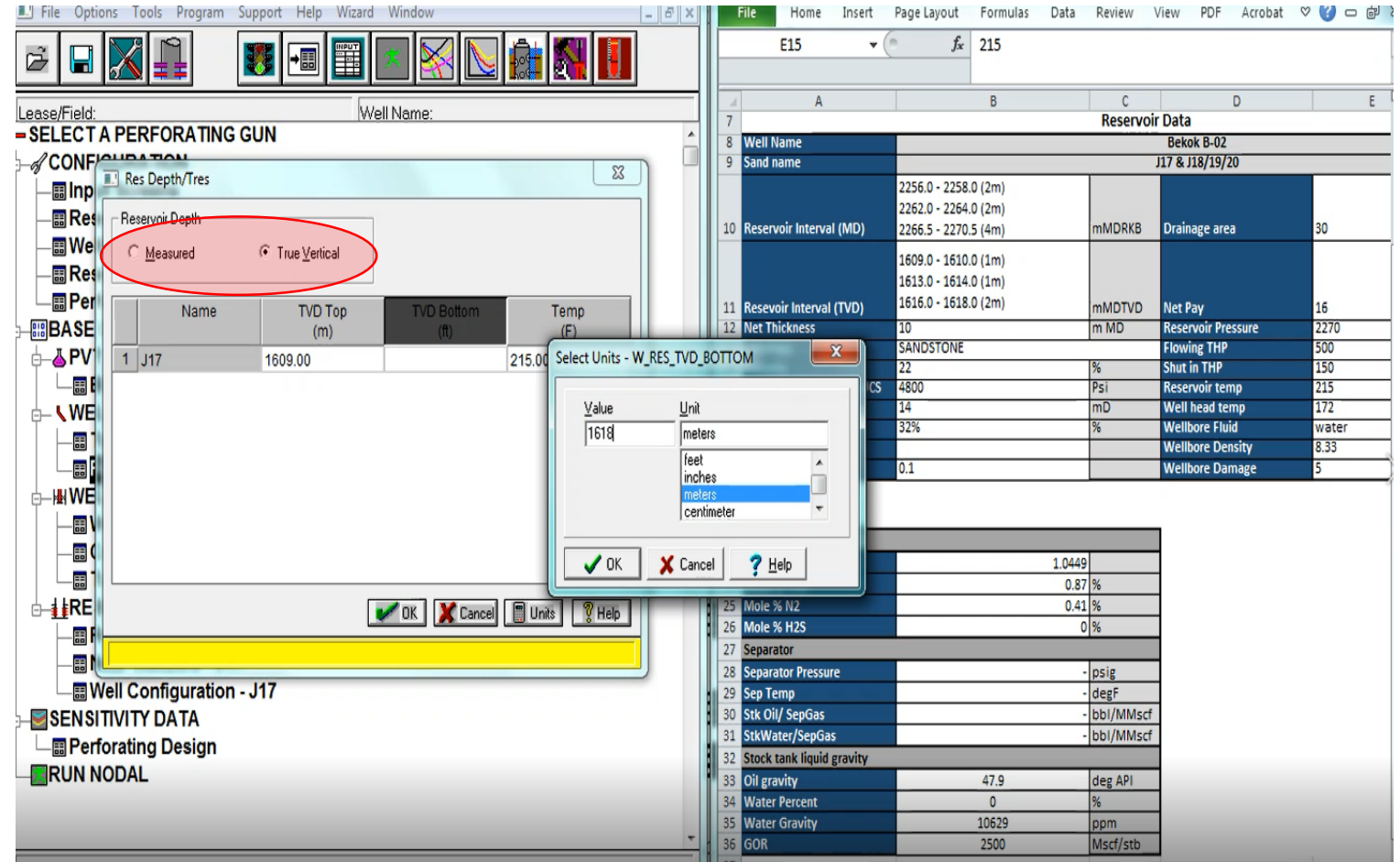
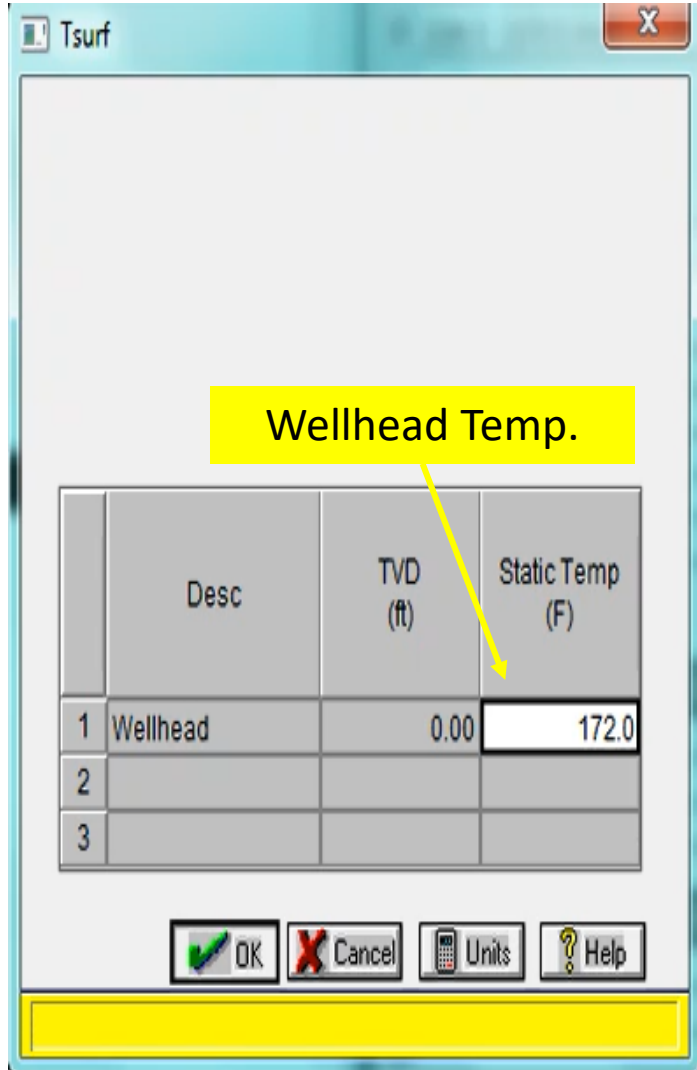
A schematic diagram shows a wellbore with a separator and a stock tank. Labels include 'Recomb GOR', 'Psc', 'Tsc', and 'Free Gas Dissolved Gas'.

