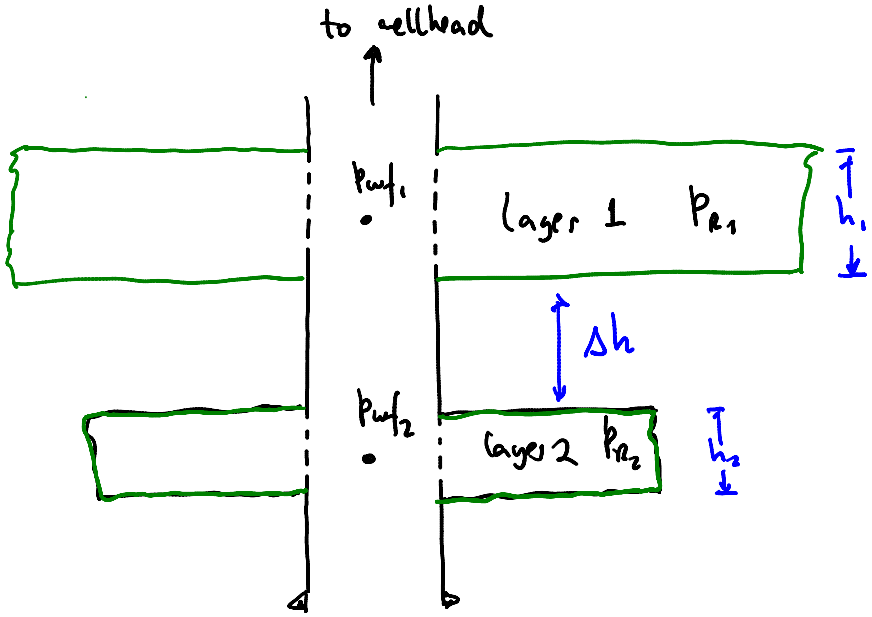
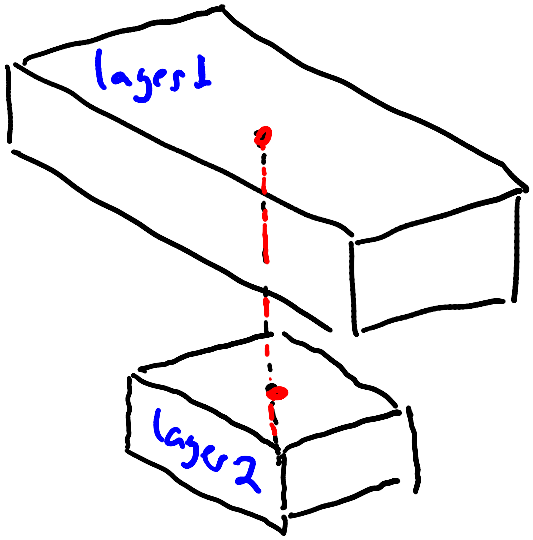
<u>Problem 1:</u> Planning a subsea well in the Alta-Gohta field

You are part of the well planning team in Lundin that is in charge to design a vertical production well for the Alta-Gohta field development. The plan is to produce two oil layers using the same well. The well will be fully perforated throughout each layer. The two layers contain undersaturated oil. Assume the wellbore radius is 8-1/2".



A reservoir engineer has determined, considering neighboring wells, structural seals, etc. that the drainage volume of the well can be approximated by two rectangular boxes that are vertically stacked one above the other.



The layers have different lengths, widths, and thicknesses (as shown in Table 1). There is a 100 m thick shale layer in between the two oil bearing layers.

	Layer 1	**Layer 2**
Thickness [m]	200	50
Length [m]	1000	500

Width [m]	800	400
Horizontal permeability [md]	150	400
Permeability anisotropy	20	10
Reservoir pressure [bara]	400	500

Samples were taken of each layer and the PVT expert has created tables of black oil properties Bo and oil viscosity for your use (available in the Excel file attached). Because the composition of each layer is slightly different, there is one BO table for each layer.

Due to the height difference between the layers, the flowing bottom-hole pressure of layer 1 is not the same as layer 2. The pressure difference between the bottom-hole pressures can be calculated using the hydrostatic oil column between 1 and 2. Assume that the bottom-hole location of each layer is located exactly in the middle of the layer.

Task 1.

Estimate the productivity index of each layer. To calculate the BO properties needed in the IPR equation, use the average between reservoir pressure and the bubble point pressure of the fluid (at reservoir temperature). Consider that the well is fully perforated throughout each layer.

