Well #2 Chilson Southwest of Burdock

Q=extraction rate gpm (rate from historic records was higher than SEO allows without water rights permit so using default max from SEO)			1,000	gpd	133.681 ft^3/day
tx(days)=	43100	App B Part 1 p. 13 of pdf; Table 1:constructed 1930s; used 1930			
b screened interval	63	Notice of Well Completion			
Min porosity (n)=	0.296				
Max porosity (n) =	0.319				
hydraulic gradient (i)	0.00316	ft/ft	Tech Mem Fig 4		
min transmissivity T	150	ft^2/day	KP Chilson Burdock	p. 39 App J pdf	
max transmissivity T	190	ft^2/day	TVA Chilson Burdock	p. 21 App J pdf	
Z=Q/2πKbi			Z=	44.909	T min (B9)
KB=T Z=Q/2πTi			Z=	35.454	T max (B10)

tx = n/Ki[rx-Z*LN{1 + rx/z}]

tx = (n/((T/b)*i))[rx-Z*LN{1 + rx/z}]

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F	n/((T/b)*i)	n min, Tmin	39.342	tx/(n/((T/b)*i))	1095.528
	n/((T/b)*i)	n max,Tmin	42.399	tx/(n/((T/b)*i))	1016.540
	n/((T/b)*i)	n min,Tmax	31.059	tx/(n/((T/b)*i))	1387.668
	n/((T/b)*i)	n max, Tmax	33.473	tx/(n/((T/b)*i))	1287.617

[rx-Z*LN{1 + rx/z}]

rx=	1247	1096.140	T min (D11)	n min match F16
rx=	1165	1017.085	T min (D11)	n max match F17
rx=	1522 max	1387.892	T max (D12)	n min match F18
rx=	1420	1288.293	T max (D12)	n max match F19

well is 4,600 downgradient from B-WF2

using the distance from the AE boundary as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 4600 tx = (n/((T/b)i))*[rx-Z*LN{1 + rx/z}]

for T min, n min	tx =	172776.1897 days	473.0354271 years
for T max, n min	tx =	137506.4004	376.4720065 years

Y max calculation

$Y_{max} = \pm Q/2bKi$

$Y_{max} = \pm Q/2Ti$

Y_{max}=	141.0137131 ft	T min	
Y_{max}=	111.3266156 ft	T max	

$$t_x = n/Ki\,[r_x - (Q/2\pi Kbi)\ln\{1 + (2\pi Kbi/Q)r_x\}] \quad (4\text{-}7)$$

where
t_x = travel time from point x to a pumping well
n = porosity
r_x = distance over which ground water travels in T_x, r_x is positive (+) if the point is upgradient, and negative (–) is downgradient

Q = discharge
K = hydraulic conductivity
b = aquifer thickness
I = hydraulic gradient

Well #7 Fall River South of Burdock

EPA 1994 p. 94 TOT with sloping regional potentiometric surface

Q=extraction rate gpm					
when well was new			1000	gpd	133.681 ft^3/day
tx (days) =	32873	App B Part 1 p. 12 of pdf; Table 1:constructed late 1950s; used 1958			
					from oil and gas test well API
b=aquifer thickness (Fall River)			186	ft	4004705093
porosity (n)=	0.29				
hydraulic gradient (i)	0.00308	ft/ft	Tech Memo Fig 5		
min Transmissivity T	54	ft^2/day	TVA Fall River Burdock		
max Transmissivity T	255	ft^2/day	KP Fall River Dewey		
Z=Q/2πKbi KB=T					
Z=Q/2πTi		Z=	127.987	T min	
		Z=	27.103	T max	

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F

K=T/b	n/Ki	n/[(T/b)*i]	324.315	tx/{n/[(T/b)*i]}	101.361	T min
	n/Ki	n/[(T/b)*i]	68.678	tx/{n/[(T/b)*i]}	478.651	T max
			rx-Z*LN{1 + rx/z}			
rx=	235		101.581	match F14	T min	
rx=	563	max	479.505	match F15	T max	

Y max calculation — well is 4,750' crossgradient from B-WF2

$Y_{max} = \pm Q/2bKi$

$Y_{max} = \pm Q/2Ti$

Y_{max}=	401.8789081	ft T min	0.07611343 miles
Y_{max}=	85.10376878	ft T max	

using the distance from the AE boundary of B-WF2 as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 4750 tx = (n/((T/b)i))*[rx-Z*LN{1 + rx/z}]

for T min tx =	1389381.791	days	3806.525 years
for T max tx =	316595.2675	days	867.3843 years

