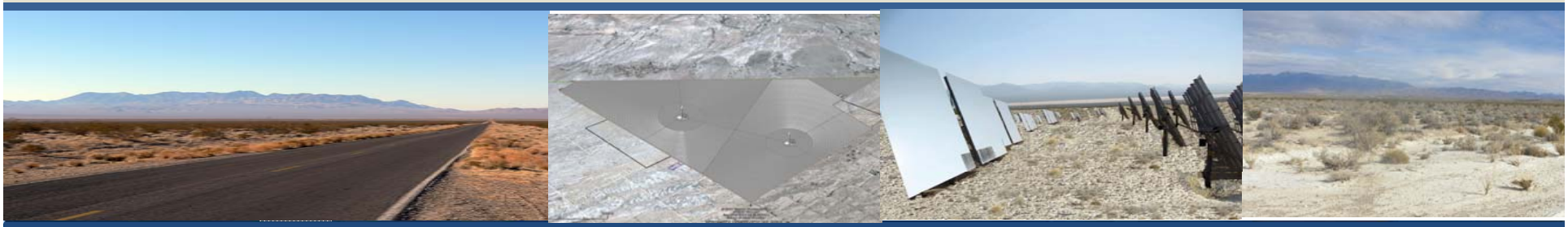
DOCKET
11-AFC-2
DATE JUN 14 2012
RECD JUN 15 2012

Cardno ENTRIX
Shaping the Future



People | Clients | Growth | Quality | Performance

BrightSource - Hidden Hills SEGS Analysis of Groundwater Conditions

Cardno ENTRIX

Santa Barbara, California

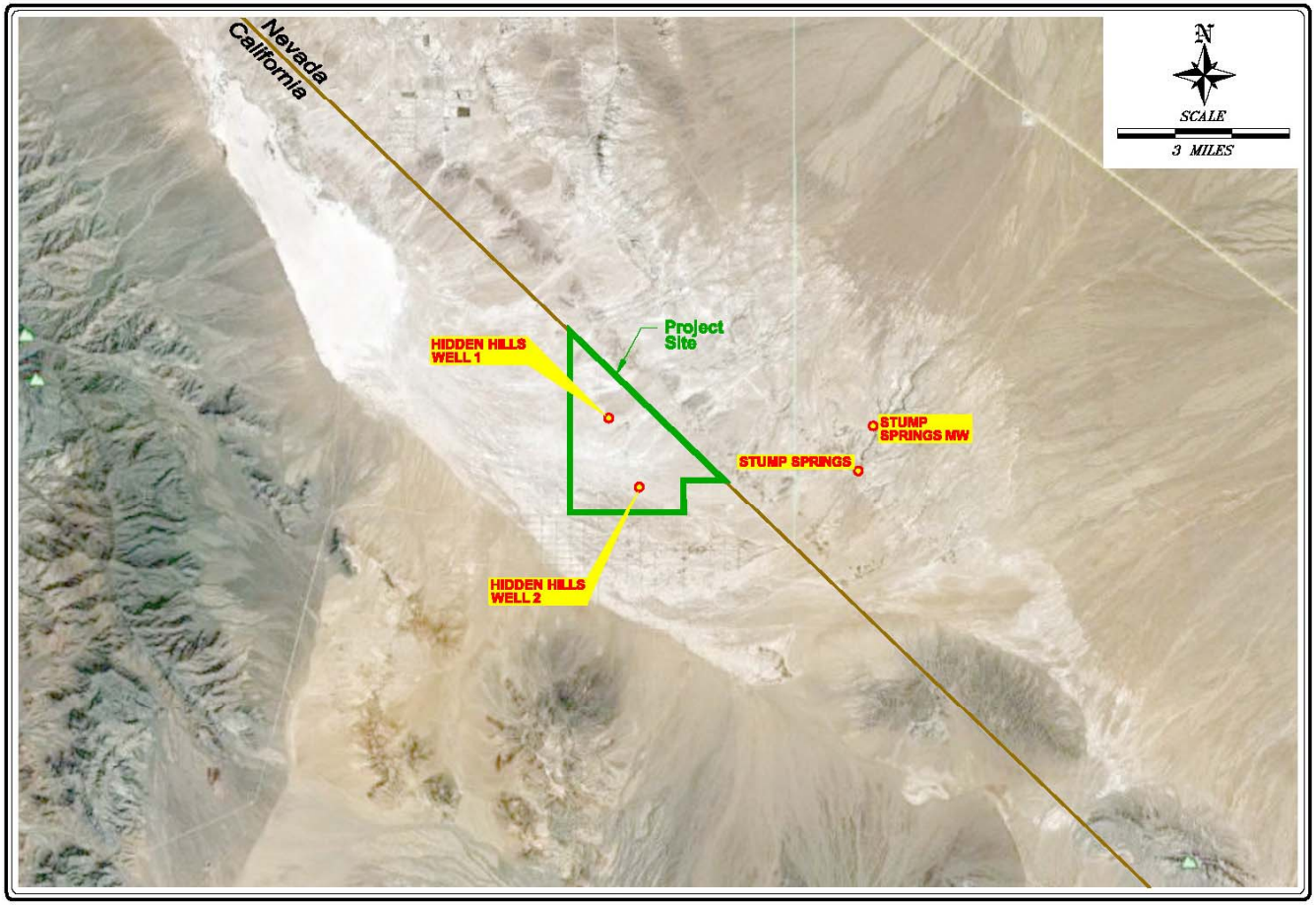
June 14, 2012

DRAFT 6/14/2012

Major Points

- The pumping test data demonstrated that the aquifer can easily support the project
- Pumping represents about 8% of normal flow beneath site
- The test data clearly showed that the aquifer receives recharge from leakance
- CEC staff assumed a flat aquifer with no recharge (not representative of site conditions)
- Regional flow and recharge from leakance must be considered to match pumping test data
- No drawdown will propagate to springs from the Hidden Hills site
- No significant drawdown is expected at any private wells.
- Earlier models did not reflect aquifer properties as they are now understood.

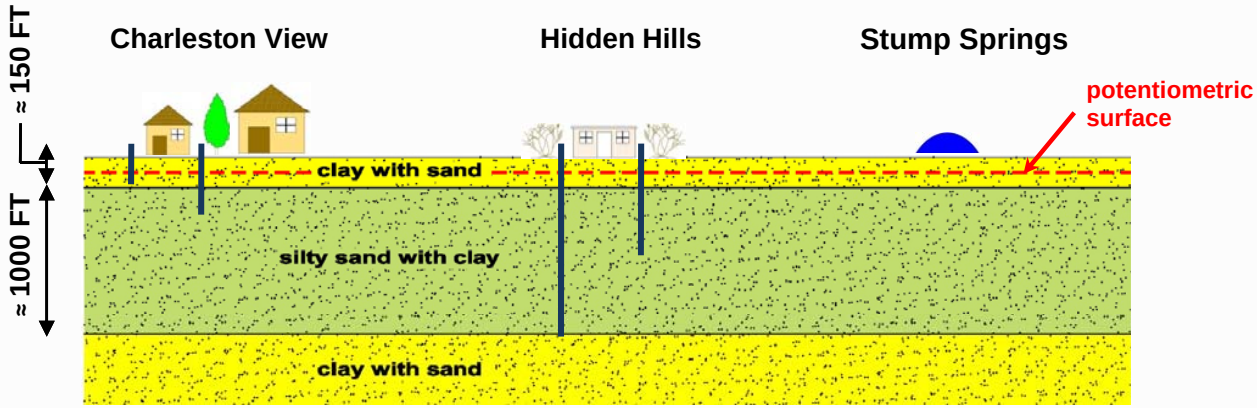
Site Location Map



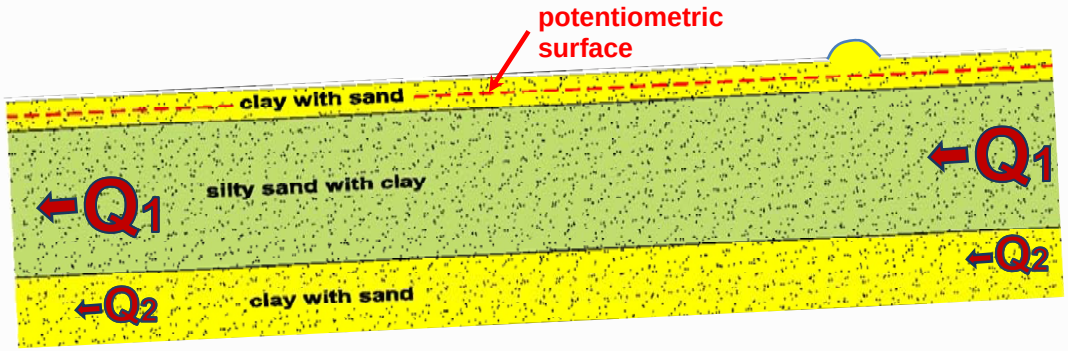
Cardno ENTRIX	PROJECT NAME: BRIGHTSOURCE ENERGY HIDDEN HILLS	DWG. NUMBER: 33153001je1
	PROJECT NUMBER: 33153001.00	DATE: 06/12/12

SITE LOCATION MAP.

