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Numerical Simulation Project #2

Figure 1. Filled contour plot of reservoir OIL pressure at (a) initial (b)500 days, (c) 1826 days, and (d) 3987 days. Include a color bar (s) (with pressures labeled) and use appropriate range of pressures. Reservoir geometry should be obvious from your plots; use NaN for pressure outside of the reservoir boundaries.

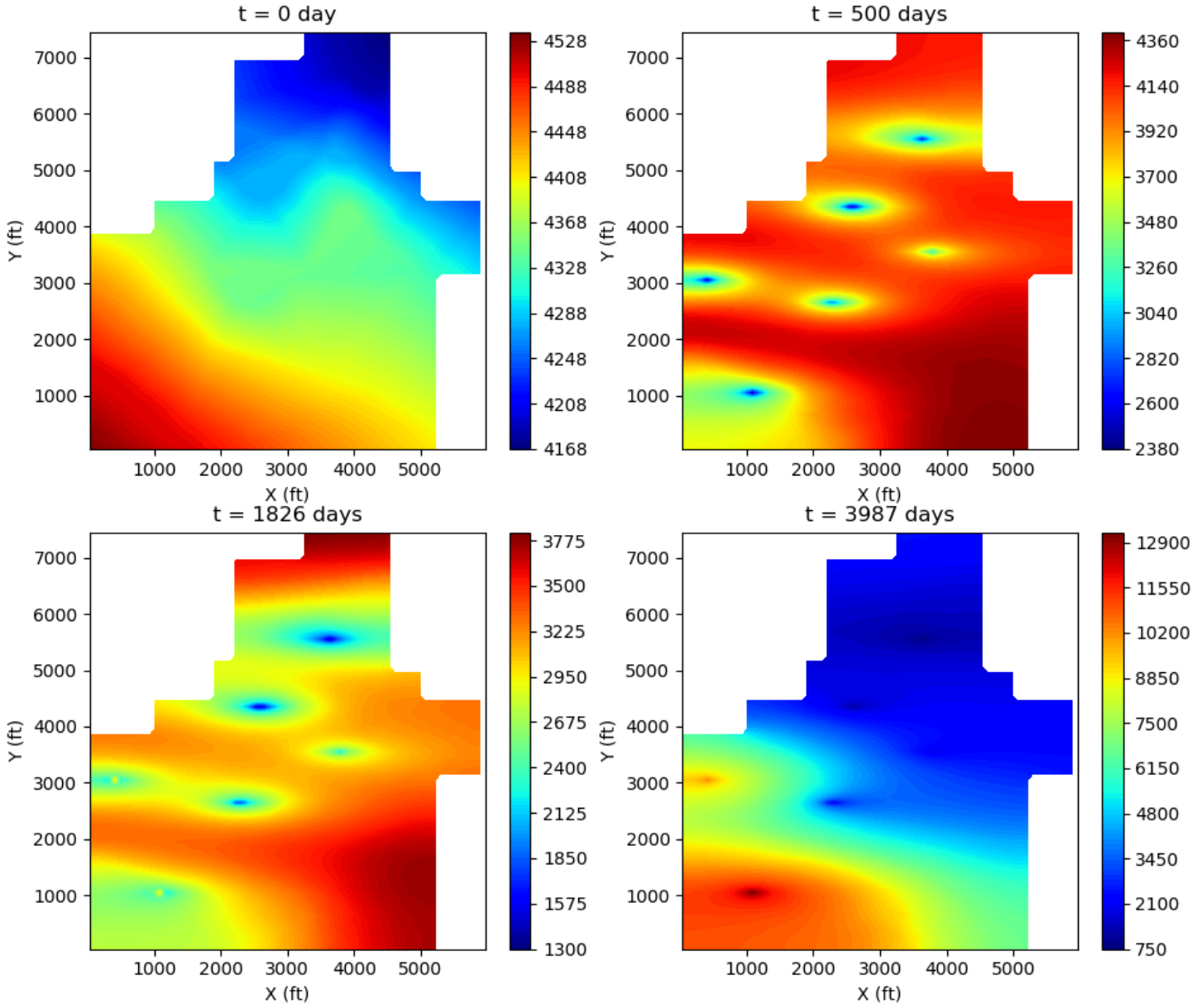


Figure 2. Filled contour plot of reservoir water saturation at (a) initial (b)500 days, (c) 1826 days, and (d) 3987 days. Include a color bar (s) (with water saturations labeled) and use appropriate range of water saturations . Reservoir geometry should be obvious from your plots; use NaN for pressure outside of the reservoir boundaries.