However, well 7 is cross-gradient from B-WF2 and Ymax will not increase beyond 401.8 ft so capture zone will never reach B-WF2.

$$t_x = n/Ki\,[r_x - (Q/2\pi Kbi)\ln\{1 + (2\pi Kbi/Q)r_x\}] \quad (4\text{-}7)$$

where

t_x = travel time from point x to a pumping well

n = porosity

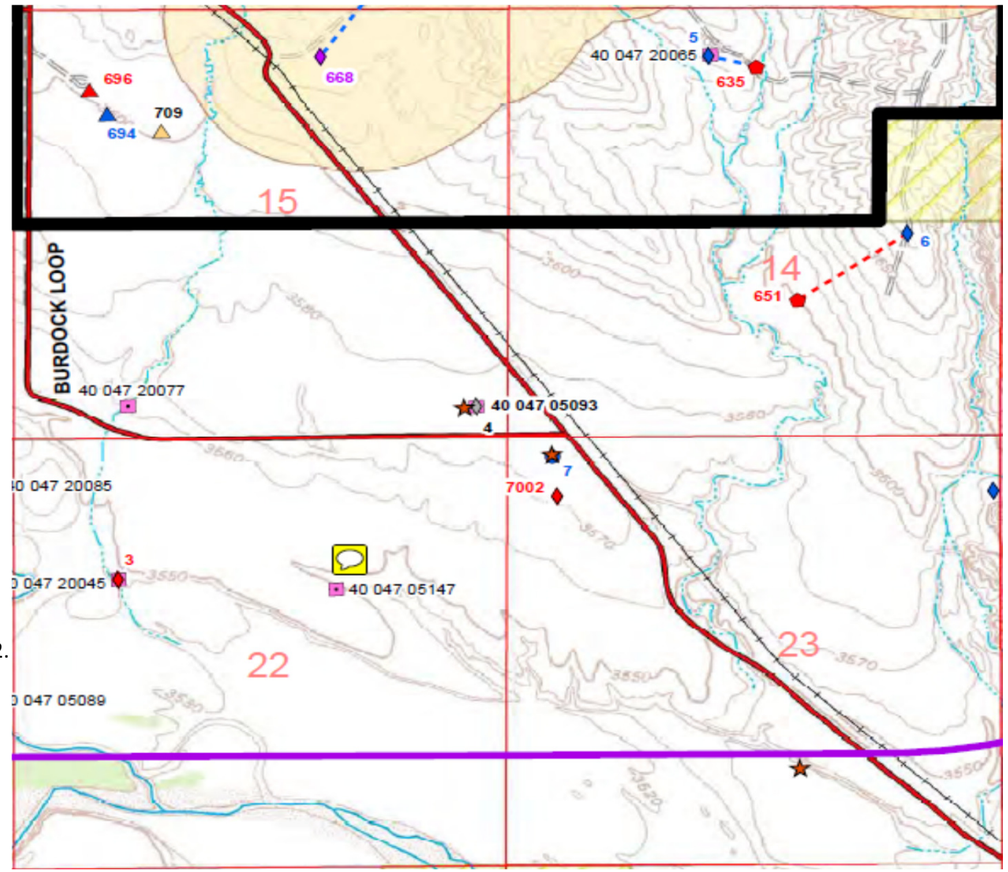
r_x = distance over which ground water travels in T_x, r_x is positive (+) if the point is upgradient, and negative (–) is downgradient

Q = discharge

K = hydraulic conductivity

b = aquifer thickness

I = hydraulic gradient



Well #8 Fall River South of Burdock

Q=extraction rate gpm			1000	gpd	133.681 ft^3/day
tx (days) =	43100	Well repair form 1951. Casing had corroded away. Assume original well drilled in 1930			
b=aquifer thickness (Fall River)			20	ft	perforations from well repair form
porosity (n)=	0.29				
hydraulic gradient (i)	0.00364	ft/ft	Tech Memo Fig 5		
min Transmissivity T	54	ft^2/day	TVA Fall River Burdock		
max Transmissivity T	255	ft^2/day	KP Fall River Dewey		
Z=Q/2πKbi					
Z=Q/2πTi			Z=	108.296619	T min (B6)
			Z=	22.933	T max (B7)