On the right, a spreadsheet displays the following data:

Reservoir Data				
Well Name	Bekok B-02			
Sand name	J17 & J18/19/20			
Reservoir Interval (MD)	2256.0 - 2258.0 (2m) 2262.0 - 2264.0 (2m) 2266.5 - 2270.5 (4m)	mMDRKB	Drainage area	30
Reservoir Interval (TVD)	1609.0 - 1610.0 (1m) 1613.0 - 1614.0 (1m) 1616.0 - 1618.0 (2m)	mMDTVD	Net Pay	16
Net Thickness	10	m MD	Reservoir Pressure	2270
Lithology	SANDSTONE			
Porosity	22	%	Shut in THP	150
Compressive strength, UCS	4800	Psi	Reservoir temp	215
Permeability	14	mD	Well head temp	172
Net/Gross	32%	%	Wellbore Fluid	water
kd/k			Wellbore Density	8.33
kh/kv	0.1		Wellbore Damage	5

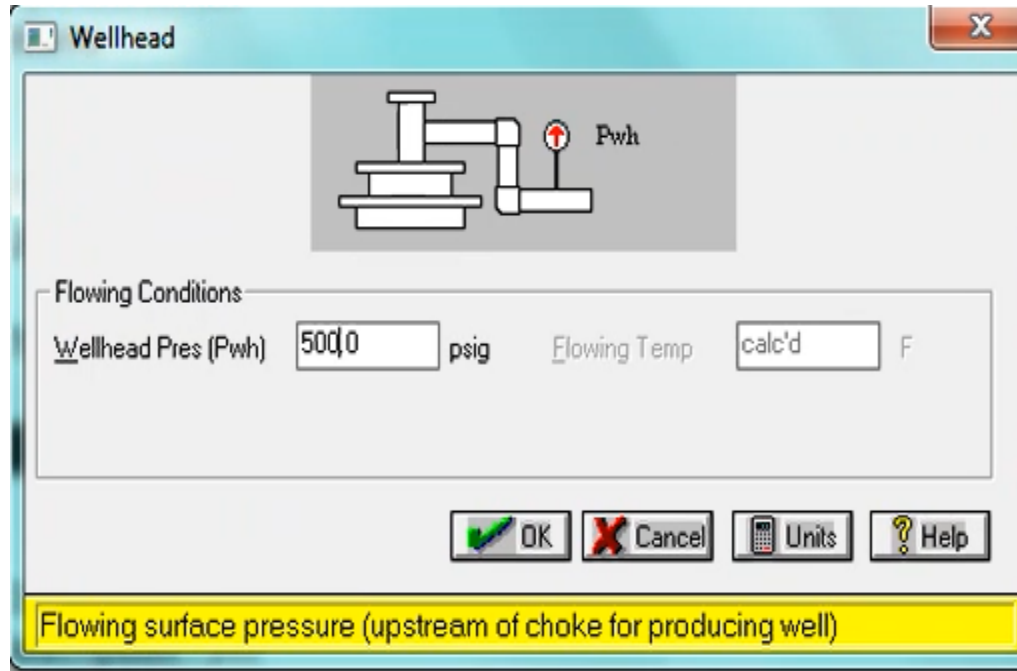
PVT Data		
Gas Mixture		
Gas Gravity	1.0449	
Mole % CO2	0.87	%
Mole % N2	0.41	%
Mole % H2S	0	%
Separator		
Separator Pressure	-	psig
Sep Temp	-	degF
Stk Oil/ SepGas	-	bbl/MMscf
StkWater/SepGas	-	bbl/MMscf
Stock tank liquid gravity		
Oil gravity	47.9	deg API
Water Percent	0	%
Water Gravity	10629	ppm
GOR	2500	Mscf/stb

Refer to the data that filled by client on WEM Input Template and fill in the PVT accordingly.

