

Skinner, Corey

From: Charles G. Brockway [charles.g.brockway@brockwayeng.com]
Sent: Thursday, April 30, 2009 2:58 PM
To: Skinner, Corey
Subject: Transfer No. ?? -- Dawson
Attachments: Page from Todd(1980).pdf; Stream-aquifer analytical1 revised.pdf; Curve fit to Glover & Balmer.pdf

Corey,

I checked my spreadsheet and it seems I made the same error I made 7 years ago for the Burdick transfer because I didn't change the spreadsheet back then! Thanks for pointing this out.

The Glover & Balmer curve for Qs/Q can be fit extremely well using a second-order polynomial. See attached. I revised the stream-aquifer spreadsheet to use the fitted equation, and calculated that with a well 175 feet from the river, the 50% depletion in 24 hours criteria can be met. FYI – also attached is the page from Todd (1980) which reproduces the Glover curve.

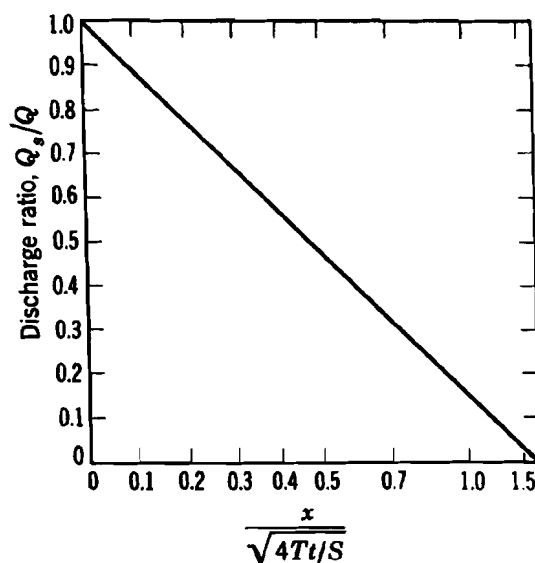
It should not be problem for Mr. Dawson to locate the well 175 feet from the river rather than 200 feet as originally planned.

Thanks,
Chuck

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Fig. 4.22 Graph for determining the portion of well discharge furnished by a nearby stream (after Glover and Balmer²⁰).



Well Flow Near Other Boundaries. In addition to the previous example, the method of images can be applied to a large number of groundwater boundary problems. As before, actual boundaries are replaced by an equivalent hydraulic system, which includes imaginary wells and permits solutions to be obtained from equations applicable only to extensive aquifers. Three boundary conditions to suggest the adaptability of the method are shown in Figs. 4.23 and 4.24. Figure 4.23 shows a well pumping near an impermeable boundary. An image discharging well is placed opposite the pumping well with the same rate of discharge and at an equal distance from the boundary; therefore, along the boundary the wells offset one another, causing no flow across the boundary, which is the desired condition. Figure 4.24a shows a discharging well in an aquifer bounded on two sides by impermeable barriers. The image discharge wells I_1 and I_2 provide the required flow but, in addition, a third image well I_3 is necessary to balance drawdowns along the extensions of the boundaries. The resulting system of four discharging wells in an extensive aquifer represents hydraulically the flow system for the physical boundary conditions. Finally, Fig. 4.24b presents the situation of a well near an impermeable boundary and a perennial stream. The image wells required follow from the previous illustrations.

For a wedge-shaped aquifer, such as a valley bounded by two converging impermeable barriers, the drawdown at any location within the aquifer can be calculated by the same method of images.⁶² Consider the aquifer formed by two barriers intersecting at an angle of 45 degrees shown in Fig. 4.25. Seven image pumping wells plus the

Estimation of Timing of Aquifer-Stream Interaction

Dawson well - Big Wood River near Chocolate Gulch

Brockway Engineering, PLLC 2/24/09

Qs/Q curve corrected 4/30/09 CGB

Hydraulic conductivity 104 ft/day
 Aquifer saturated thickness 50 feet
 Transmissivity 5200 ft²/d
 Storage coefficient 0.15

These assumptions apply.
 Method of images used to estimate
 gradient at constant-head stream boundary.