Representing the Aquifer: Theory Vs. Reality



Theoretical Model for Analytical Solutions

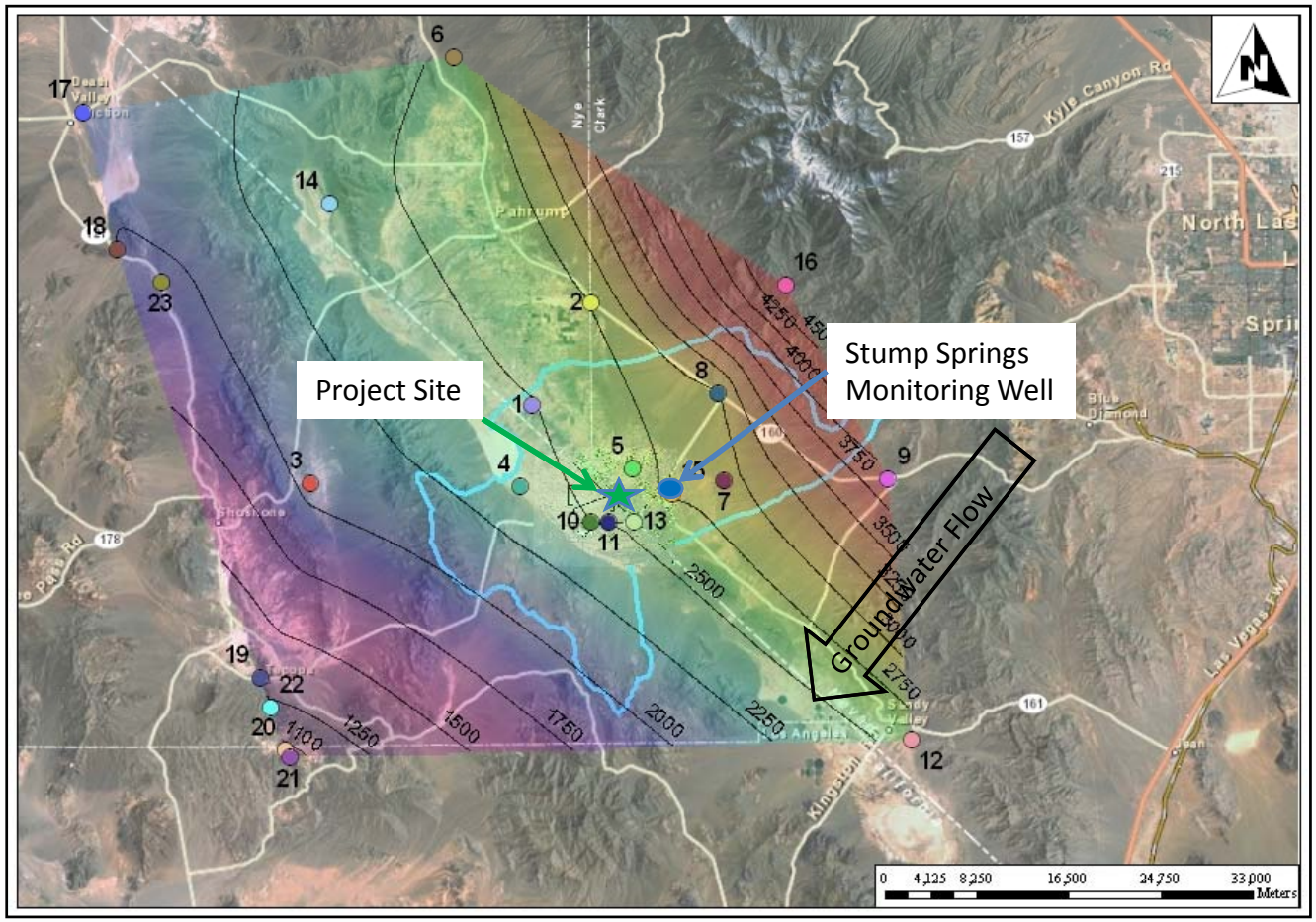


The Real World

Review of Private Well Construction

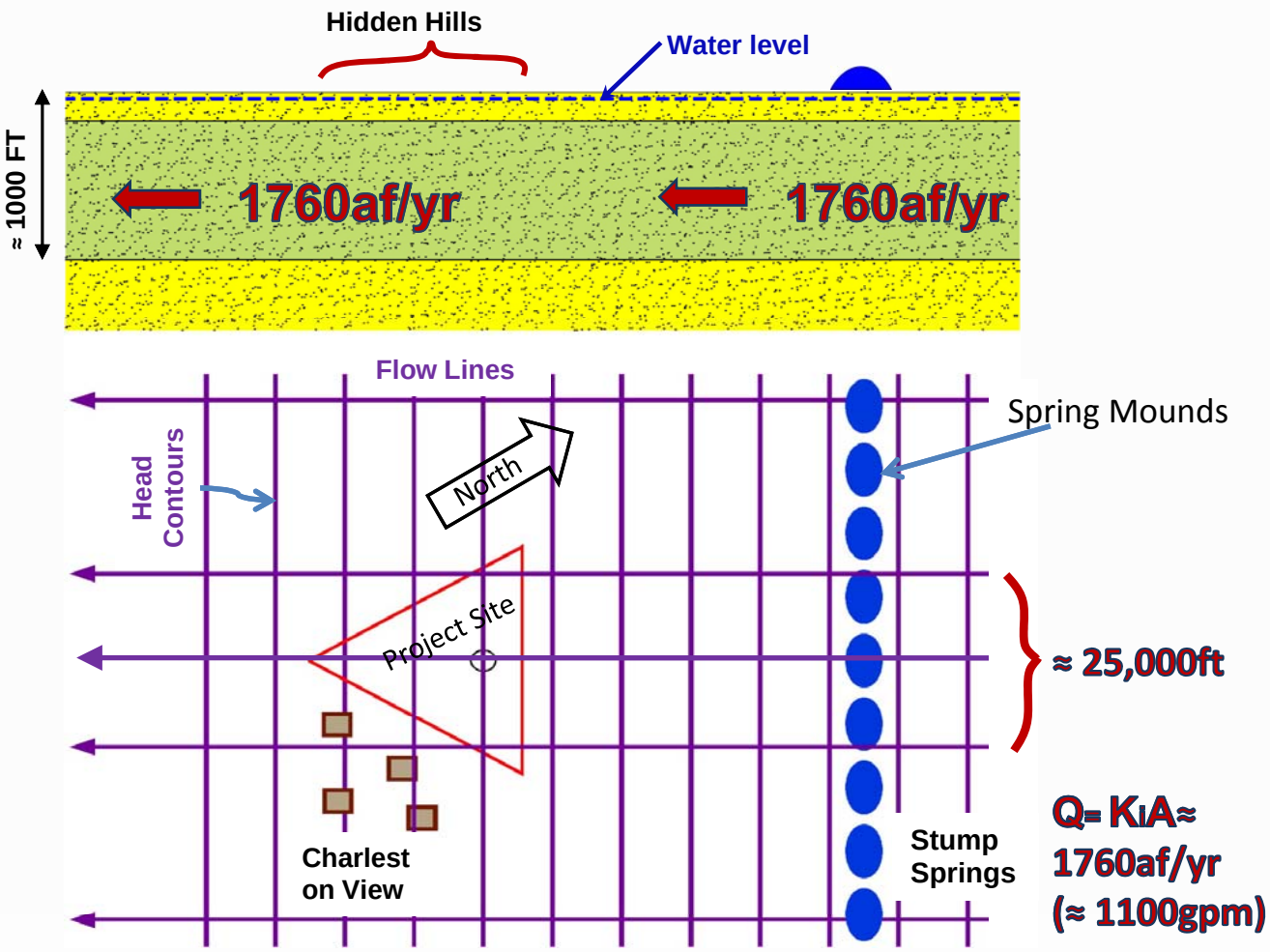
- On site wells 93 to 1100 feet deep, pumped at up to 400 gpm
- Nearby Private Wells 175 to 310 feet deep, pumped at 5 to 30 gpm
- Private wells have Specific Capacity Values 3.5 to 12.5 gpm/ft (Good producers)
- Static Water levels at time of completion 60 to 156 feet
- Decline in water levels about 0.2 to 0.3 ft/yr