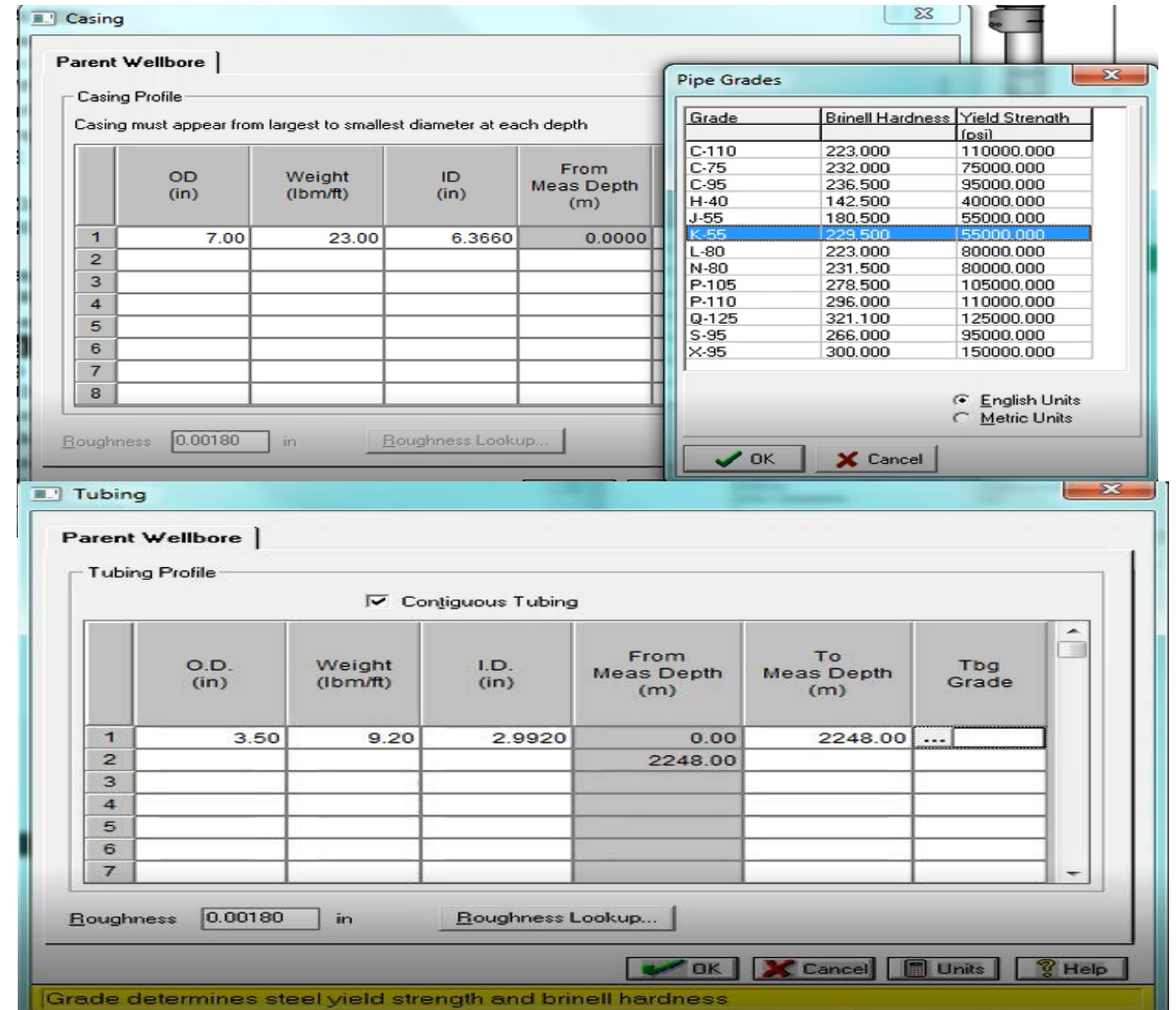


Res Depth/Tres – Fill up both Perforation depth in ‘Measured’ & ‘TVD’.

WELL PROFILE



Pwh – Flowing THP



Fill up the casing and tubing details as per well schematic provided

RESERVOIR DESCRIPTION

Reservoir Description - J17

Reservoir Pressure psig Temperature F

Rock Data | Geometry | Future IPR Effects

	TVD to Top (m)	TVD to Btm (m)	Lithology	Net/Gross (%)	Perm (md)	Poros (%)
1	1609.00	1618.00	Sandstone	32.00	14.00	22.00

Add Before Add After Delete

Anisotropic Properties
Kh/Ky

OK Cancel Units Help

Reservoir Description - J17

Reservoir Pressure psig Temperature F

Rock Data | **Geometry** | Future IPR Effects

Drainage Area

Radius ft Borehole Diam in

Area acre Shape Factor Shape Factor Lookup...