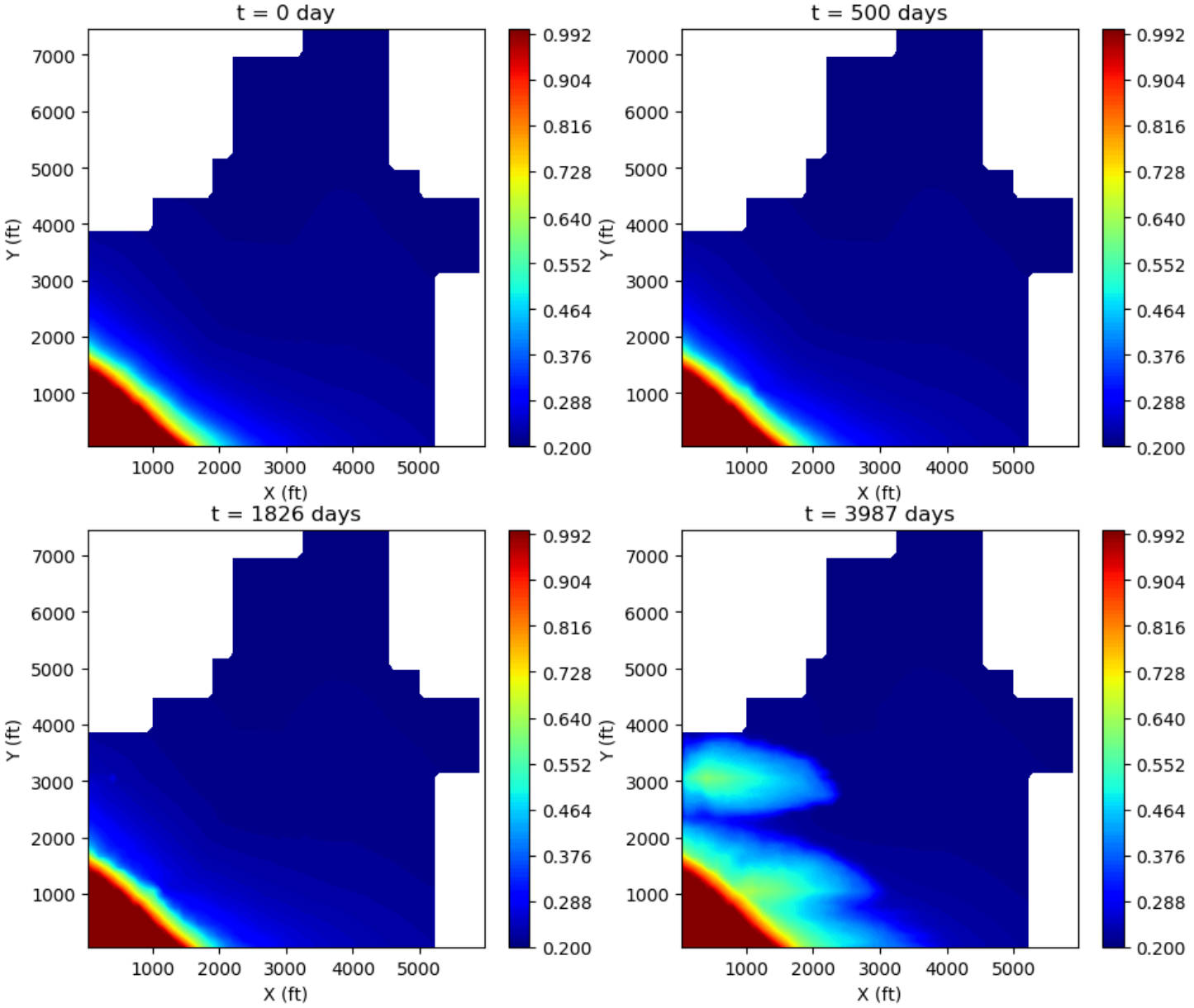


Figure 3. well flow rate (STB/day) versus time (days) for all 6 wells (include a legend). Both axis should be linear. Time scale should be 0 to ~4000 days.