Groundwater Gradient Across Site



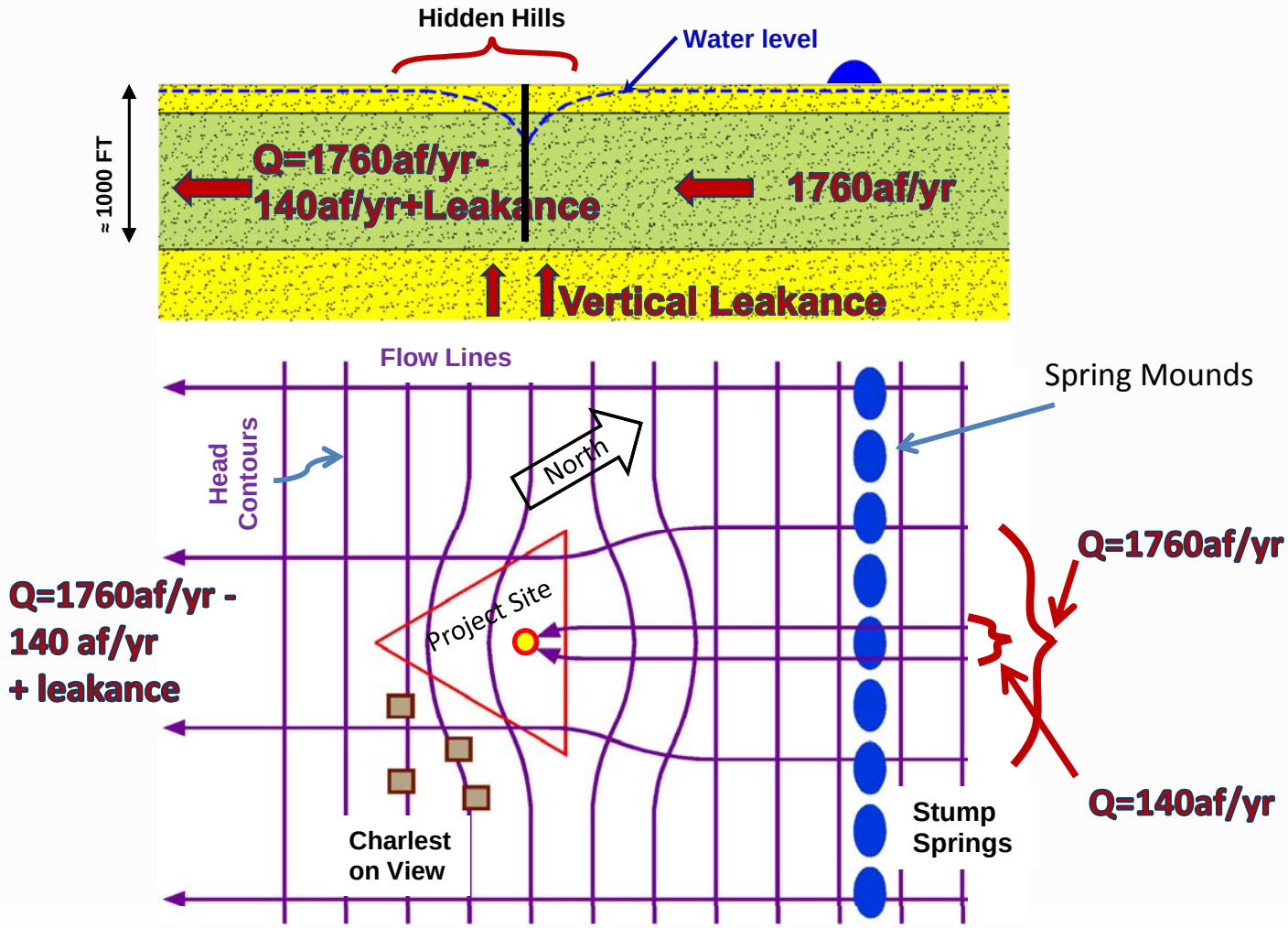
- Approximately 250 feet of head drop from Stump Springs to Site
- Gradient approximately 0.01 to southwest

Groundwater Flow Under Ambient Conditions



Approximately 1800 af/yr Flows Through Aquifer Beneath Site

Pumping Diverts Flow to Well and Stabilizes Cone



- Pumping Diverts Flow to Replace Water Being Pumped
- Reduces Water Leaving site by less than 8%

Aquifer Performance Test Feb 2012

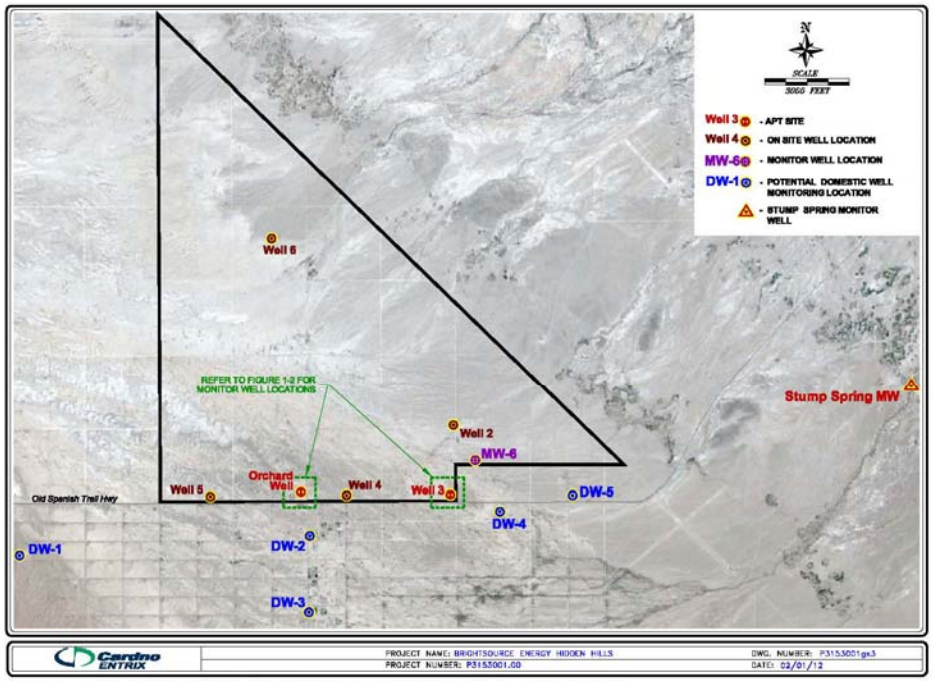


FIGURE 1-1. MAP SHOWING AQUIFER PERFORMANCE TEST WELLS AND ADJACENT MONITOR WELLS.

- Begin APT at 1100 on Friday Feb 17
- Orchard well and Well #3 pumped at constant rate of 45 gpm each
- Regular verifying of water level sensors and conducting hand measurements
- Biological resources monitoring
- Discharge monitoring
- Water Quality sampling
- Conduct dust control measures
- Orchard well and Well #3 operated from 11:00 Feb 17 thru 19:00 Feb 21 (approximately 4.5 days)
- Vandalism at Well #3 caused pump to drop into well.