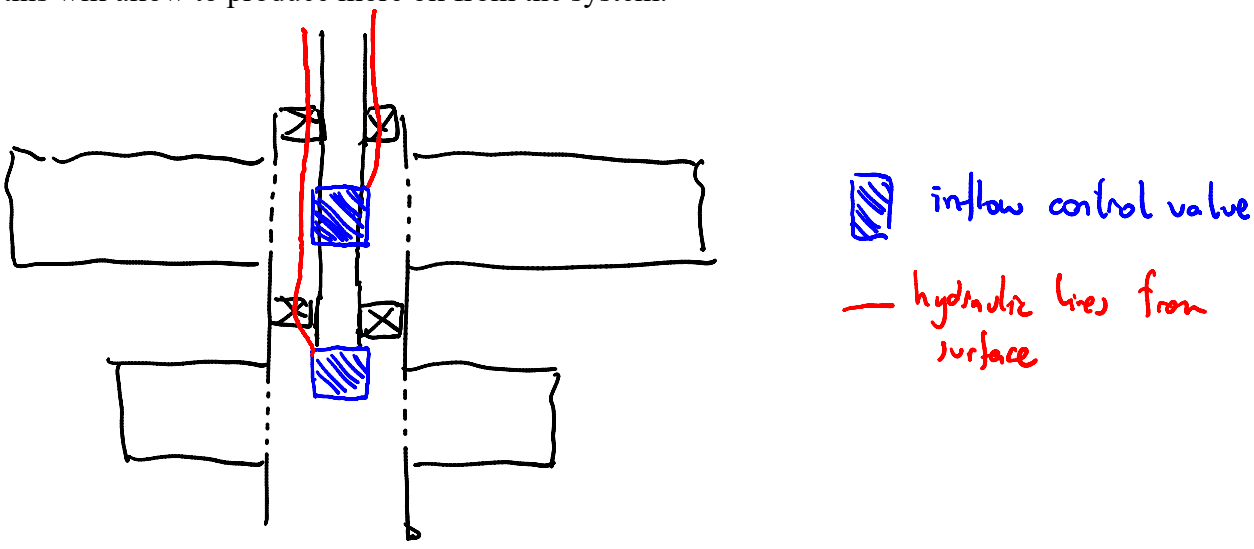
Task 2.

What is the maximum oil rate that can be produced from the well and the well GOR (R_p) while ensuring the two following conditions:

- There is no gas is liberated in the reservoir
- There is no gas liberated in the wellbore section from layer 1 to layer 2

Task 3.

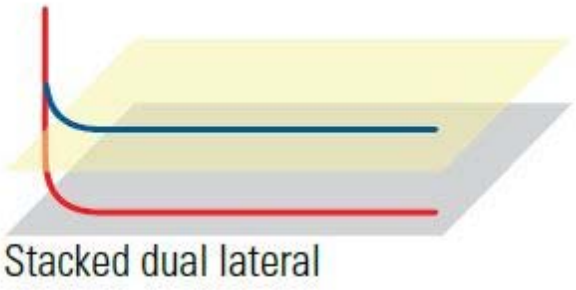
Based on the results from task 2, one of your colleagues has suggested to use an inflow control valve to regulate the inflow of each layer, by creating a pressure drop. The colleague claims that this will allow to produce more oil from the system.

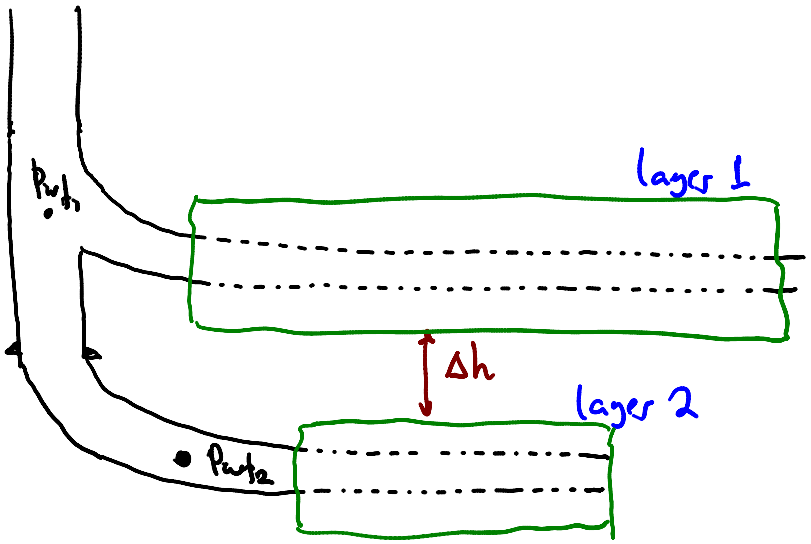


Do some calculations to verify the feasibility of this idea.

Task 4.

One of your colleagues is suggesting drilling a multilateral well with two stacked horizontal laterals, to produce the two layers, instead of a single vertical well.