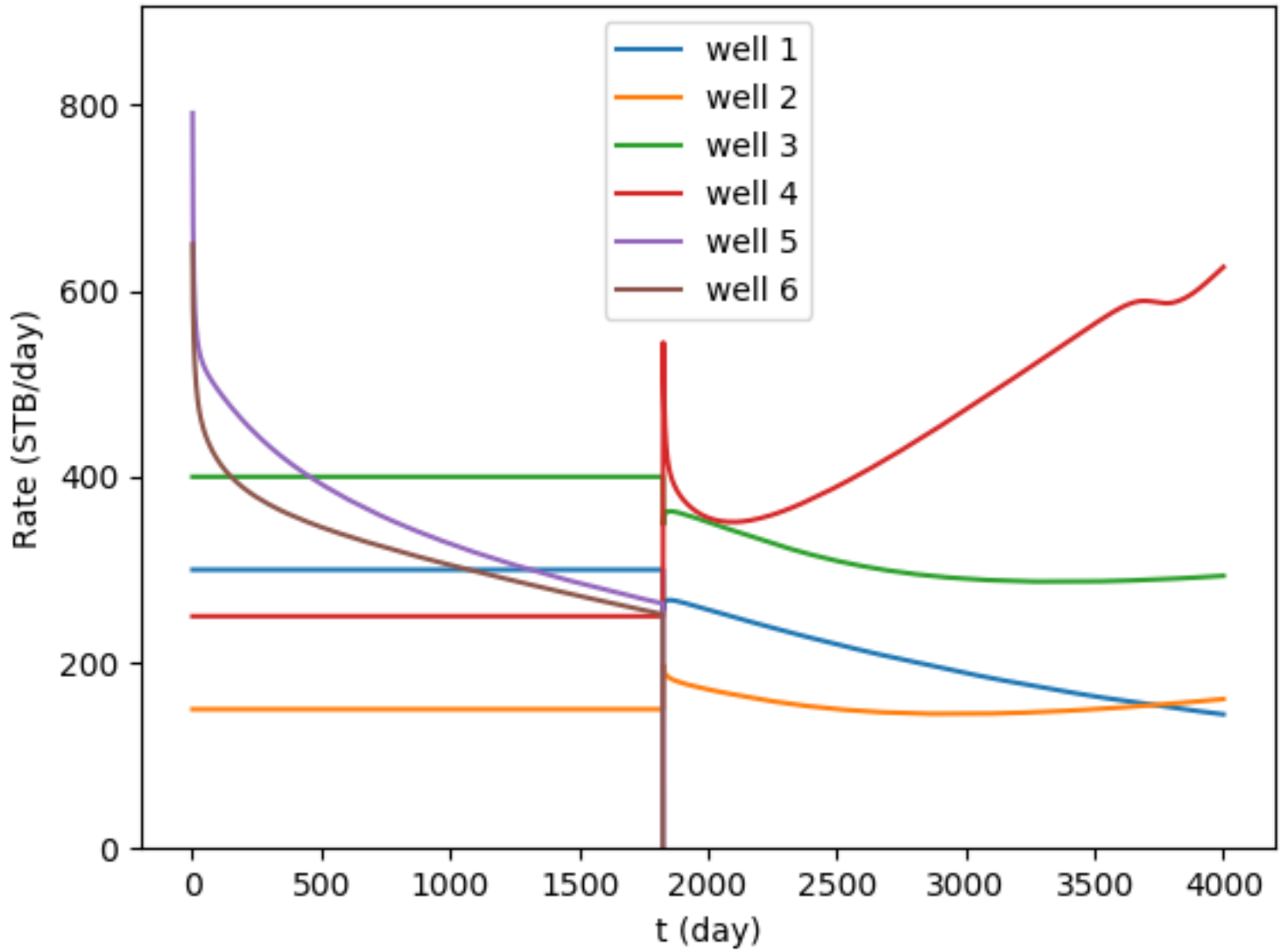


Figure 4. well water cut (%) at standard conditions versus time (days) for all 6 wells (include a legend). Both axis should be linear. Time scale should be 0 to ~4000 days and 0 to 100%.