Measured Drawdown: Day 1 and Day 4

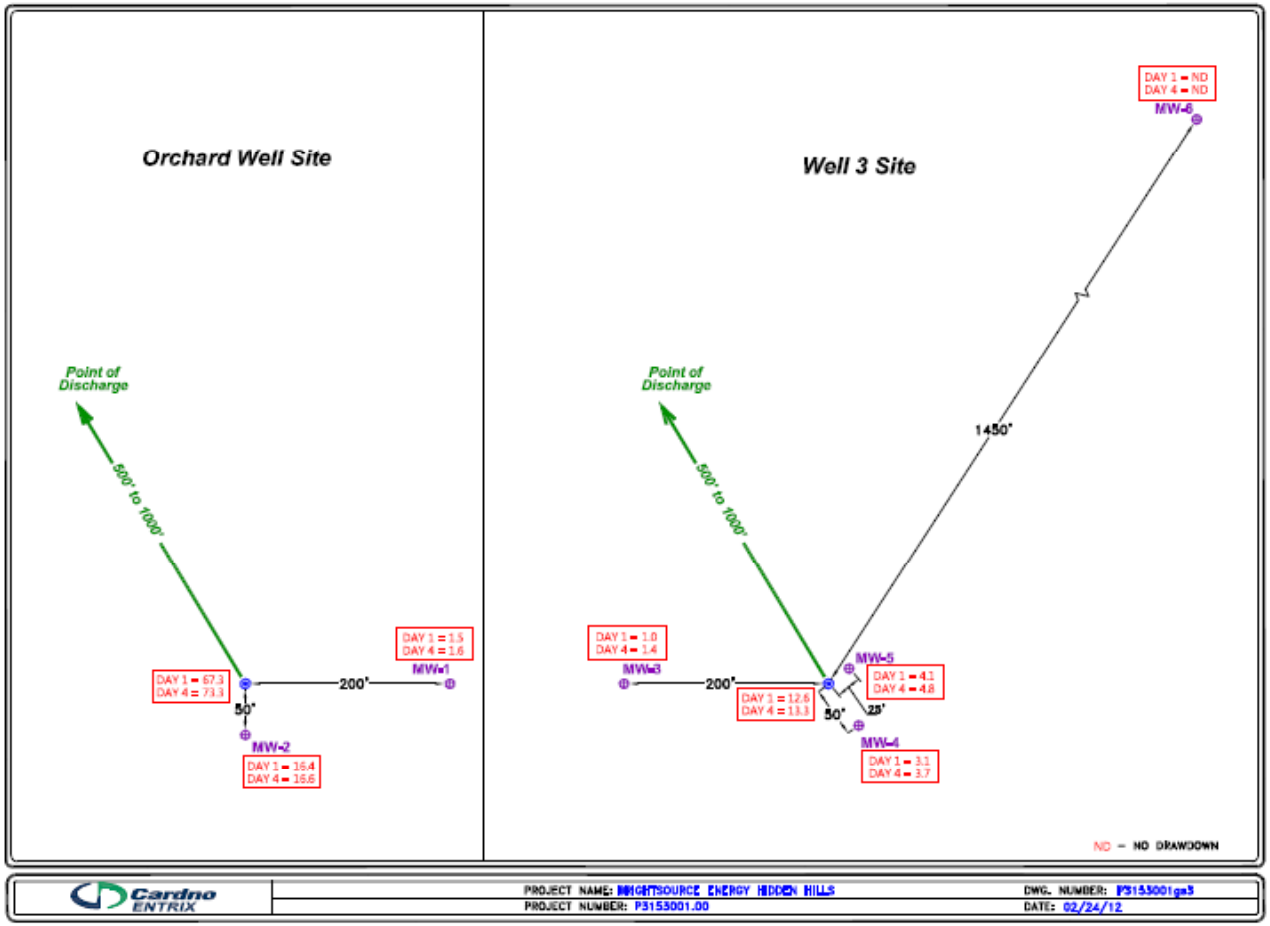
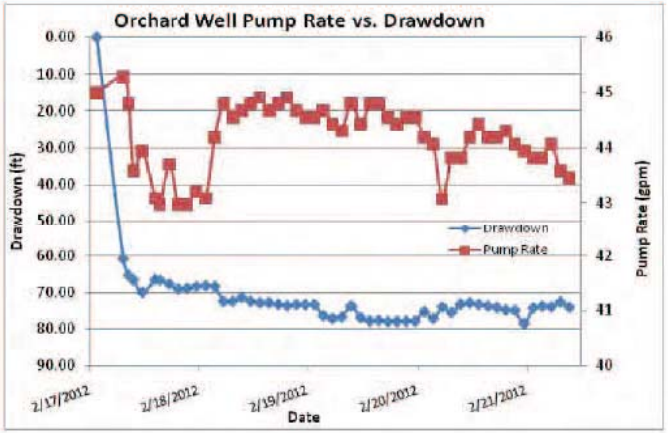


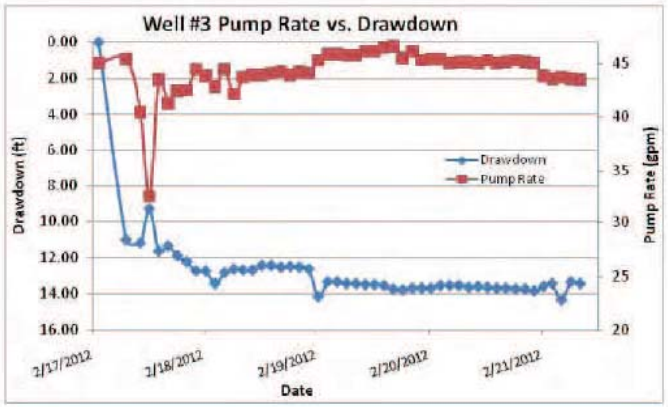
FIGURE 1. APT WELL LOCATIONS AND DRAWDOWN IN FEET AT DAY 1 AND DAY 4.

Pumping Rates Held to +/- 5% During Test

WATER SUPPLY - FIGURE 28
Hidden Hills Solar Electric Generating System (HHSEGS)

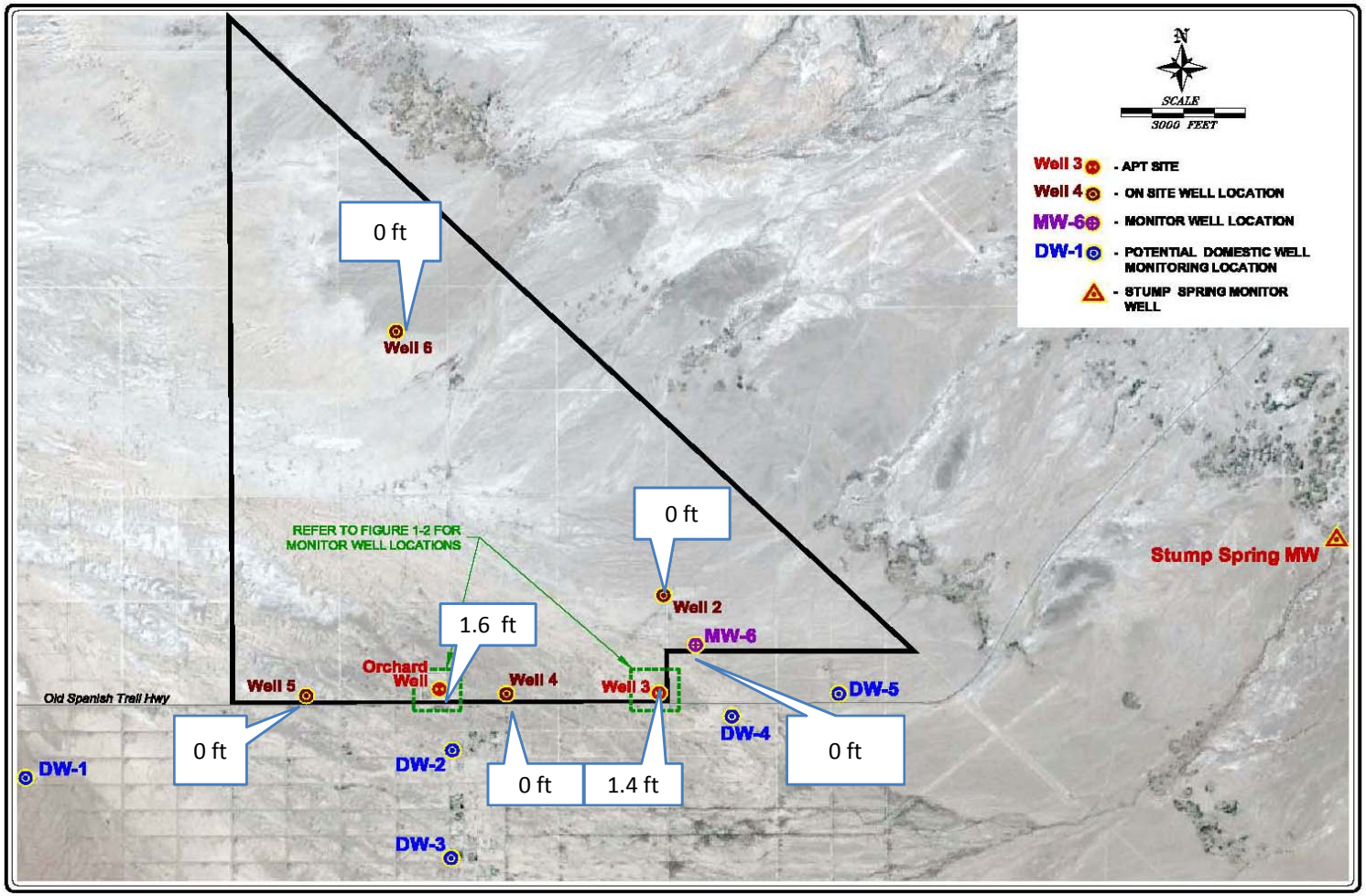
This figure shows the pump rates and associated drawdowns in each pump well during the February 2012 pump test.