In this case, assume the flowing bottom-hole pressure of each layer is constant along the lateral.

A multilateral well is expensive, riskier and more complex to drill, compared to a vertical well. Additionally, in this case, the multilateral well must be drilled from another location on the sea floor which adds some extra costs in subsea equipment. Therefore, the cost department has determined that the cost of drilling such a well could be almost twice the cost of the vertical well.

However, if a multilateral well gives higher oil rates, the well revenue will also be higher, which would make it a better option. The reservoir group has indicated that an X increase in initial rate will give roughly the same increase in well revenue.

Assume that the lateral is located in the center of the layer, and it is completed all across with a slotted liner.

Task 5. Effect of uncertainties

The value of horizontal permeability of each layer is highly uncertain. Formation tests have been performed on each layer using exploration wells, but the locations of the samples are far away the planned well location and the petrophysicist has indicated there is some permeability heterogeneity in the layers. He recommends using the following horizontal permeability range.

Horizontal permeability [md]	**Min**	**Max**
Layer 1	50	300
Layer 2	200	500

Additionally, due to formation damage (mud invasion) during the drilling process, one of your colleagues has mentioned that the skin of the vertical well could be of up to 5.

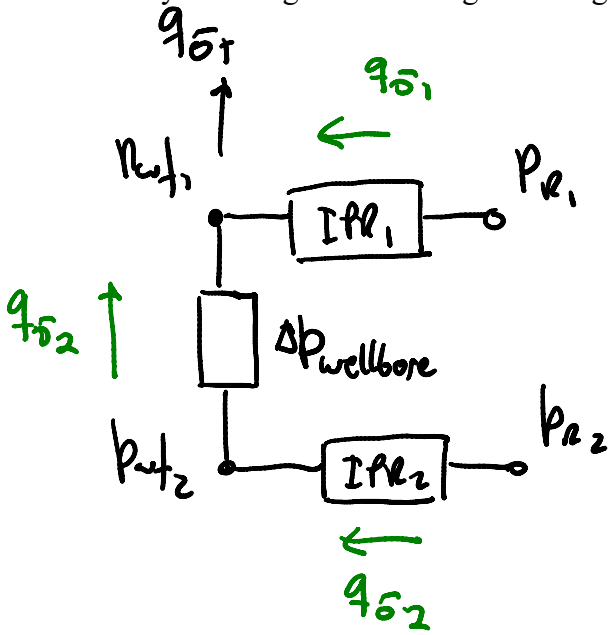
Does this change your conclusions regarding tasks 1-4 above?

Task 6.

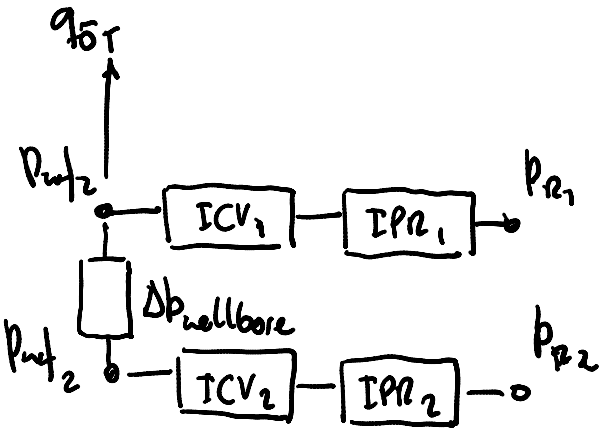
Each layer has slightly different oil composition. Because of these two BO tables have been provided for each layer. Provide some advice about what BO table should be used for the well flow downstream the bottom-hole location of layer 1?

Tips:

- Task 2. The vertical well configuration with two layers or the multilateral well with two horizontal laterals can be analyzed using the following flow diagram