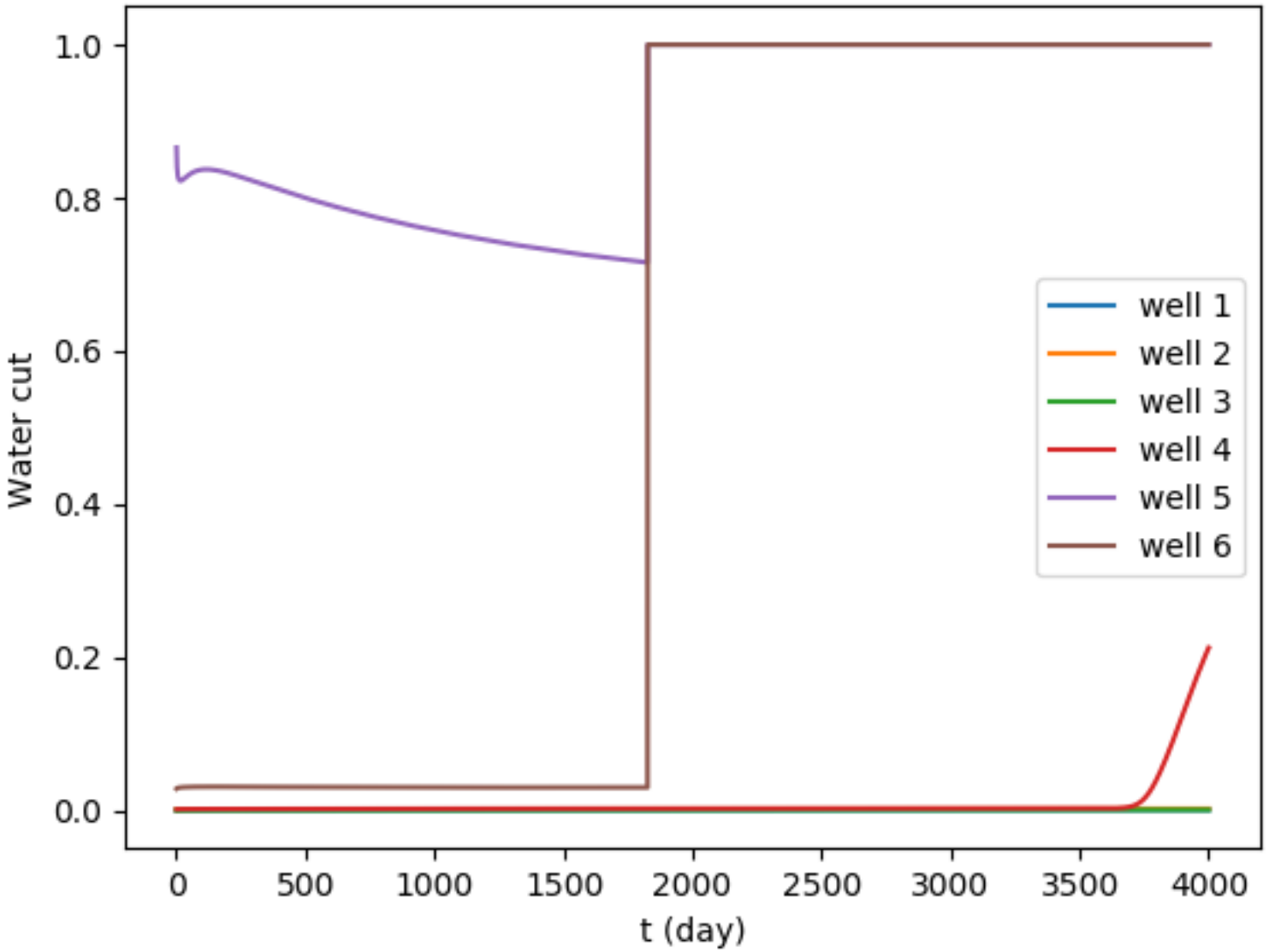
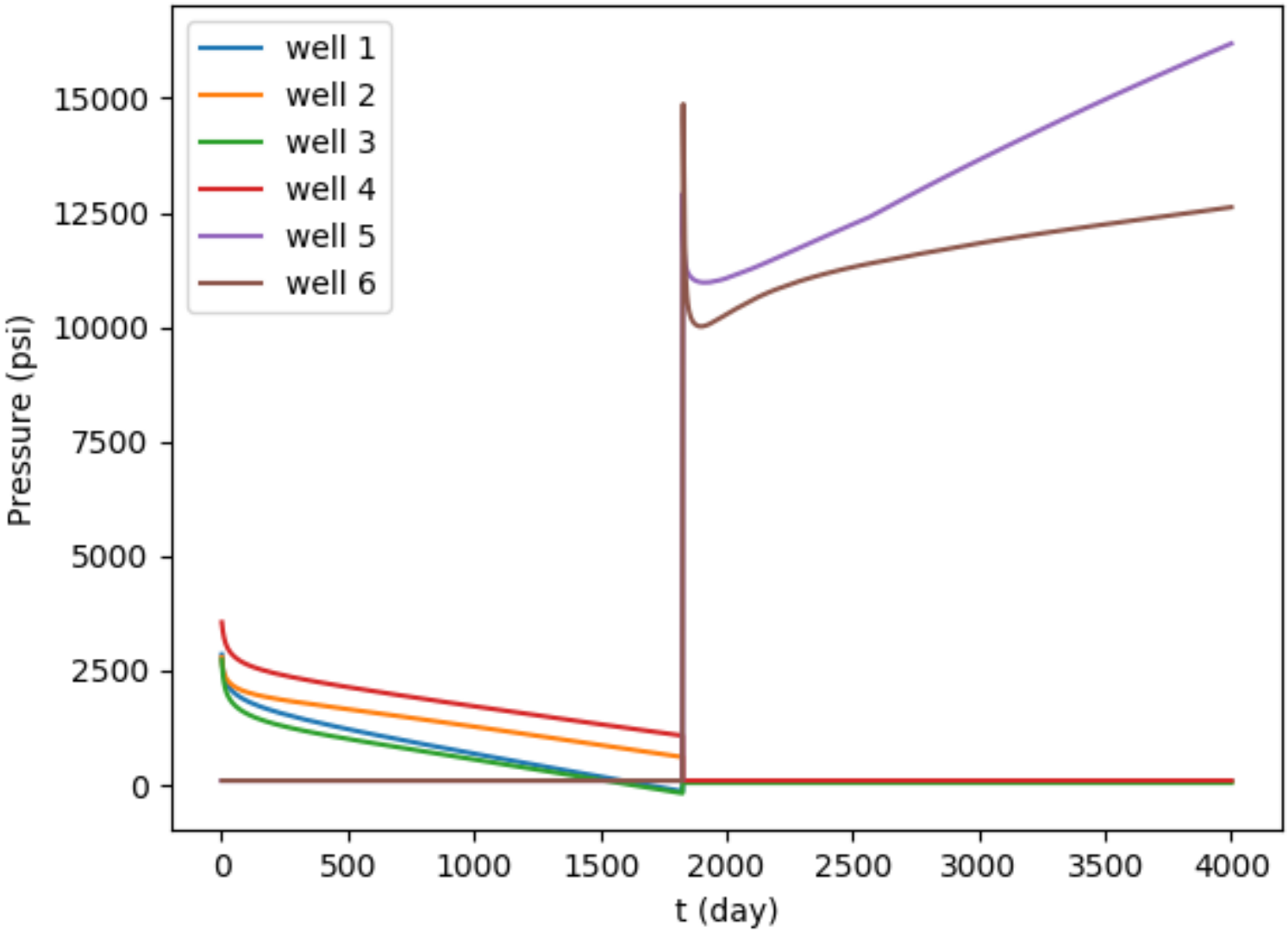


Figure 5. well bottomhole pressure (psi) versus time (days) for all 6 wells (include a legend). Both axis should be linear. Time scale should be 0 to ~4000 days.