Net Pay Option

User Entered

Net Pay ft Meas Net Pay ft

Calculate from Wellbore Geometry and Reservoir Orientation

Reservoir Orientation

Dip Azimuth deg

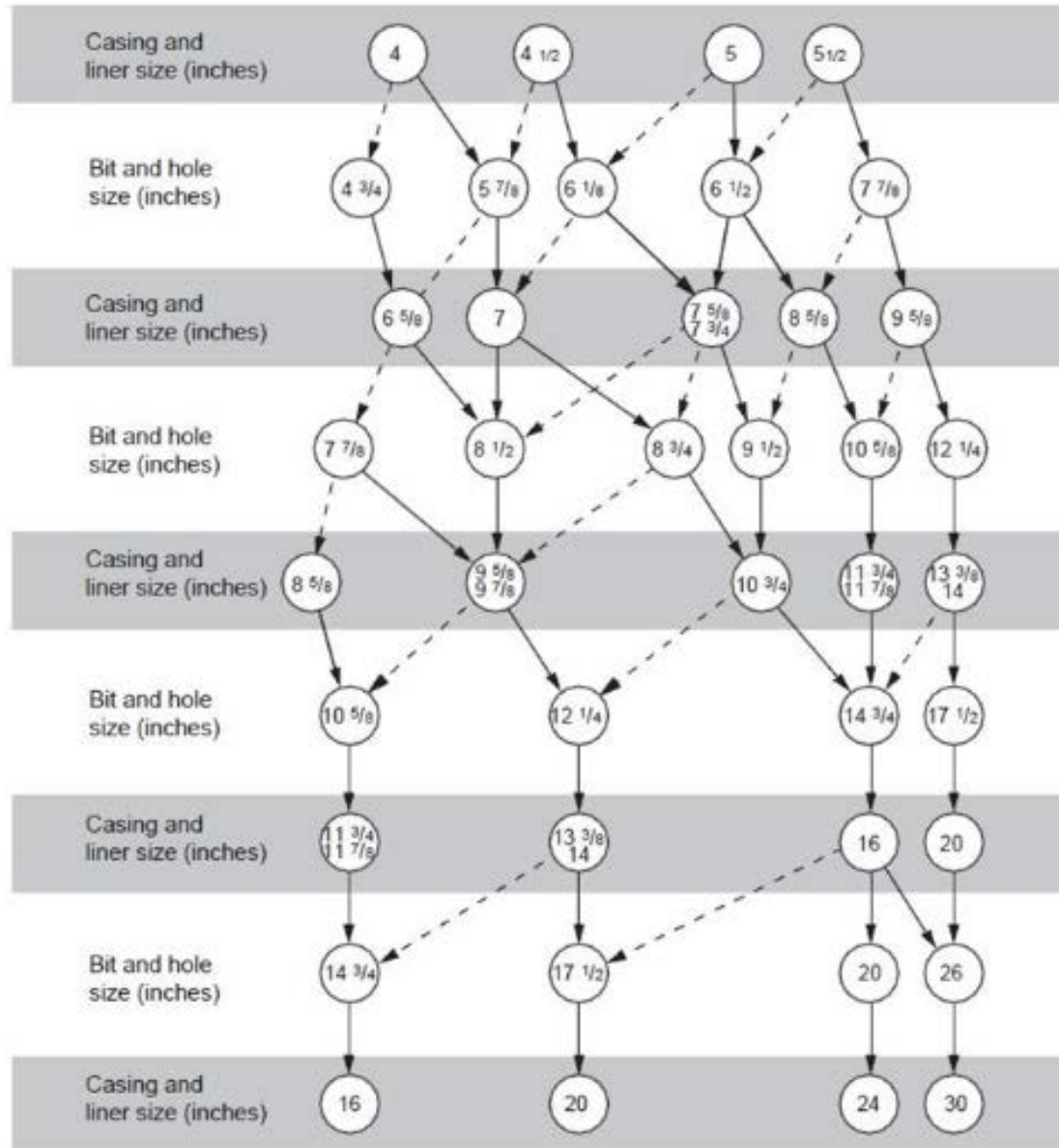
Inclination deg

OK Cancel Units Help

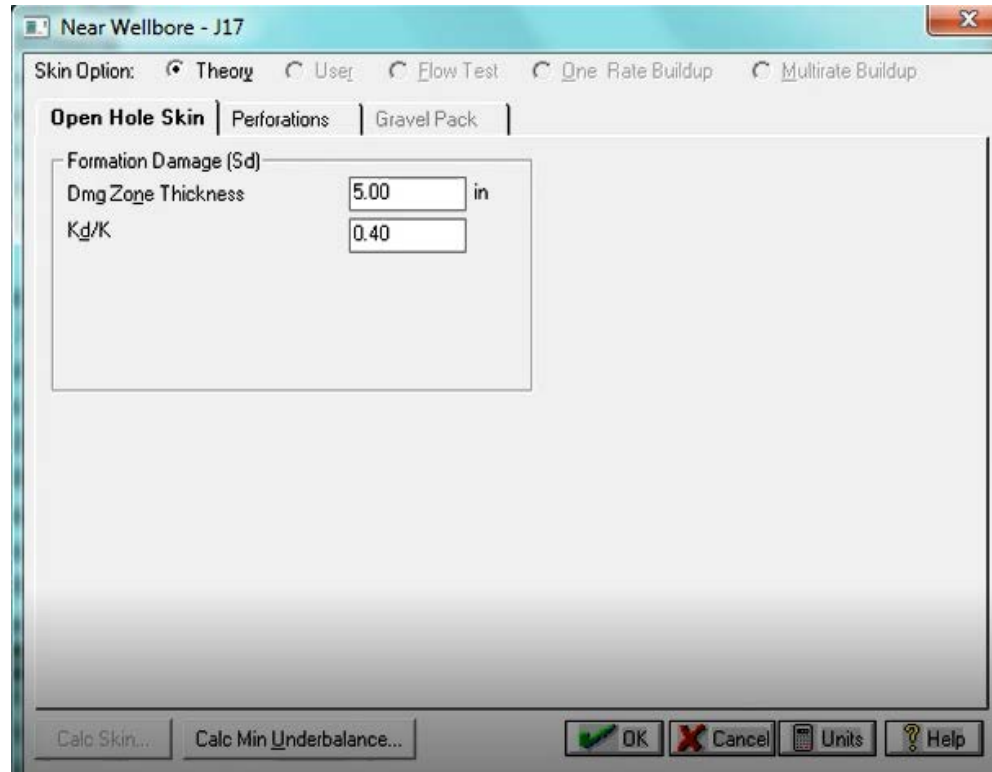
Fill up the reservoir details for rock data and geometry. You may refer to drill bit size chart for borehole diameter if no information provide by client.

Note: For radius of drainage area, minimum value is 150ft.