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F

tx = n/Ki[rx-Z*LN{1 + rx/z}]

tx =(n/((T/b)*i))*[rx-Z*LN{1 + rx/z}]

n/((T/b)*i)	29.508	tx/(n/((T/b)i))	1460.644	T min
n/((T/b)*i)	6.249	tx/(n/((T/b)i))	6897.486	T max

rx-Z*LN{1 + rx/z}

T min rx=	1770	1461.00	match F14
T max rx=	7029 max	6897.63	match F15

Y max calculation — well is 9,625 ft crossgradient from B-WF2

$Y_{max} = \pm$ Q/2bKi Ymax= 340.0513838 ft T min 0.064403671 miles

Ymax =+ Q/2Ti Ymax= 72.01088128 ft T max

using the distance from the AE B-WF2 as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 9625 tx = (n/((T/b)i))*[rx-Z*LN{1 + rx/z}]

for T min tx =	269634.9302	days	738.2202 years
for T max tx =	59277.46578		162.2929 years

However, well 8 is cross-gradient from B-WF2 and Ymax will not increase beyond 340 ft so capture zone will never reach B-WF2.

Well #13 Chilson Burdock

when well was new			1000	gpd	133.681 ft^3/day
tx(days)=	35795	App B Part 1 p. 14 of pdf; Table 1:constructed 1950s; used 1950			
b=Min aquifer thickness (Chilson)			45	ft	Notice of Well Construction
b=Max aquifer thickness (Chilson)			145	ft	Plate 6.7 Chilson Isopach Map
Min porosity (n)=	0.296				
Max porosity (n) =	0.319				
hydraulic gradient (i)	0.00215	ft/ft	Tech Memo Fig 6		
minimum Transmissivity (T)	150	ft^2/day	KP Chilson Burdock		
maximumTransmissivity (T)	190	ft^2/day	TVA Chilson Burdock		
Z=Q/2πKbi			Z=	66.006	T min (B8)
Z=Q/2πTi			Z=	52.110	T max (B9))

tx =(n/((T/b)*i))*[rx-Z*LN{1 + rx/z}]

	n/((T/b)i)	n min (B5), Tmin (B8), b min (D3)	41.302	tx/(n/((T/b)i))	866.658
	n/((T/b)i)	n min (B5), Tmin (B8), b max (D4)	133.085	tx/(n/((T/b)i))	268.963
adjust the values in red so numbers	n/((T/b)i)	n min (B5), Tmax (B9), b min (D3)	32.607	tx/(n/((T/b)i))	1097.767
in purple cells in column D match	n/((T/b)i)	n min (B5), Tmax (B8), b max (D4)	105.067	tx/(n/((T/b)i))	340.686
the number in cell shaded same	n/((T/b)i)	n max (B6),Tmin (B8), b min (D3)	44.512	tx/(n/((T/b)i))	804.172
color in column F	n/((T/b)i)	n max (B6),Tmin (B8), b max (D4)	143.426	tx/(n/((T/b)i))	249.571
	n/((T/b)i)	n max (B6), Tmax (B9), b min (D3)	35.141	tx/(n/((T/b)i))	1018.618
	n/((T/b)i)	n max (B6), Tmax (B9), b max (D4)	113.231	tx/(n/((T/b)i))	316.123

rx-Z*LN{1 + rx/z}

rx=	1054	867.115	n min, T min, b min	use D10 in equation; match number at F14
rx=	398		n min, T min, b max	use D10 in equation; match number at F15
rx=	1267 max value	1098.615	n min, T max, b min	use D10 in equation; match number at F16
rx=	460		n min, T max, b max	use D10 in equation; match number at F17
rx=	959	804.471	n max, T min, b min	use D11 in equation; match number at F18
rx=	375		n max, T min, b max	use D11 in equation; match number at F19
rx=	1184	1019.001	n max, T max, b min	use D11 in equation; match number at F20
rx=	433		n max, T max, b max	use D11 in equation; match number at F21

Y max calculation

well is 1,750 ft downgradient from B-WF10

Y_{max} =± Q/2bKi

Ymax=	207.2573643	ft with Tmin (B8)	0.039253289	miles
Ymax=	163.624235	ft with Tmax (B9)	0.030989438	miles

Ymax =+ Q/2Ti

using the distance from the AE boundary as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 1750 tx = (n/((T/b)i))*[rx-Z*LN{1 + rx/z}]