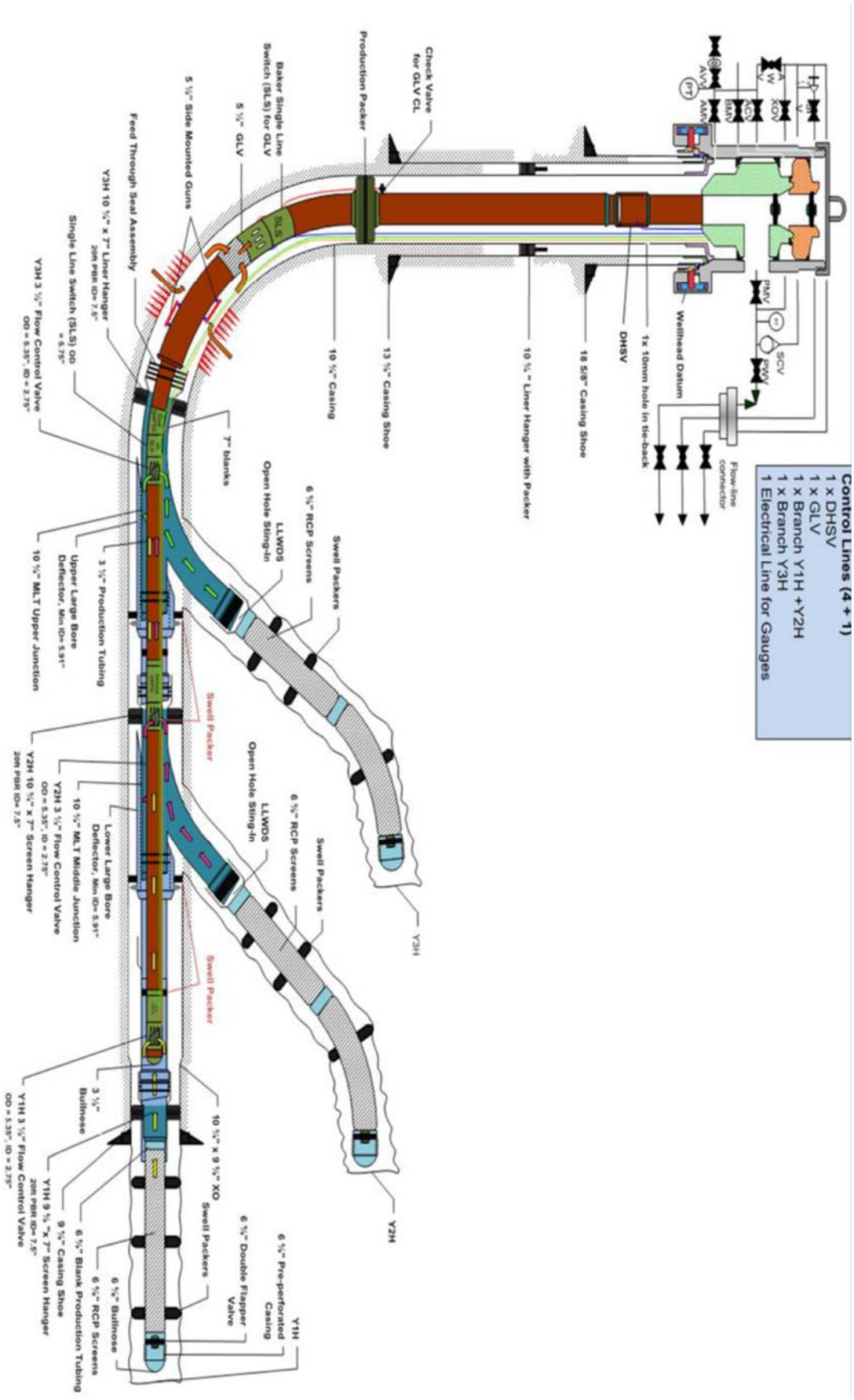


- Task 3. The vertical well configuration with ICVs can be analyzed using the following line diagram



Additional material

- Check out the completion diagram of a Troll well with three laterals (taken from SPE180037-MW):


Control Lines (4 + 1)
1 x DHSV
1 x GLV
1 x Branch Y1H +Y2H
1 x Branch Y3H
1 Electrical Line for Gauges
Wellhead Datum
1x 10mm hole in tie-back
DHSV
18 5/8" Casing Shoe
10 ¾ " Liner Hanger with Packer
13 ⅜" Casing Shoe
10 ¾" Casing
Production Packer
Check Valve for GLV CL
Baker Single Line Switch (SLS) for GLV
5 ½" GLV
5 ½" Side Mounted Guns
Feed Through Seal Assembly
Y3H 10 ¾" x 7" Liner Hanger
Single Line Switch (SLS) OD
Y3H 3 ½" Flow Control Valve
7" blanks
10 ¾" MLT Upper Junction
3 ½" Production Tubing
Upper Large Bore Deflector, Min ID= 5.91"
Open Hole Sting-in
LLWDS
6 ¾" RCP Screens
Swell Packers
Swell Packer
Y3H
Y2H 10 ¾" x 7" Screen Hanger
Y2H 3 ½" Flow Control Valve
10 ¾" MLT Middle Junction
Lower Large Bore Deflector, Min ID= 5.91"
3 ½" Bullnose
10 ¾" x 9 ⅝" XO
Y1H 3 ½" Flow Control Valve
Y1H 9 ⅝" x 7" Screen Hanger
9 ⅝" Casing Shoe
6 ¾" Blank Production Tubing
6 ¾" Double Flapper Valve
6 ¾" Pre-perforated Casing
Y1H
Y2H