CALIFORNIA ENERGY COMMISSION - SITING, TRANSMISSION AND ENVIRONMENTAL PROTECTION DIVISION
SOURCE: Energy Commission Staff

Drawdown After 4 Days Pumping



Cardno ENTRIX	PROJECT NAME: BRIGHTSOURCE ENERGY HIDDEN HILLS PROJECT NUMBER: P3153001.00	DWG. NUMBER: P3153001gs3 DATE: 02/01/12

FIGURE 1-1. MAP SHOWING AQUIFER PERFORMANCE TEST WELLS AND ADJACENT MONITOR WELLS.

No Impact Observed on Stump Springs

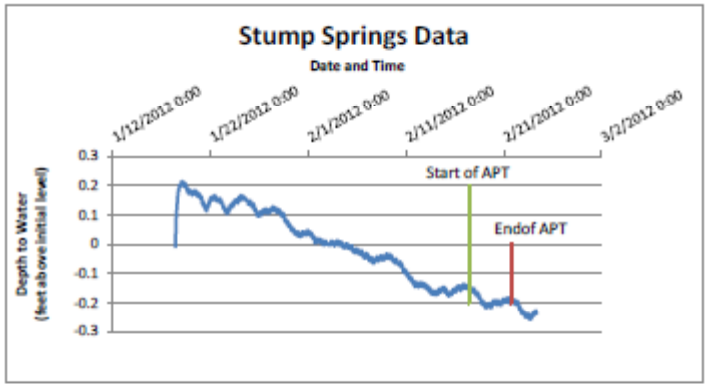


Figure 4-1 Stump Springs Background and APT Results

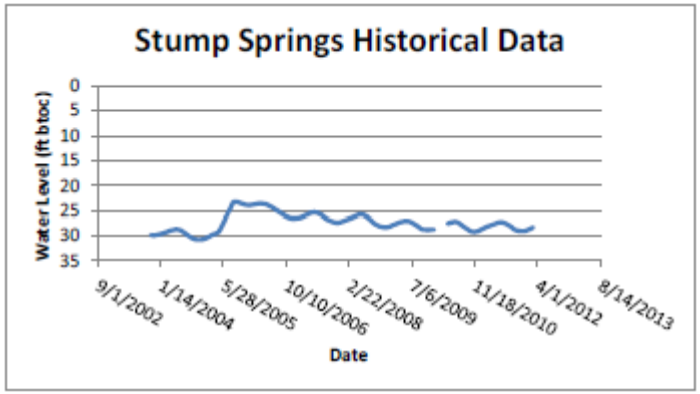
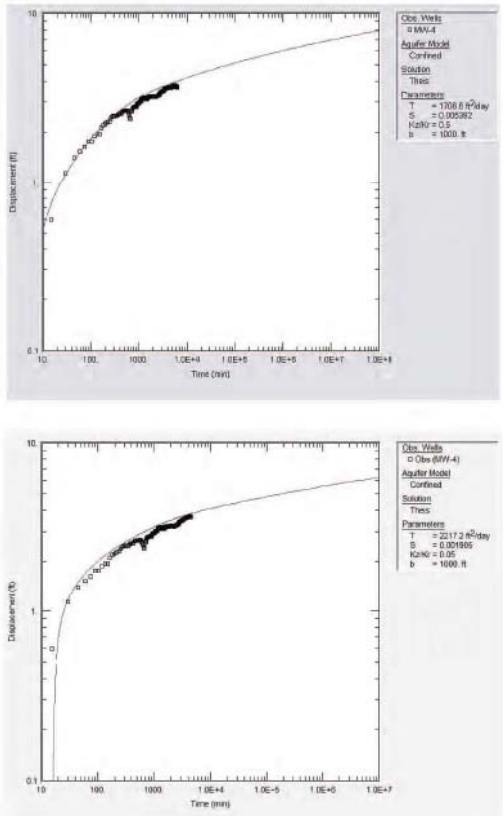


Figure 4-2 Stump Springs Historical Water Level Data provided by BLM

CEC Staff Asserted Aquifer May Be Fully Confined

WATER SUPPLY - FIGURE 21
Hidden Hills Solar Electric Generating System (HHSEGS)

Type-curve fitting of aquifer pump test data from MW-4. The data in the samples below were matched to a Theis type curve

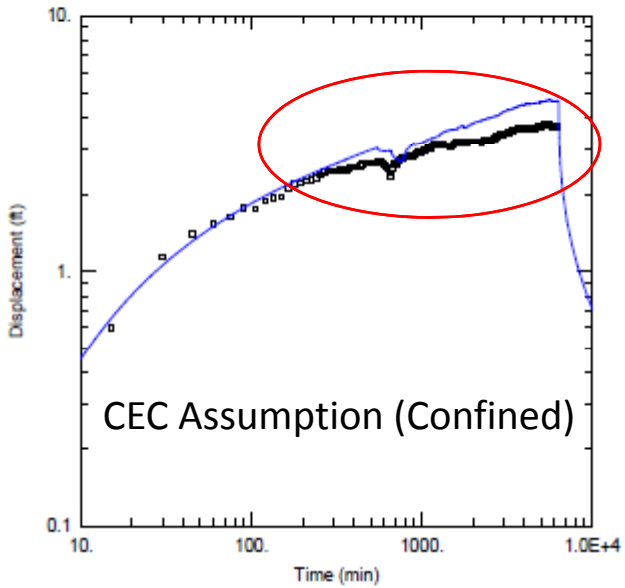


CALIFORNIA ENERGY COMMISSION - SITING, TRANSMISSION AND ENVIRONMENTAL PROTECTION DIVISION
SOURCE: Energy Commission Staff

- Data from MW4 appears to fit fully confined curve reasonably well when plotted with compressed time axis (7 log cycles when data is only 4 logs)
- Compresses the curve and minimizes departures from type curve
- Staff suggested Deviation from type curve may be due to variations in pumping rate
- Difference in interpretation hangs on interpretation of vertical flow from layers above and below pumping zone
- Significantly changes projected growth of the cone of depression

MW4 Fits Better to a Leaky Solution

(50 feet from Well 3)



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW4 Theis variable rate.aqt
Date: 06/07/12 Time: 20:41:43

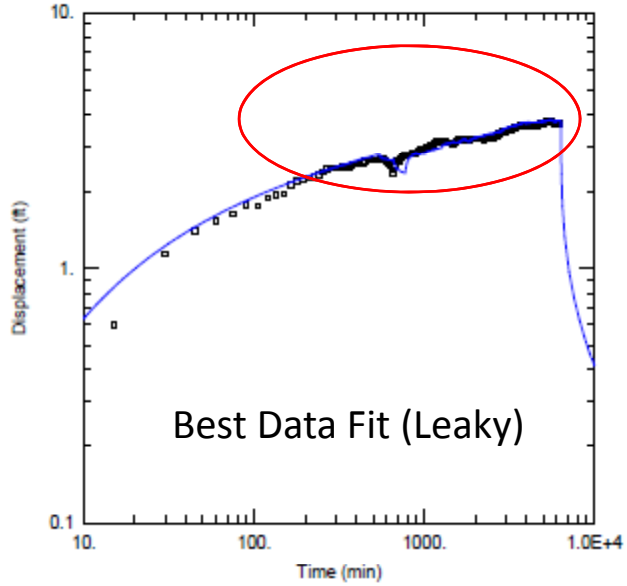
WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Well 3	0	0	MW4	50	0