(for n min, T min, b min) tx = 51041.7392 days 139.7446658 years

it would take 139.75 years for the capture zone of this well to reach the AE boundary for B-WF10

Well #16 Chilson Burdock

Q=extraction rate gpm			1000 gpd	133.681 ft^3/day
tx(days)=	no well age was needed for the Ymax calculation	App B Part 1 p. 14 of pdf; Table 1:constructed mid 1970s		
Min porosity (n)=	0.296			
Max porosity (n) =	0.319			
hydraulic gradient (i)	0.00215	ft/ft	Tech Memo Fig 6	
minimum Transmissivity (T)	150	ft^2/day	KP Chilson Burdock	
maximumTransmissivity (T)	190	ft^2/day	TVA Chilson Burdock	

$Y_{max} = \pm Q/2bKi$

Ymax =+ Q/2Ti

Ymax=	1.505416667	ft with Tmin (B8); n min (B5)	0.000285117 miles
Ymax=	1.396875653	ft with Tmin (B8); n max (B6)	0.00026456 miles
Ymax=	1.188486842	ft with Tmax (B9); n min (B5)	0.000225092 miles
Ymax=	1.102796568	ft with Tmax (B9); n max (B6)	0.000208863 miles

Well #18 Fall River West of Burdock

Q=extraction rate gpm		1000 gpd	133.681 ft^3/day	
tx (days) =	43100	App B Part 1 p. 13 of pdf; Table 1:constructed late 1920s early 1930s; used 1930		
b=aquifer thickness (Fall River)		128 ft		Plate 6.9 Fall River Isopach Map
porosity (n)=	0.29			
hydraulic gradient (i)	0.00364 ft/ft	Tech Memo Fig 7		
min Transmissivity T	54 ft/day	TVA Fall River Burdock		
max Transmissivity T	255 ft^2/day	KP Fall River Dewey		

Z=Q/2πKbi
Z=Q/2πTi

Z=	108.297	T min	
Z=	22.933	T max	

tx = n/Ki[rx-Z*LN{1 + rx/z}]
tx = (n/((T/b)*i))*[rx-Z*LN{1 + rx/z}]

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F

n/Ki=n/((T/b)i)	188.848	tx/(n/Ki)=tx/(n/((T/b)*i))	228.226	T min
n/Ki=n/((T/b)i)	39.991	tx/(n/Ki)=tx/(n/((T/b)*i))	1077.732	T max

rx-Z*LN{1 + rx/z}

T min rx=	395	228.623	match F15
T max rx=	1169	1078.396	match F16

well is 7,880 ft downgradient from B-WF4

Y max calculation
Ymax =± Q/2bKi
Ymax =+ Q/2Ti

T min Ymax=	340.0513838 ft		
T max Ymax=	72.01088128 ft		

using the distance from the AE boundary as rx, solved for tx

rx= 7880

tx= n/Ki[rx-Z*LN{1 + rx/z}]
tx = (n/((T/b)i))*[rx-(Z*LN{1 + (rx/z)})]

T min tx =	1400164.195 days	3836.066	years
T max tx =	309773.7989 days	848.1144	

0.064403671 miles

Wells #40 & #4002 Inyan Kara Dewey

these two wells are very close together, so they are being treated as 1 well pumping at 2,880 + 25,920 gpd

when well was new — 2000 gpd — 267.362 ft^3/day

App B Part 1 p. 15 of pdf; Table 1: well 40 constructed about 1969
4002 constructed in 1940s, used 1940; 4002 is the older well so used its age.

tx (days) = 39,448.00

b=aquifer thickness (Fall River) — 150 ft — Plate 6.9 Fall River isopach map

porosity (n)= 0.29

hydraulic gradient (i) 0.00364 ft/ft — Tech Memo Fig 8

Using T from Fall River because historic records indicate the wells are 660 and 680 feet deep. Top of Chilson in that area is 734'

Transmissivity (T) 255 ft^2/day

Z=Q/2πTi — Z= 45.867

T/b=K Z=Q/2πTi

$$t_x = n/K_i\,[r_x - (Q/2\pi Kb_i)\ln\{1 + (2\pi Kb_i/Q)r_x\}] \quad (4\text{-}7)$$

where
t_x = travel time from point x to a pumping well
n = porosity
r_x = distance over which ground water travels in T_x, r_x is positive (+) if the point is upgradient, and negative (–) is downgradient