Provide a screen shot of the portion of the code that computes interblock transmissibility including UPWINDING. I just need to see enough information to know how you completed this task

```
def RelaPermCalc(Sw):
    if Sw < para.Rel_P.Swcrit:
        Sw = para.Rel_P.Swcrit
    elif Sw > 1-para.Rel_P.Sorw:
        Sw = 1-para.Rel_P.Sorw
    S1 = (Sw-para.Rel_P.Swcrit)/(1-para.Rel_P.Swcrit-para.Rel_P.Soirw)
    krw = para.Rel_P.krw0 * np.power(S1, para.Rel_P.Nw)
    kro = para.Rel_P.kro0 * np.power(S1, para.Rel_P.No)
    return (krw,kro)


def Thalfy(i,j):
    temp = 2*6.33e-3 * para.res.ky[i] * para.res.ky[j] *para.block.dx * para.res.z[i] * para.res.z[j]
           / ((para.res.ky[i]*para.res.z[i] + para.res.ky[j]*para.res.z[j])*para.block.dy)
    if Poten[i] > Poten[j]:
        Sw_wind = Sw[i]
        Bo1 = Bo[i]
        mu_o1 = mu_o[i]
    else:
        Sw_wind = Sw[j]
        Bo1 = Bo[j]
        mu_o1 = mu_o[j]
    (krw,kro) = RelaPermCalc(Sw_wind)
    return (temp*krw/para.fluid.Bw/para.fluid.mu_w, temp*kro/Bo1/mu_o1)
```

Provide a screen shot of the portion of the code that shows how capillary pressure (imbibition) is included in the code

```
def Pc1(Sw, Pe, lamda):
    Sw[Sw <= para.Rel_P.Swcon] = para.Rel_P.Swcon + 0.0001
    Sw[Sw > 1 - para.Rel_P.Sorw] = 1 - para.Rel_P.Sorw
    S1 = (Sw - para.Rel_P.Swcon) / (1 - para.Rel_P.Swcon - para.Rel_P.Sorw)
    S2 = (Sw - para.Rel_P.Swcrit) / (1 - para.Rel_P.Swcrit - para.Rel_P.Soirw)
    return (Pe * (np.power(S1, -1/lamda) - 1)
            , -Pe / lamda / (1 - para.Rel_P.Swcrit - para.Rel_P.Soirw) * np.power(S2, -1/lamda-1))
    #returns Pc and dPc_dSw
```

Provide a screen shot of the portion of the code that computes the water and oil rates (e.g. water cut) in the code.

```
for i in r:
    Qw[i,0] = Qw_rate[i,0] + Jw[i,i] * (P_wf[i,0] - P[i])
    Qo[i,0] = Qo_rate[i,0] + Jo[i,i] * (P_wf[i,0] - P[i])
```

Table 1. Complete the following table. In some cases, the answer will be the same before and after the history match.