SOLUTION

Aquifer Model: Confined
T = 7196.6 gal/day/ft
Kz/Kr = 0.1

Solution Method: Theis
S = 0.004768
b = 1000. ft



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW4 variable rate Hantush.aqt
Date: 06/09/12 Time: 15:38:15

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Well 3	0	0	MW4	50	0

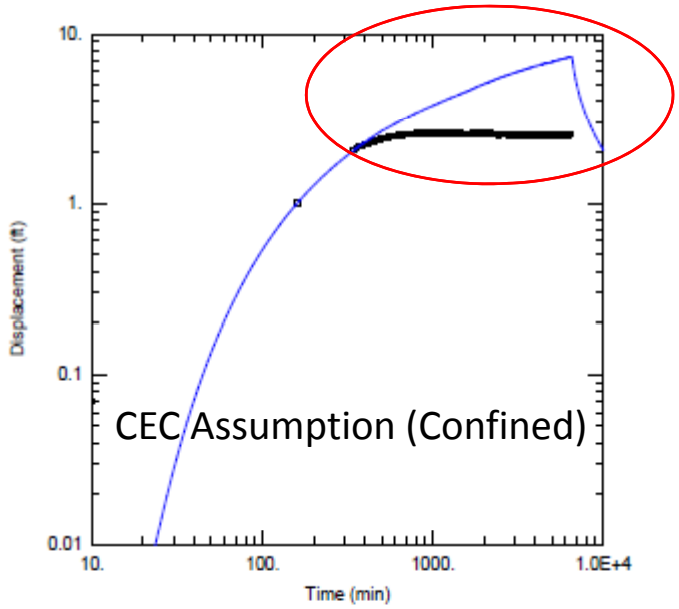
SOLUTION

Aquifer Model: Leaky
T = 6914.1 gal/day/ft
ß = 0.05
b = 1000. ft

Solution Method: Hantush
S = 0.002833
Kz/Kr = 0.1

- Plotting on 4 log time axis shows differences
- The difference seems minor but it is significant
- Data Corrected for variable pumping rates

MW1 Only Fits Leaky Type Curve
(200 feet from Orchard Well)



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW1 Theis variable rates.aqt
Date: 06/07/12 Time: 20:38:08

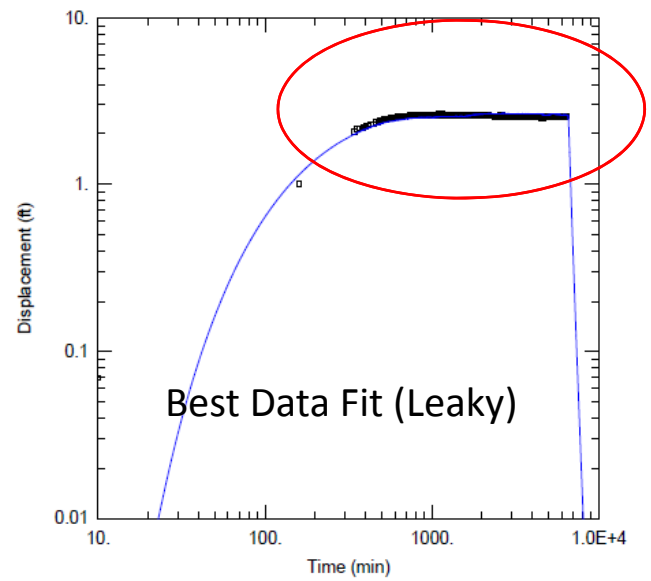
WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Orchard Well	0	0	MW1	200	0

SOLUTION

Aquifer Model: Confined
T = 2565. gal/day/ft
Kz/Kr = 0.1

Solution Method: Theis
S = 0.002115
b = 1000. ft



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW1 variable rates.aqt
Date: 06/07/12 Time: 20:37:04

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Orchard Well	0	0	MW1	200	0

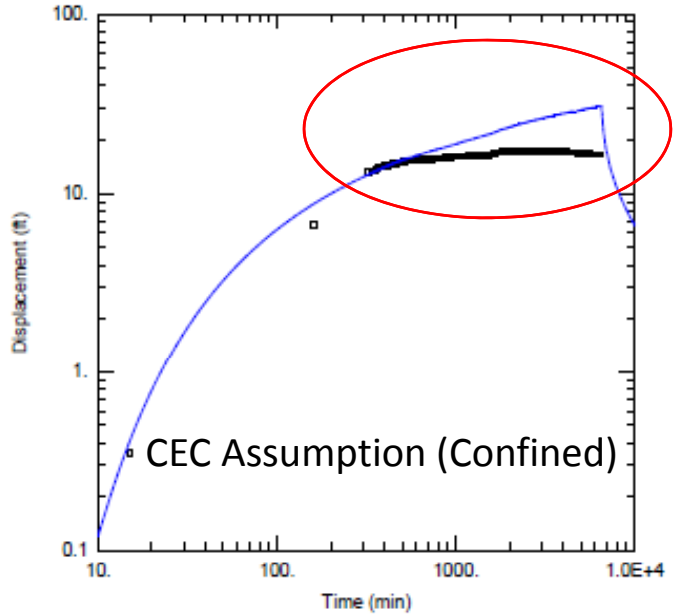
SOLUTION

Aquifer Model: Leaky
T = 1634.7 gal/day/ft
r/B = 1.
b = 1000. ft

Solution Method: Hantush-Jacob
S = 0.001431
Kz/Kr = 0.1

Type Curves corrected for variations in pumping rate

MW2 Only Fits Leaky Type Curve
(50 feet from Orchard Well)



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW2 Theis variable rates.aqt
Date: 06/07/12 Time: 20:39:24

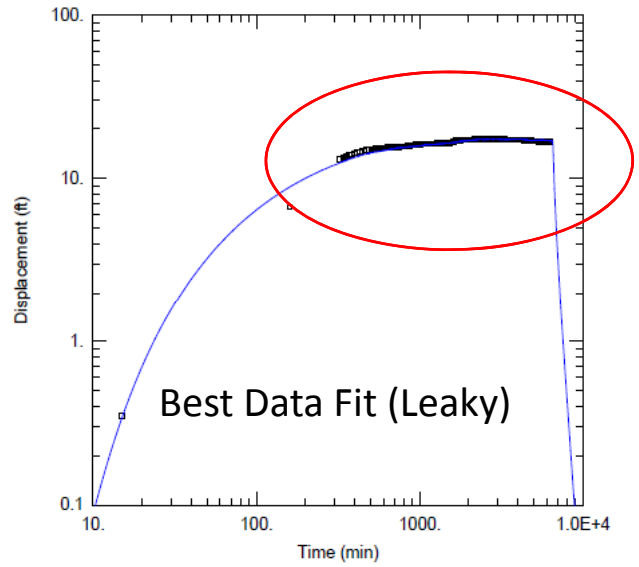
WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Orchard Well	0	0	MW2	50	0

SOLUTION

Aquifer Model: Confined
T = 802.1 gal/day/ft
Kz/Kr = 0.1

Solution Method: Theis
S = 0.003242
b = 1000. ft



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW2 variable rates.aqt
Date: 06/07/12 Time: 20:38:45

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Orchard Well	0	0	MW2	50	0

SOLUTION

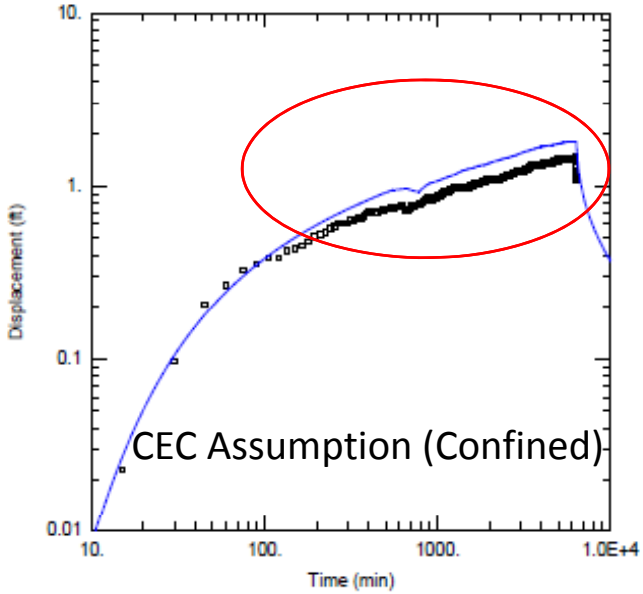
Aquifer Model: Leaky
T = 659.8 gal/day/ft
r/B = 0.4
b = 1000. ft