Z=Q/2πKbi 1/Z=2πKbi/Q
T/b=K
Z=Q/2πTi 1/Z=2πTi/Q

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F

n/Ki	n/((T/b)*i)	46.865	tx/(n/((T/b)*i))	841.739	
rx=	985	842.244			

Y max calculation

$Y_{max} = \pm Q/2bKi$

Ymax = ±Q/2Ti Ymax= 144.0217626 ft 0.027276849 miles

The closest well 4002 is 2,125 feet away from D-WF2 cross-gradient. Since the width of the capture zone doesn't change over time, the capture zone for these two wells will never intersect the AE boundary for D-WF2

stagnation point (X_0)= Q/2πTi 45.86680336

Well #41 Fall River Dewey

pumping rate from Source B = 12 gpm

Q=extraction rate 1,000 gpd 133.681 ft^3/day

tx (days) = 43,100.00 no info so used date of older well in the area: 1930

b=aquifer thickness (Fall River) from Fall River isopach map

from Hydro ID 2 well completion form 165 ft Plate 6.9

porosity (n)= 0.29

hydraulic gradient (i) 0.00421 ft/ft Tech Memo Fig 9

Transmissivity (T) 255 ft^2/day KP Fall River Dewey

Z=Q/2πTi Z= 19.828

T/b=K Z=Q/2πTi

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F

n/Ki n/((T/b)*i) 44.572 tx/(n/((T/b) 966.980

rx= 1046 966.996

well is 2,750 downgradient from D-WF3

Y max calculation

Y_{max} =± Q/2bKi

Ymax =±Q/2Ti Ymax= 62.26118951 ft 0.011792 miles

Well 41 is 3,300 feet away from D-WF1 cross-gradient

stagnation point (X_0)= Q/2πTi 19.8284043

using the distance from the AE boundary as rx, solved for tx

rx= 2750

tx= n/Ki[rx-Z*LN{1 + rx/z}]

tx = (n/((T/b)i))*[rx-(Z*LN{1 + (rx/z)})]

tx = 118206.9089 days 323.6328785 years

it will take 355 years for the capture zone of this well to reach the upgradient AE boundary

Well #41 Chilson Dewey

pumping rate from Source B = 12 gpm

12 gpm= 17280 gpd

Q=extraction rate gpm 1,000 gpd 133.681 ft^3/day

tx(days)= 43,100.00 no info so used date of older well in the area: 1930

b=Max aquifer thickness (Chilson) 140 Plate 6.7 Chilson isopach map (see Slide 20)

Min porosity (n)= 0.296

Max porosity (n) = 0.319

hydraulic gradient (i) 0.00631 ft/ft Tech Memo Fig 10

Transmissivity (T) 590 ft^2/day TVA Chilson Dewey

Z=Q/2πKbi

Z=Q/2pTi Z= 5.718

n/Ki K=T/b n/((T/b)*i) tx = n/Ki[rx-Z*LN{1 + rx/z}]

adjust the values in red n/((T/b)*i) n min (B6) 11.131 tx/(n/Ki)=t› 3872.032

so numbers in purple n/((T/b)*i) n max (B7) 11.996 tx/(n/Ki)=t› 3592.857

cells in column D

match the number in

rx= 3910 max 3872.668 n min

rx= 2692 2680.126 n max

well is 3,000 downgradient from D-WFs 2&4

Y max calculation

Ymax =+ Q/2bKi

Ymax =+ Q/2Ti Ymax= 17.95388004 ft

using the distance from the AE boundary as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 3000 tx = (n/((T/b)i))*[rx-(Z*LN{1 + (rx/z)})]

(for n min) tx = 32994.6 days 90.39617 years

The capture zone of this well will reach the upgradient AE boundary in 2020

Wells #42 and # 704 Chilson Dewey

these two wells are very close together, so they are being treated as 1 well pumping at 2 x 25,920 gpd

when well was new — 2000 gpd — 267.362 ft^3/day

tx(days)= 36,160.00 — App B Part 1 ; Table 1: well 42 p. 14 of pdf constructed 1949; well 4002 p. 15 of pdf constructed 2008-2009; well 42 is older so that age was used

b=Max aquifer thickness (Chilson) — 150 Plate 6.7 Chilson isopach map (see Slide 20)