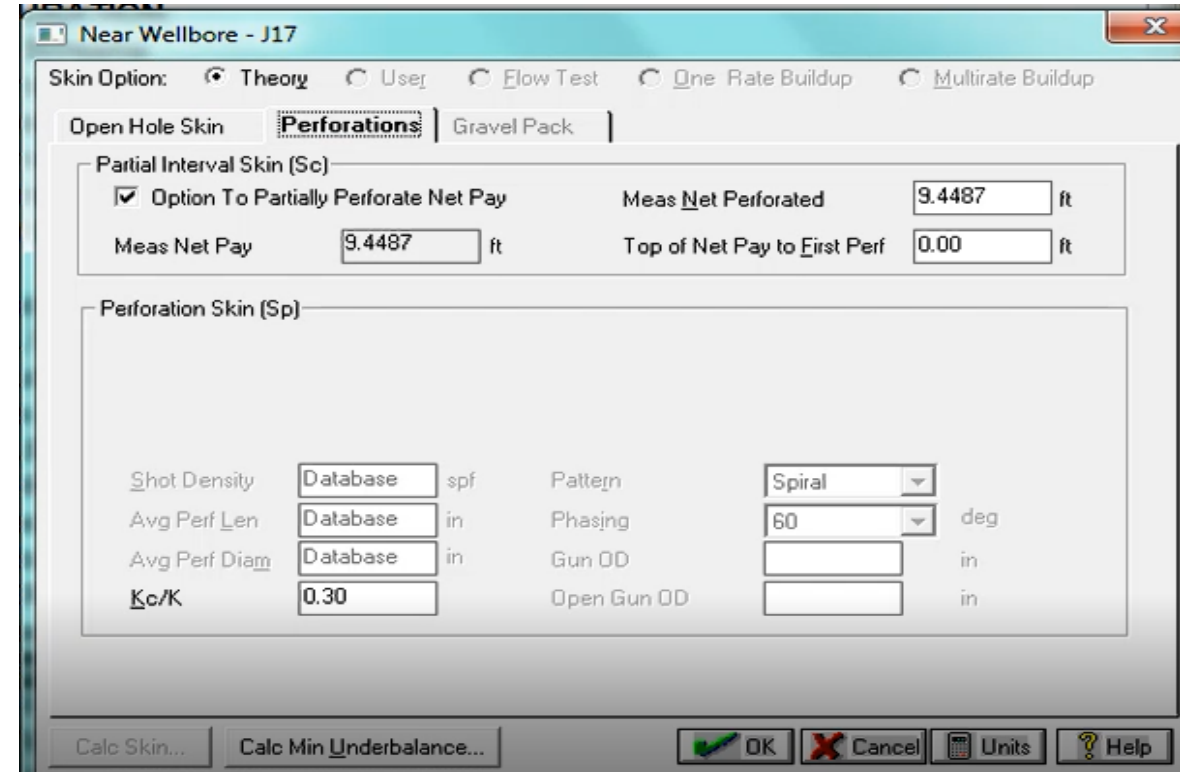
RESERVOIR DESCRIPTION



Use straight line as primary bit size and dotted line as secondary bit size.



Fill in formation damage zone thickness and K_d/K (ratio of permeability in damage zone to virgin zone).
Note: Use default value of 6" for damage zone thickness and 0.40 for the ratio.



Tick partial skin (Sc) if you're intended to partially perforated the zone. If no, leave the box unchecked.

Cut the video from 3:15mins to 7:31mins – not using

WELL CONFIGURATION

Well Configuration - J17

Completion Fluid: Water
Completion Fld Den: 8.330 lbm/gal

Centralized Casing

<----- Annulus Exterior to Csg ----->

	Standoff (in)	Csg Grade	Material	Fluid Den (lbm/gal)	Cmt C.S. (psi)
7.00 in Csg	0.750	K-55	Cement		3500.00
8.50 in Borehole					

Overburden Gradient: 1.00 psi/ft
Effective Stress: 5155.35 psi

Formation Compr Str: [] psi
Calc from Porosity

Buttons: Diagram, OK, Cancel, Units, Help

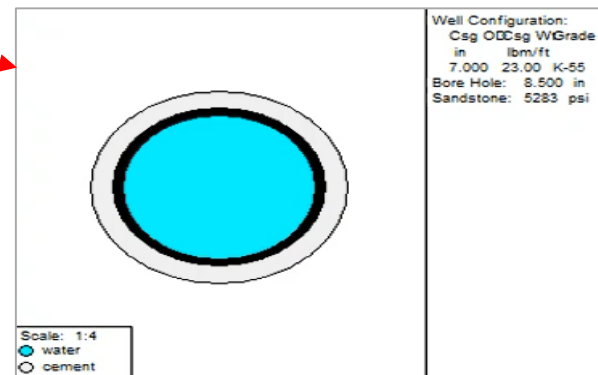
Current wellbore fluid and density (ppg) inside the tubing/casing during the perforation job –[Water/diesel/mud/gas](#).

Input referring to tubular annulus (exterior to casing). Eg. Behind 7" casing is cement thus cement compressive strength input is required. If you choose water, then the water density is required.

Note: If you are perforating through tubing, where you tick perforated tubing (in Perforating Options @ configuration setup branch), the tubing size will appear here. Therefore, you will need to define type of material for both tubing and casing.

Formation CS: use as per input from client; IF no info, it can be calculated from porosity.

Click on Diagram to check if your wellbore configuration setup is OK (without gun).



Blue: Water (completion fluid inside the wellbore where your gun is)

Black: Casing

Grey: Cement

WELL CONFIGURATION

CemCRETE Type	Density		Vp (m/s)	acoustic impedance (MRayl)	Compressive Strength (psi)
	(kg/m3)	(ppg)			
LiteCRETE-2	1.20	10.0	2694	3.23	1500
LiteCRETE-3	1.40	11.8	2883	4.04	2100
LiteCRETE-4	1.46	12.2	2870	4.19	2100
LiteCRETE-5	1.54	12.8	2988	4.60	3500
SqueezeCRETE-1	1.68	14.0	2822	4.74	5500
SqueezeCRETE-2	1.68	14.0	2988	5.02	3700
SqueezeCRETE-3	1.68	14.0	2419	4.06	2000
LiteCRETE UL-1	1.03	8.6	2540	2.62	1400
LiteCRETE UL-2	1.03	8.6	2566	2.64	1420
LiteCRETE UL-3	1.04	8.7	2117	2.20	760
LiteCRETE UL-4	1.04	8.7	2490	2.59	1400
LiteCRETE UL-5	1.04	8.7	2674	2.78	1950
LiteCRETE UL-6	1.04	8.7	1954	2.03	320