Solution Method: Hantush-Jacob
S = 0.003053
Kz/Kr = 0.1

Type Curves corrected for variations in pumping rate

MW3 Fits Leaky Type Curve Much Better Than Confined Type Curve

(200 feet from Well 3)



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW3 Theis variable rate.aqt
Date: 06/07/12 Time: 20:40:39

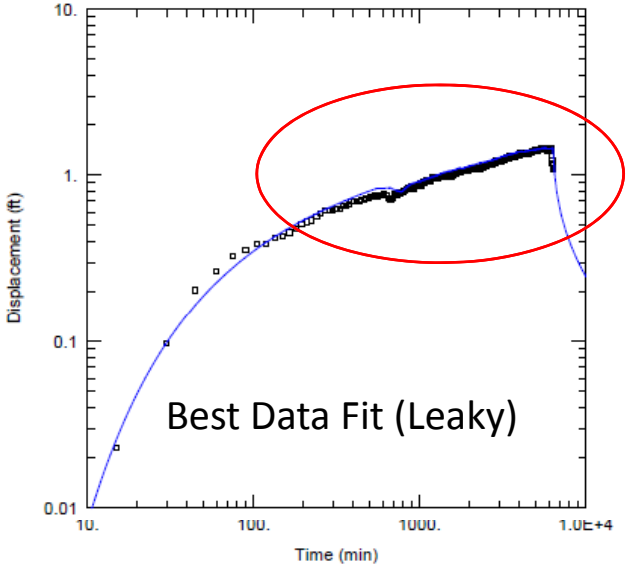
WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Well 3	0	0	▫ MW3	200	0

SOLUTION

Aquifer Model: Confined
T = 1.386E+4 gal/day/ft
Kz/Kr = 0.1

Solution Method: Theis
S = 0.003309
b = 1000. ft



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW3 variable rate Hantush.aqt
Date: 06/09/12 Time: 15:35:43

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Well 3	0	0	▫ MW3	200	0

SOLUTION

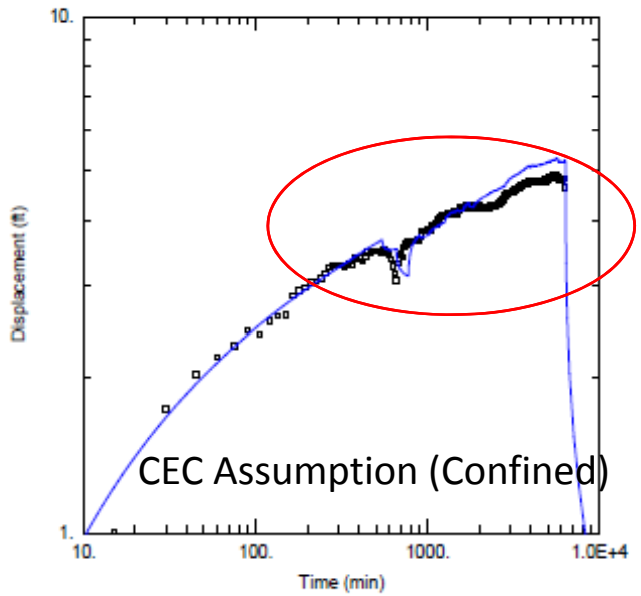
Aquifer Model: Leaky
T = 1.175E+4 gal/day/ft
ß = 0.1
b = 1000. ft

Solution Method: Hantush
S = 0.002805
Kz/Kr = 0.1

Type Curves corrected for variations in pumping rate

MW5 Fits Leaky Type Curve Much Better Than Confined Type Curve

(25 feet from Well 3)



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW5 Theis variable rate.aqt
Date: 06/07/12 Time: 20:43:13

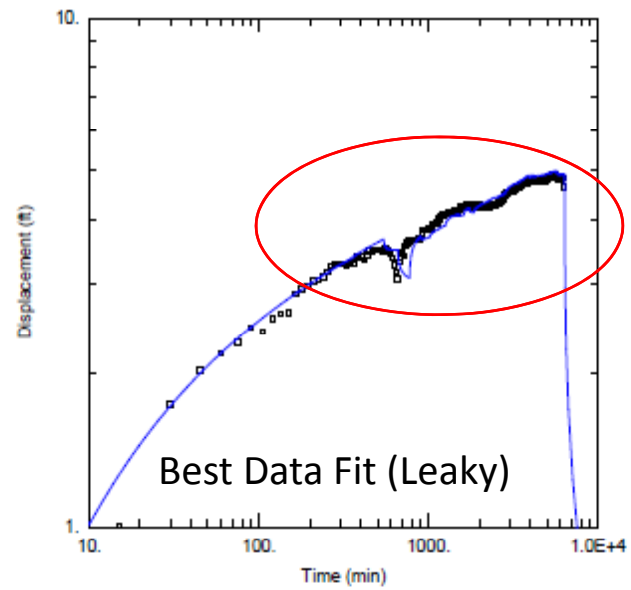
WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Well 3	0	0	MW5	25	0

SOLUTION

Aquifer Model: Confined
T = 7416. gal/day/ft
Kz/Kr = 0.1

Solution Method: Theis
S = 0.007045
b = 1000. ft



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW5 variable rate Hantush.aqt
Date: 06/09/12 Time: 15:37:01

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
Well 3	0	0	MW5	25	0

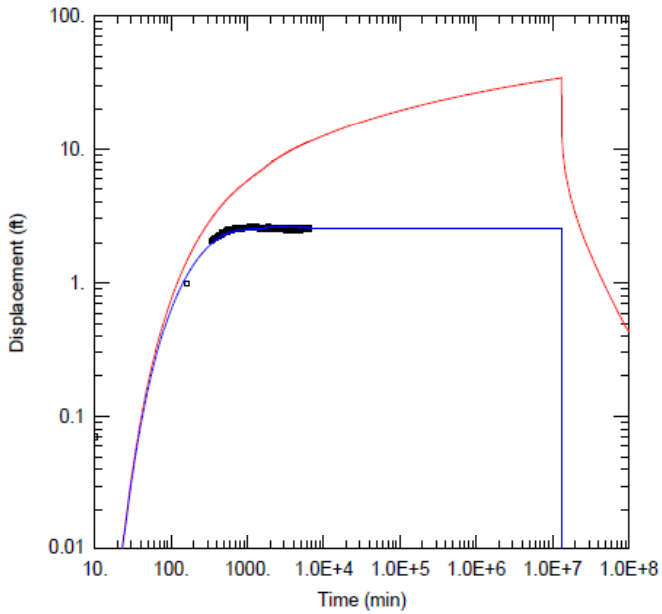
SOLUTION

Aquifer Model: Leaky
T = 6914.1 gal/day/ft
ß = 0.01
b = 1000. ft

Solution Method: Hantush
S = 0.006668
Kz/Kr = 0.1

Type Curves corrected for variations in pumping rate

Using The Wrong Aquifer Type Significantly Over Estimates Future Drawdown



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW1 variable Hantush with Theis 25 yrs.aqt
Date: 06/08/12 Time: 18:05:26