Well #		Your Solution	CMG
1	Block #	4449	4449
	Jw, Jo, and J (scf/day-psi)	Changing over time	N/A
	Initial Pressure (psi)	4263.5	4226.4
	Initial Water Saturation	0.2046	0.2248
	Oil Pressure (psi) at 500 days	2559.8	2437.2
	Sw at 500 days	0.2057	0.2251
	BHP at 500 days	1223.5	957.63
	Po at 1826 days	1283.4	1382.6
	Sw at 1826 days	0.2064	0.2254
	BHP at 1826 days	14.7	14.7
2	Jw, Jo, and J (scf/day-psi)	Changing over time	N/A
	Initial Pressure (psi)	4343.3	4318.3
	Initial Water Saturation	0.2096	0.2266
	Oil Pressure (psi) at 500 days	2559.8	3051.2
	Sw at 500 days	0.2057	0.2268
	BHP at 500 days	1659.0	1447.22
	Po at 1826 days	1283.4	2175.2
	Sw at 1826 days	0.2064	0.2268
	BHP at 1826 days	614.4	525.49
3	Jw, Jo, and J (scf/day-psi)	Changing over time	N/A
	Initial Pressure (psi)	4283.4	4249
	Initial Water Saturation	0.2054	0.2249
	Oil Pressure (psi) at 500 days	2552.6	2389.1
	Sw at 500 days	0.2066	0.2252
	BHP at 500 days	1010.3	725.02
	Po at 1826 days	1446.7	1567
	Sw at 1826 days	0.2072	0.2253
	BHP at 1826 days	14.7	14.7

Table 1. Complete the following table. In some cases, the answer will be the same before and after the history match.

Well #		Your Solution	CMG
4	Block #	2110 2111 2112	2110 2111 2112
	Jw, Jo, and J (scf/day-psi)	Changing over time	N/A
	Initial Pressure (psi)	4344.9	4320
	Initial Water Saturation	0.2098	0.2273
	Oil Pressure (psi) at 500 days	2906.4	2830
	Sw at 500 days	0.2109	0.2283
	BHP at 500 days	2141.0	2424.35
	Po at 1826 days	1882.7	1898
	Sw at 1826 days	0.2117	0.2299
	BHP at 1826 days	1080.9	1060.61
5	Jw, Jo, and J (scf/day-psi)	Changing over time	N/A
	Initial Pressure (psi)	4487.0	4484.3
	Initial Water Saturation	0.4369	0.4402
	Oil Pressure (psi) at 500 days	2385.3	2333.3
	Sw at 500 days	0.4094	0.4146
	BHP at 500 days	100	100
	Po at 1826 days	1858.1	1844.8
	Sw at 1826 days	0.3852	0.3930
	BHP at 1826 days	100	100
6	Jw, Jo, and J (scf/day-psi)	Changing over time	N/A
	Initial Pressure (psi)	4430.0	4418.4
	Initial Water Saturation	0.2358	0.2747
	Oil Pressure (psi) at 500 days	2386.0	2420.3
	Sw at 500 days	0.2358	0.2717
	BHP at 500 days	150	150
	Po at 1826 days	1814.9	1887.3
	Sw at 1826 days	0.2352	0.2680
	BHP at 1826 days	150	150

Grading Rubric

	Description	Points Possible	Received
Code	Code is well written and easy to follow, read, edit, and run. The code is flexible and allows for changes in inputs for a specific reservoir. Code runs quickly by employing sparse storage and written efficiently	15	
Heterogeneities	Interblock transmissibilities are calculated correctly. This includes the inclusion of UPWINDING for relative permeability	10	
Depth and Pc	Reservoir pressures and saturations are initialized properly and gravity/imbibition are modeled correctly in the simulator	5	
Wells	Variable number and location allowed. May be producer or injector and can follow a schedule. Constant rate or bottomhole pressure. Both vertical and horizontal wells possible. Relative amounts of water and oil (i.e. water cut) are properly calculated.	10	
Pressure plots	Filled contour plots of the oil pressure field in the reservoir for the application problem are included at the 4 times. The plots should mimic the actual reservoir geometry (i.e. not show the “inactive” regions”)	10	
Saturation plots	Filled contour plots of the water saturation field in the reservoir for the application problem are included at the 4 times. The plots should mimic the actual reservoir geometry (i.e. not show the “inactive” regions”)	10	
Well plots	Accurate plots of well rates, BHP, and WATER CUT versus time for every well. Include units	20	
Table	Values in the table (see ppt) are correct, +/-5%. (it is possible to lose points here and the original place, e.g. if the reservoir was not initialized properly).	20	
TOTAL		**100**	