CemCRETE Type	Density		Vp (m/s)	acoustic impedance (MRayl)	Compressive Strength (psi)
	(kg/m3)	(ppg)			
G + Silica-1	1.90	15.8	2822	5.36	3500
G + Silica-2	2.00	16.7	2988	5.98	4200
G Neat	1.90	15.8	2822	5.36	3000
CemCRETE-1	2.00	16.7	3256	6.51	5550
CemCRETE-2	2.00	16.7	3256	6.51	5000
CemCRETE-3	2.00	16.7	2988	5.98	3600
CemCRETE-4	2.00	16.7	2822	5.64	5200
CemCRETE-5	2.00	16.7	3098	6.20	3300
DensCRETE-1	2.30	19.2	3024	6.95	4500
DensCRETE-2	2.50	20.8	3387	8.47	6000
DensCRETE-3	2.50	20.8	3175	7.94	5000
DuraSTONE	2.08	17.4	3387	7.00	8000
FlexSTONE-1	2.00	16.7	3387	6.77	5000
FlexSTONE-2	2.00	16.7	2761	5.52	2750
FlexSTONE-3	2.00	16.7	2702	5.40	2000
LiteCRETE-1	1.20	10.0	2679	3.22	1400

Typical SLB cement properties – can be use as guideline as well. If there is no info from completion report, use G-cement properties with 15.8 ppg and cement CS 3500 psi.

1. On the Rates tab – use **Auto Range**
2. Click Gun Database tab, click filter to choose gun manufacturer.
3. Click other gun parameters tab to filter gun size or shape charges type.

Perforating Design

Rates | Gun Database | Outflow Sensitivity

Rates

Auto Range

Enter minimum/maximum and increment

Minimum rate: bbl/d

Maximum rate: bbl/d

Rate increment: bbl/d

Enter list of values

Initialize list with min/max above

Rates | **Gun Database** | Outflow Sensitivity

Gun Database: Surface Perf Depth and EH

	Co	Trade Name	Gun OD (in)	Part Number	Lp (in)
1	DYNAE	DW 114mm-16,5spm-60, 4	4.5000	2327051	73.51
2	Owen	4.5"OD, TAG, 5-60, 39G, HER	4.5000	SDP-4539-410	71.91
3	Owen	4"OD, TAG, 5-60, 39G, HER	4.0000	SDP-4539-410	68.06
4	Owen	7" OD, TAG, 12SPF, 135/45,	7.0000	SDP-4539-410	67.98
5	SWS	4.50-in. PURE High Shot De	4.5000	100019791	67.44

Select Gun | View API... | Plot Gun | Columns... | **Filter...** | Print | Sort By: Lp

Selected Guns for IPR Sensitivity: Surface Perf Depth and EH

	Plot Name	Depth (in)	EH (in)	Ns (spf)	Charge Pattern	Phasing (deg)

Deselect | View API... | Plot Gun | Calc Skin...

Gun Company | Other Gun Parameters

Available Gun Companies

- BVT, JSC
- Chartered Oiltech Services
- Chuannan Machinery Manufacturing
- Daqing Perforating Charge Plant
- Directional Wireline Services
- DYNAenergetics GmbH & Co. KG**
- ETA
- GEODynamics
- Geoinform Ltd
- GOEX International, Inc.
- IBP Company Limited
- Innicor Perforating Systems
- Jet Research Center
- Jilin City Shuanglin Perforation
- JSC VNIPIvzryvgeophysica
- NKMZ
- North Schlumberger Oilfield Tech
- NTF PerfoTech, CJSC
- Oilfield Production Services
- Oiltech Services Pte Ltd
- Owen Oil Tools
- Perfolink, LLC
- PerfoTech STF, JSC
- Dromperforator Ltd

Selected Gun Companies

- DYNAenergetics GmbH & Co. KG
- Titan

Gun Company | Other Gun Parameters

Gun Type

Hollow Carrier, Port Plug

Hollow Carrier, Expendable

Semi-Expendable

Fully Expendable

API Report Type

RP 43 19B

Explosive

RDX HNS HTX

HMX PYX SX1

Charge

DP BH GH

Gun Outer Diameter

Minimum: 2 in

Maximum: 4 in

Certification

All Data

Current

Out of Date (before 1/14/19)

SENSITIVITY DATA

Rates **Gun Database** | Outflow Sensitivity

Gun Database: Surface Perf Depth and EH

	Co	Trade Name	Gun OD (in)	Part Number	Lp (in)*	EH (in)	Ns (spf)	Ch
5	DYNAE	DW51mm-20spm-60 for DV	2.0000	2323268	24.15	0.24	6.00	Spi
6	Titan	2" RTG, 6 spf 0 deg	2.0000	RTG-2106-420T	23.35	0.24	6.00	In L
7	Titan	2" RTG Low Swell Gun, 6 SF	2.0000	RTG-2104-421T	21.45	0.20	6.00	In L
8	DYNAE	2" / EHRG	2.0000	2314658	19.92	0.22	6.00	Spi
9	DYNAE	2" EHRG	2.0000	2314473	19.39	0.21	6.00	Spi

Select Gun View API... Plot Gun Columns... Filter... Print Sort By: Lp EH Gun OD Sort...

Selected Guns for IPR Sensitivity: Surface Perf Depth and EH

	Plot Name	Depth (in)	EH (in)	Ns (spf)	Charge Pattern	Phasing (deg)	Position	Standoff (in)	Rot (d)
1	PERFECTA	28.73	0.29	6.00	Spiral	60.0	Eccentered		
2	DP2	24.15	0.24	6.00	Spiral	60.0	Eccentered		
3	PER ORIENT	23.35	0.24	6.00	In Line	0.0	Eccentered		

Deselect View API... Plot Gun Calc Skin... Downhole Surface

Click select gun for the gun chosen and name the shape charges (SC) accordingly.