Pumping rate 62.8 gpm = 12090 ft³/d
 Pumping time 48 hrs

PUMPING WELL

Time (hrs)	R = 176 feet			R = 174 feet		
	u	W(u)	z (feet)	u	W(u)	z (feet)
0	—	—	0.000	—	—	0.000
1	5.4E+00	0.000	0.000	5.2E+00	0.000	0.000
2	2.7E+00	0.020	0.004	2.6E+00	0.021	0.004
3	1.8E+00	0.066	0.012	1.7E+00	0.070	0.013
4	1.3E+00	0.127	0.024	1.3E+00	0.133	0.025
5	1.1E+00	0.195	0.036	1.0E+00	0.203	0.037
6	8.9E-01	0.263	0.049	8.7E-01	0.273	0.050
7	7.7E-01	0.331	0.061	7.5E-01	0.341	0.063
8	6.7E-01	0.396	0.073	6.6E-01	0.408	0.075
9	6.0E-01	0.458	0.085	5.8E-01	0.471	0.087
10	5.4E-01	0.518	0.096	5.2E-01	0.532	0.098
11	4.9E-01	0.575	0.106	4.8E-01	0.590	0.109
12	4.5E-01	0.630	0.117	4.4E-01	0.645	0.119
13	4.1E-01	0.682	0.126	4.0E-01	0.697	0.129
14	3.8E-01	0.732	0.135	3.7E-01	0.748	0.138
15	3.6E-01	0.780	0.144	3.5E-01	0.796	0.147
16	3.4E-01	0.825	0.153	3.3E-01	0.842	0.156
17	3.2E-01	0.869	0.161	3.1E-01	0.886	0.164
18	3.0E-01	0.911	0.169	2.9E-01	0.928	0.172
19	2.8E-01	0.951	0.176	2.8E-01	0.969	0.179
20	2.7E-01	0.990	0.183	2.6E-01	1.008	0.186
21	2.6E-01	1.028	0.190	2.5E-01	1.046	0.193
22	2.4E-01	1.064	0.197	2.4E-01	1.082	0.200
23	2.3E-01	1.099	0.203	2.3E-01	1.117	0.207
24	2.2E-01	1.133	0.210	2.2E-01	1.151	0.213
25	2.1E-01	1.166	0.216	2.1E-01	1.184	0.219
26	2.1E-01	1.198	0.222	2.0E-01	1.216	0.225

IMAGE WELL

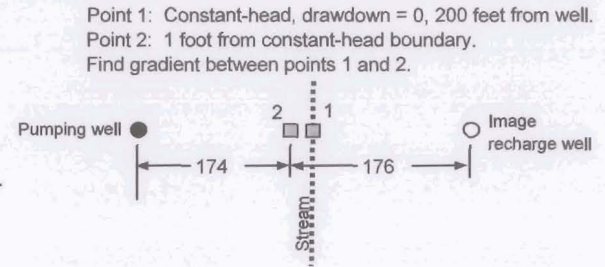
R = 176 feet
z (feet)
0.000
0.000
-0.004
-0.012
-0.024
-0.036
-0.049
-0.061
-0.073
-0.085
-0.096
-0.106
-0.117
-0.126
-0.135
-0.144
-0.153
-0.161
-0.169
-0.176
-0.183
-0.190
-0.197
-0.203
-0.210
-0.216
-0.222

RESULTANT using
 R = 174' (pumping) and
 R = 176' (image)

z (feet)	Gradient at river
0.0000	0.0000
0.0000	0.0000
0.0003	0.0003
0.0007	0.0007
0.0011	0.0011
0.0015	0.0015
0.0017	0.0017
0.0020	0.0020
0.0022	0.0022
0.0023	0.0023
0.0025	0.0025
0.0026	0.0026
0.0027	0.0027
0.0028	0.0028
0.0029	0.0029
0.0030	0.0030
0.0030	0.0030
0.0031	0.0031
0.0032	0.0032
0.0032	0.0032
0.0032	0.0032
0.0033	0.0033
0.0033	0.0033
0.0034	0.0034
0.0034	0.0034
0.0034	0.0034