Min porosity (n)= 0.296

Max porosity (n) = 0.319

hydraulic gradient (i) 0.00646 ft/ft — Tech Memo Fig 11

$$t_x = n/Ki\,[r_x - (Q/2\pi Kbi)\ln\{1 + (2\pi Kbi/Q)r_x\}] \quad (4\text{-}7)$$

where
t_x = travel time from point x to a pumping well
n = porosity
r_x = distance over which ground water travels in T_x, r_x is positive (+) if the point is upgradient, and negative (–) is downgradient

Transmissivity (T) 590 ft^2/day — TVA Chilson Dewey

Q = discharge
K = hydraulic conductivity
b = aquifer thickness
I = hydraulic gradient

Z=Q/2πKbi

Z=Q/2pTi — Z= 11.170

n/Ki K=T/b	n/((T/b)*i)			tx = n/Ki[rx-Z*LN{1 + rx/z}]	
adjust the values in red so	n/((T/b)*i)	n min (B6)	11.649	tx/(n/Ki)=tx/(n/((T/b)*i))	3104.059
numbers in purple cells in	n/((T/b)*i)	n max (B7)	12.554	tx/(n/Ki)=tx/(n/((T/b)*i)	2880.255
column D match the					
number in cell shaded					

rx= 3168 max — 3104.876 n min

rx= 2897 — 2880.268 n max

wells are 4,800 downgradient from D-WF4

Y max calculation

Ymax =+ Q/2bKi

Ymax =+ Q/2Ti — Ymax= 35.07398856 ft — 0.006642801 miles

using the distance from the AE boundary as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 4800 — tx = (n/((T/b)i))*[rx-(Z*LN{1 + (rx/z)})]

(for n min) tx = 55127.20569 days — 150.930063 years

it will take 112.8 years for the capture zone of this well to reach the upgradient AE boundary

Well #43 Chilson Burdock

Q=extraction rate gpm when well was new			1000	gpd	133.681	ft^3/day	max flow rate before crossing AE Boundary: 4650 gpd
tx(days)=	43100	App B Part 1 ; Table 1: p. 14 of pdf. No information so used date of oldest well in area: 1930					well is 875' crossgradient from B-WF10: 621.61665 ft^3/day
b=aquifer thickness (Chilson)			145	ft	Plate 6.7 Chilson isopach		Ymax= 874.2850211
Min porosity (n)=	0.296						
Max porosity (n) =	0.319						
hydraulic gradient (i)	0.00237	ft/ft	Tech Memo Fig 6				
minimum Transmissivity (T)	150	ft^2/day	KP Chilson Burdock				
maximum Transmissivity (T)	190	ft^2/day	TVA Chilson Burdock		150 & 187.5		
Z=Q/2πKbi		Z=	59.878	T min (B7)			
Z=Q/2πTi		Z=	47.272	T max (B8)			

tx = n/Ki[rx-Z*LN{1 + rx/z}]

adjust the values in red so numbers in purple cells in column D match the number in cell shaded same color in column F	n/((T/b)i)	n min, Tmin	120.731	tx/(n/((T/b)i))	356.991
	n/((T/b)i)	n max, Tmin	130.113	tx/(n/((T/b)i))	331.252
	n/((T/b)i)	n min, Tmax	95.314	tx/(n/((T/b)i))	452.188
	n/((T/b)i)	n max, Tmax	102.720	tx/(n/((T/b)i))	419.586
rx=	490		357.227	n min, T min (D9)	match F14
rx=	461		331.471	n max, T min (D9)	match F15
rx=	574	max	452.234	n min, T max (D10)	match F16
rx=	422		313.498	n max, T max (D10)	match F17

well is 3,600' crossgradient from B-WF8

well is 875' crossgradient from B-WF10

Y max calculation

Y_{max} =± Q/2bKi	Ymax=	188.0182841	ft with Tmin (B7)	0.035609524	miles
Ymax =+ Q/2Ti	Ymax=	148.4354875	ft with Tmax (B8)	0.028112782	miles
stagnation point (X_0)=	-Q/2πTi	-59.87843443	ft with Tmin (B7)		
		-47.27244823	ft with Tmax (B8)		

using the distance from the AE boundary as rx, solved for tx

tx= n/Ki[rx-Z*LN{1 + rx/z}]

rx= 3600 tx = (n/((T/b)i))*[rx-(Z*LN{1 + (rx/z)})]

(for n min, T max) tx = 323550.1803 days 886.43885 years

it will take 886.4 years for the capture zone of this well to reach the upgradient AE boundary