For this simulation, the type of SC are as below:

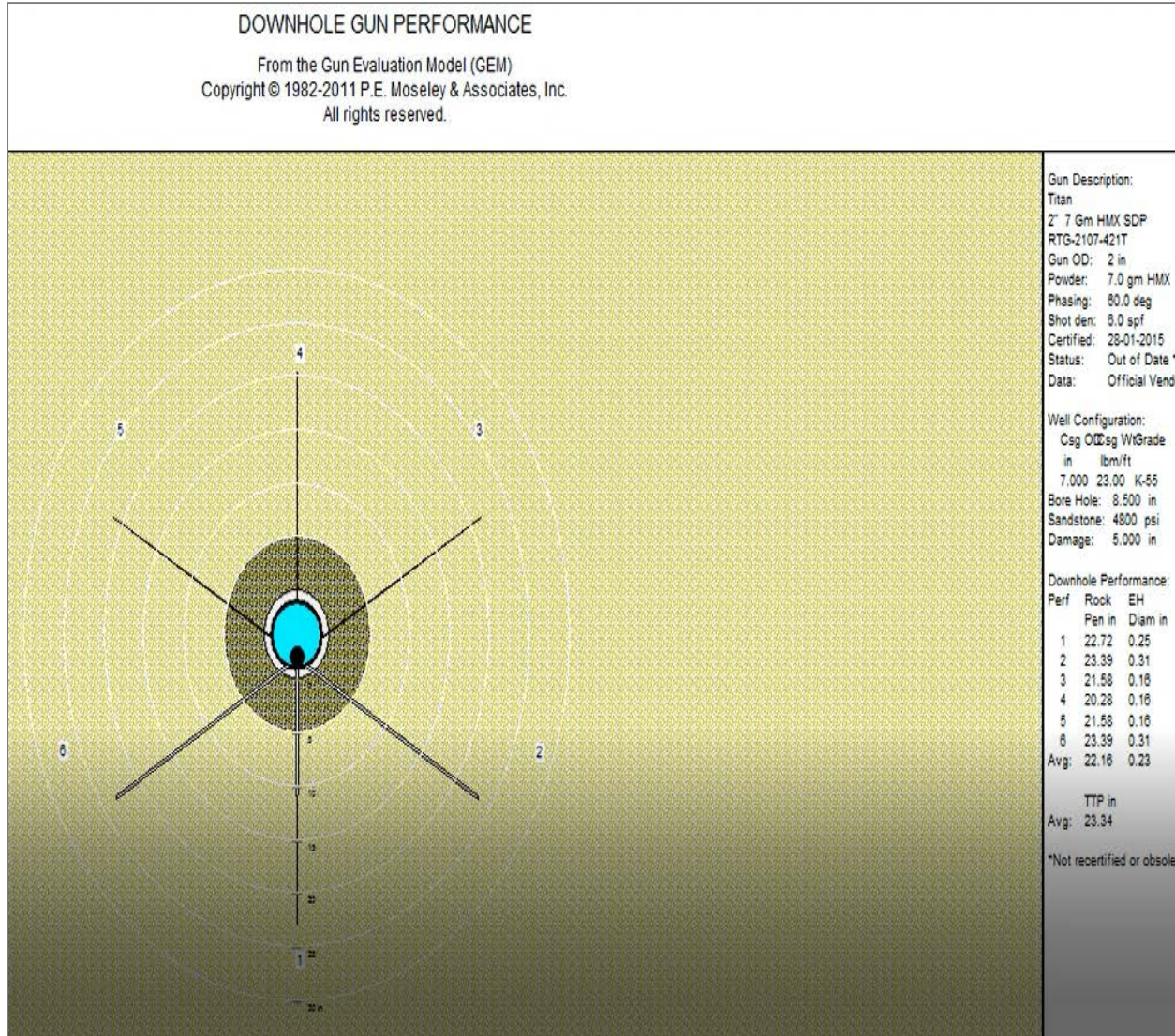
1. 2" PERFECTA, 6 SPF, 60 DEG Phasing
2. 2" DP2, 6 SPF, 60 DEG Phasing
3. 2" PERFECTA, 6 SPF, 0 DEG Phasing (Oriented Perf)

Click **View API** – to view each SC Performance according to API19B

Click **Plot Gun** – to view simulated gun plot summary for each SC Penetration Length and Entrance Hole Diameter.

Click **Calc Skin** – to view skin value.

SENSITIVITY DATA



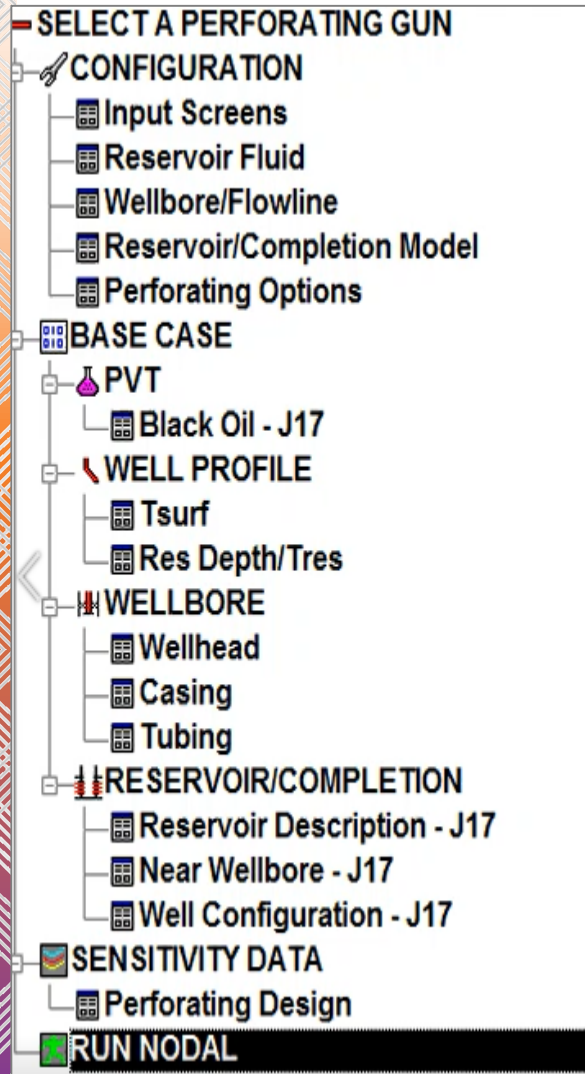
Gun Downhole Performance Plot can be view for 1 gun at a time. You may need to click at each selected gun to produce each report.