Portion of total discharge
 supplied by the stream
 (after Glover and Balmer, 1954)

x'	Qs / Q
1.337	0.05
1.158	0.09
1.035	0.14
0.945	0.18
0.875	0.22
0.819	0.25
0.772	0.28
0.732	0.30
0.698	0.33
0.668	0.35
0.642	0.37
0.619	0.38
0.598	0.40
0.579	0.41
0.562	0.43
0.546	0.44
0.531	0.45
0.518	0.46
0.505	0.47
0.494	0.48
0.483	0.49
0.473	0.50
0.463	0.51
0.454	0.52



27	2.0E-01	1.229	0.227	1.9E-01	1.247	0.231	-0.227	0.0035	0.0035	0.446	0.53
28	1.9E-01	1.258	0.233	1.9E-01	1.277	0.236	-0.233	0.0035	0.0035	0.438	0.53
29	1.8E-01	1.288	0.238	1.8E-01	1.307	0.242	-0.238	0.0035	0.0035	0.430	0.54
30	1.8E-01	1.316	0.243	1.7E-01	1.335	0.247	-0.243	0.0035	0.0035	0.423	0.55
31	1.7E-01	1.343	0.249	1.7E-01	1.363	0.252	-0.249	0.0036	0.0036	0.416	0.55
32	1.7E-01	1.370	0.253	1.6E-01	1.389	0.257	-0.253	0.0036	0.0036	0.409	0.56
33	1.6E-01	1.396	0.258	1.6E-01	1.416	0.262	-0.258	0.0036	0.0036	0.403	0.57
34	1.6E-01	1.422	0.263	1.5E-01	1.441	0.267	-0.263	0.0036	0.0036	0.397	0.57
35	1.5E-01	1.446	0.268	1.5E-01	1.466	0.271	-0.268	0.0036	0.0036	0.391	0.58
36	1.5E-01	1.471	0.272	1.5E-01	1.490	0.276	-0.272	0.0036	0.0036	0.386	0.58
37	1.4E-01	1.494	0.276	1.4E-01	1.514	0.280	-0.276	0.0037	0.0037	0.381	0.59
38	1.4E-01	1.517	0.281	1.4E-01	1.537	0.284	-0.281	0.0037	0.0037	0.376	0.59
39	1.4E-01	1.540	0.285	1.3E-01	1.560	0.289	-0.285	0.0037	0.0037	0.371	0.60
40	1.3E-01	1.562	0.289	1.3E-01	1.582	0.293	-0.289	0.0037	0.0037	0.366	0.60
41	1.3E-01	1.584	0.293	1.3E-01	1.604	0.297	-0.293	0.0037	0.0037	0.362	0.60
42	1.3E-01	1.605	0.297	1.2E-01	1.625	0.301	-0.297	0.0037	0.0037	0.357	0.61
43	1.2E-01	1.626	0.301	1.2E-01	1.646	0.305	-0.301	0.0037	0.0037	0.353	0.61
44	1.2E-01	1.646	0.305	1.2E-01	1.666	0.308	-0.305	0.0037	0.0037	0.349	0.62
45	1.2E-01	1.666	0.308	1.2E-01	1.686	0.312	-0.308	0.0038	0.0038	0.345	0.62
46	1.2E-01	1.685	0.312	1.1E-01	1.706	0.316	-0.312	0.0038	0.0038	0.341	0.62
47	1.1E-01	1.705	0.315	1.1E-01	1.725	0.319	-0.315	0.0038	0.0038	0.338	0.63
48	1.1E-01	1.723	0.319	1.1E-01	1.744	0.323	-0.319	0.0038	0.0038	0.334	0.63
49	1.1E-01	1.742	0.322	1.1E-01	1.762	0.326	-0.322	0.0038	0.0038	0.331	0.63
50	1.1E-01	1.760	0.326	1.0E-01	1.781	0.329	-0.326	0.0038	0.0038	0.327	0.64

Polynomial Fit to Glover and Balmer (1954) curve for Qs/Q
 Brockway Engineering 4/30/09

x'	Qs/Q from curve	
0	1	$x' = x / \sqrt{4Tt/S}$
0.1	0.885	
0.2	0.77	
0.3	0.665	
0.4	0.57	
0.5	0.48	
0.6	0.39	
0.7	0.325	
1	0.16	
1.5	0.025	