To save file: Go to Options and Print Auto Scale > PDF > Name the file (*Gun Performance Plot_PERFECTA_6SPF_60DEG*)

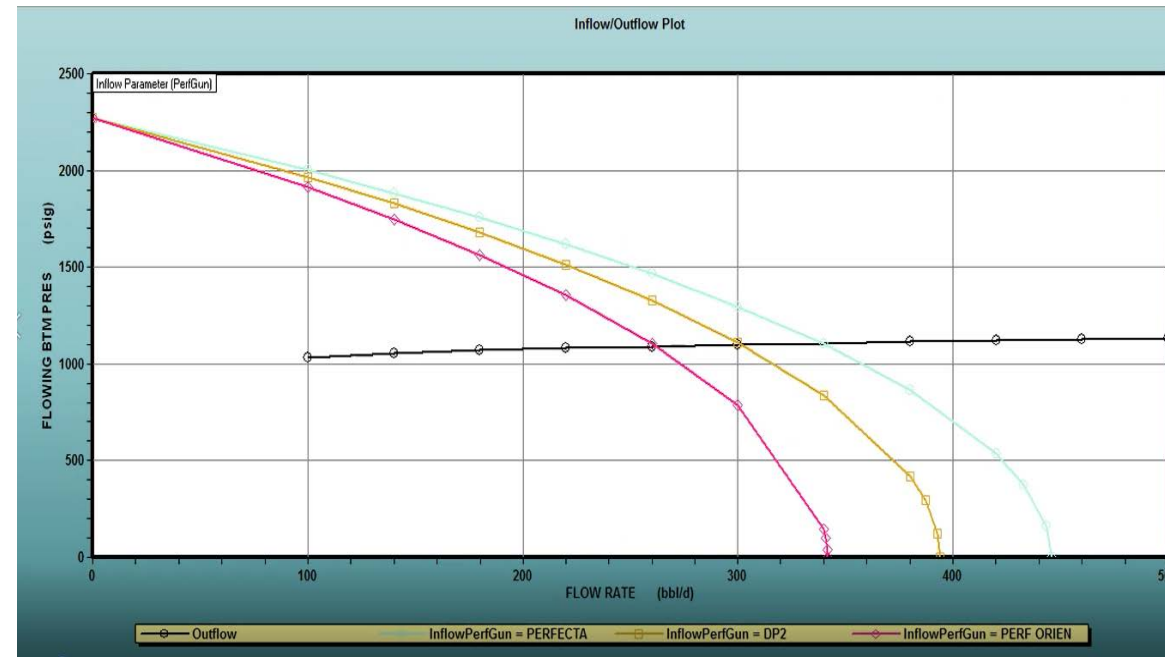
Go to [Other Plots > Tabular Results](#) to view detailed reports for the gun performance.

To save file: Go to Printer > PDF > Name the file (*PEM Tabular Report_PERFECTA_6SPF_60DEG*)

Note: Double check all the input in the summary prior to print the report(s).



1. Click Run Nodal – nodal couldn't be run until all input is fixed.
2. Once OK, the software will plot Inflow/Outflow Curves (FBHP vs Q).



To save file: Go to File > Import > Name the file > change format type to .BMP
(Inflow_Outflow Plot)

There are 3 input curves for selected SC and the intersection point of Inflow/Outflow curve is the estimated production rates (bbl/d) based on the base case you have input.

To view Nodal Report Summary, go to **View > View Tab Report > Detailed**

- All parameters input were summarized in the report as follow:
1. Fluid Properties
 2. Wellbore Data
 3. Reservoir Description
 4. Interval Profile
 5. Near Wellbore Data
 6. IPR/Tubing Performance Report for each inflow curve for perf gun.

```

*****
**                W E L L  E V A L U A T I O N  M O D E L  ( W E M )                **
**                I N P U T  S U M M A R Y                **
**                W E M  R e l e a s e  V 1 1 . 2 . 1 1                **
**                **                **
*****

Software by P.E. Moseley & Associates (http://www.pnoseley.com)

Lse/Fld :                               Date : 1/14/2020
Well   :                               Time  : 17:12:35

-----| FLUID PROPERTIES |-----
Oil Gravity      (deg API) = 47.90   Oil Vol Factor Corr = VAZQ
Gas Gravity      (air=1.0) = 1.050   Solution Gas Corr   = VAZQ
Water Gravity    (H2O=1.0) = 1.060   Oil Viscosity Corr  = ROBN
Produced GOR     (scf/bbl) = 2500.0   Oil/Water Vis Corr  = AVG
Percent Water    ( % ) = .0         Gas-Water Solubility = NO
Mole Percent N2  ( % ) = .41        Mole Percent CO2 ( % ) = .870
Mole Percent H2S ( % ) = .00
Pbp @ Tres      (psig) = 5001.09

-----| WELLBORE DATA |-----
Flowing WHD Pres (psig) = 500.0   Flowing WHD Temp    = HeatTran

a|
>> CASING/TUBING DESCRIPTION <<

```

To save file: Go to Printer > PDF > Name the file *(Inflow_Outflow Input Summary)*

-END OF SLIDE-

THANK YOU