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Orchard Well	0	0

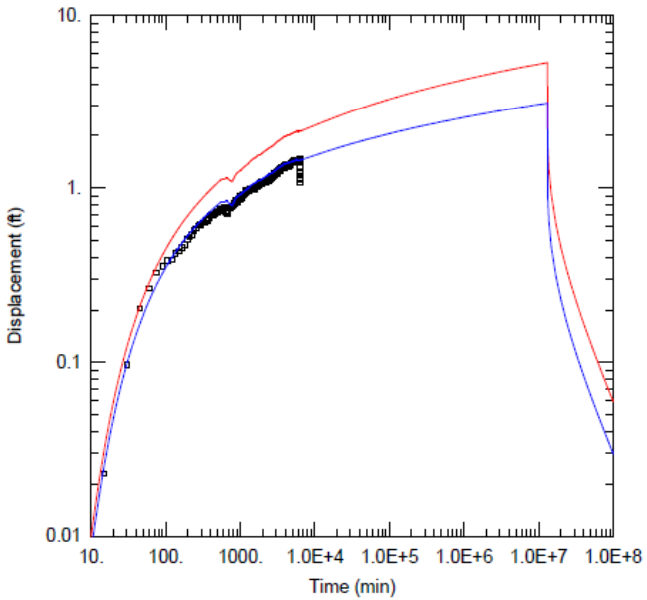
Observation Wells

Well Name	X (ft)	Y (ft)
MW1	200	0

SOLUTION

Aquifer Model: Leaky
T = 1634.7 gal/day/ft
r/B = 1.
b = 1000. ft

Solution Method: Hantush-Jacob
S = 0.001431
Kz/Kr = 0.1



WELL TEST ANALYSIS

Data Set: C:\...\BSE MW3 variable rate Hantush with Thies 25 year.aqt
Date: 06/08/12 Time: 18:40:03

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Well 3	0	0

Observation Wells

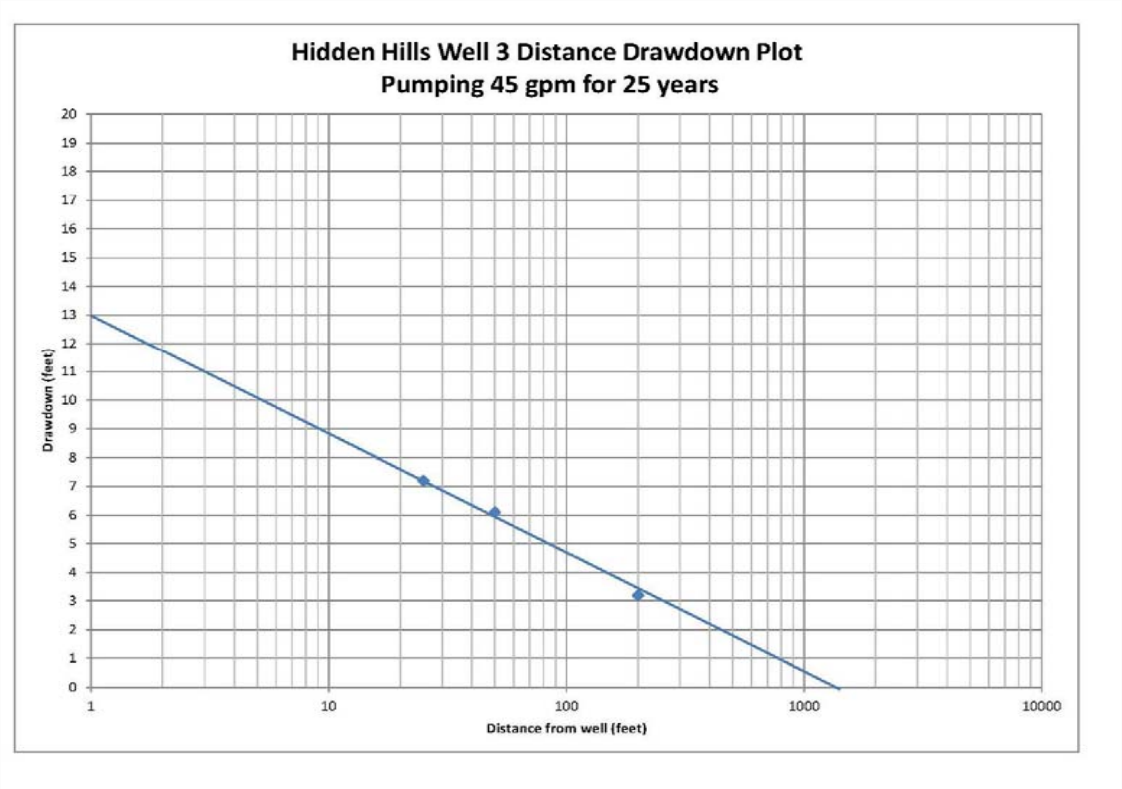
Well Name	X (ft)	Y (ft)
MW3	200	0

SOLUTION

Aquifer Model: Leaky
T = 1.175E+4 gal/day/ft
ß = 0.1
b = 1000. ft

Solution Method: Hantush
S = 0.002805
Kz/Kr = 0.1

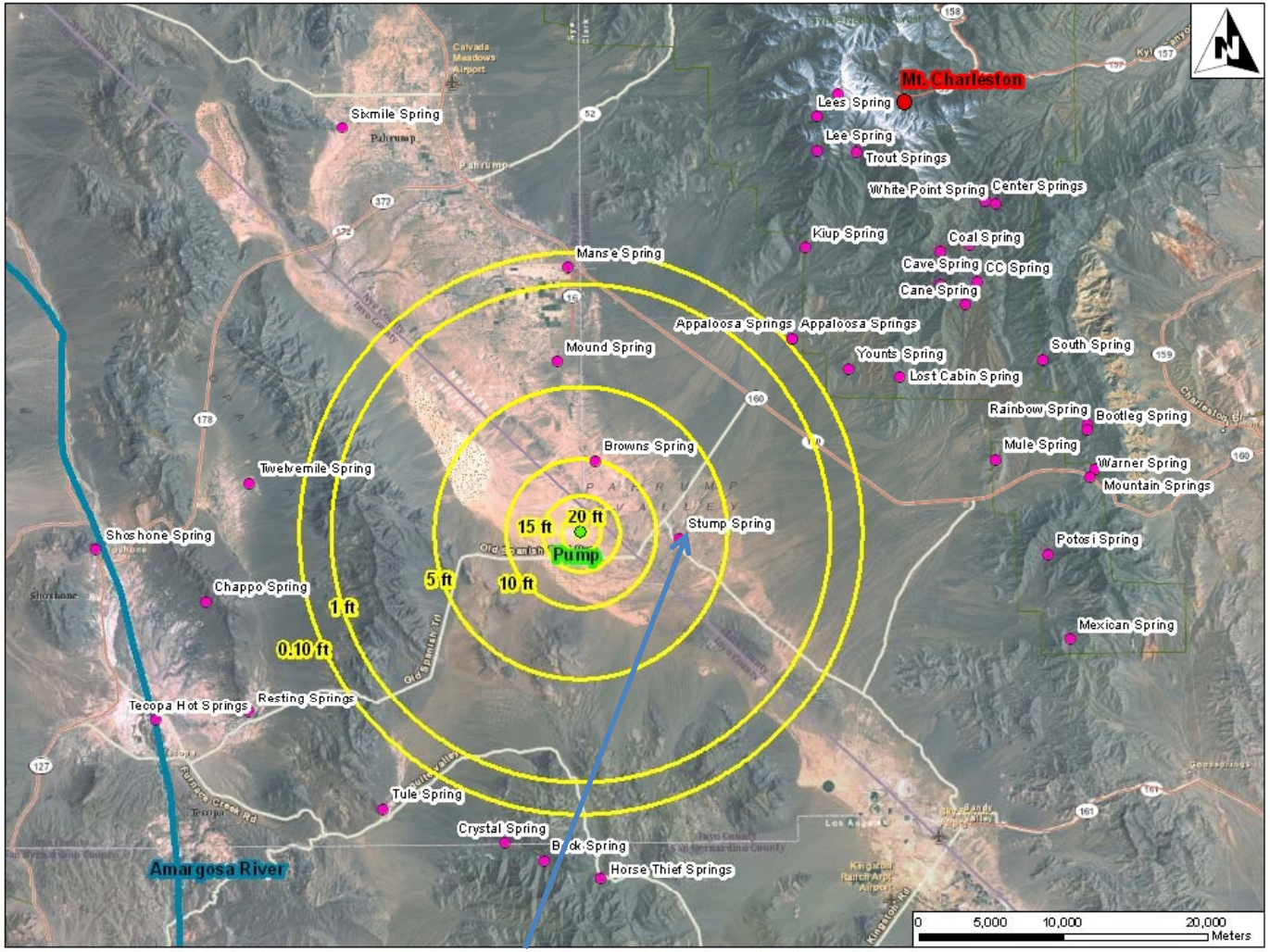
Estimating Radius of Influence From Pumping Test Data



Drawdown vs. distance from Well 3 after 25 years pumping at 45 gpm assuming no recharge from regional flow.

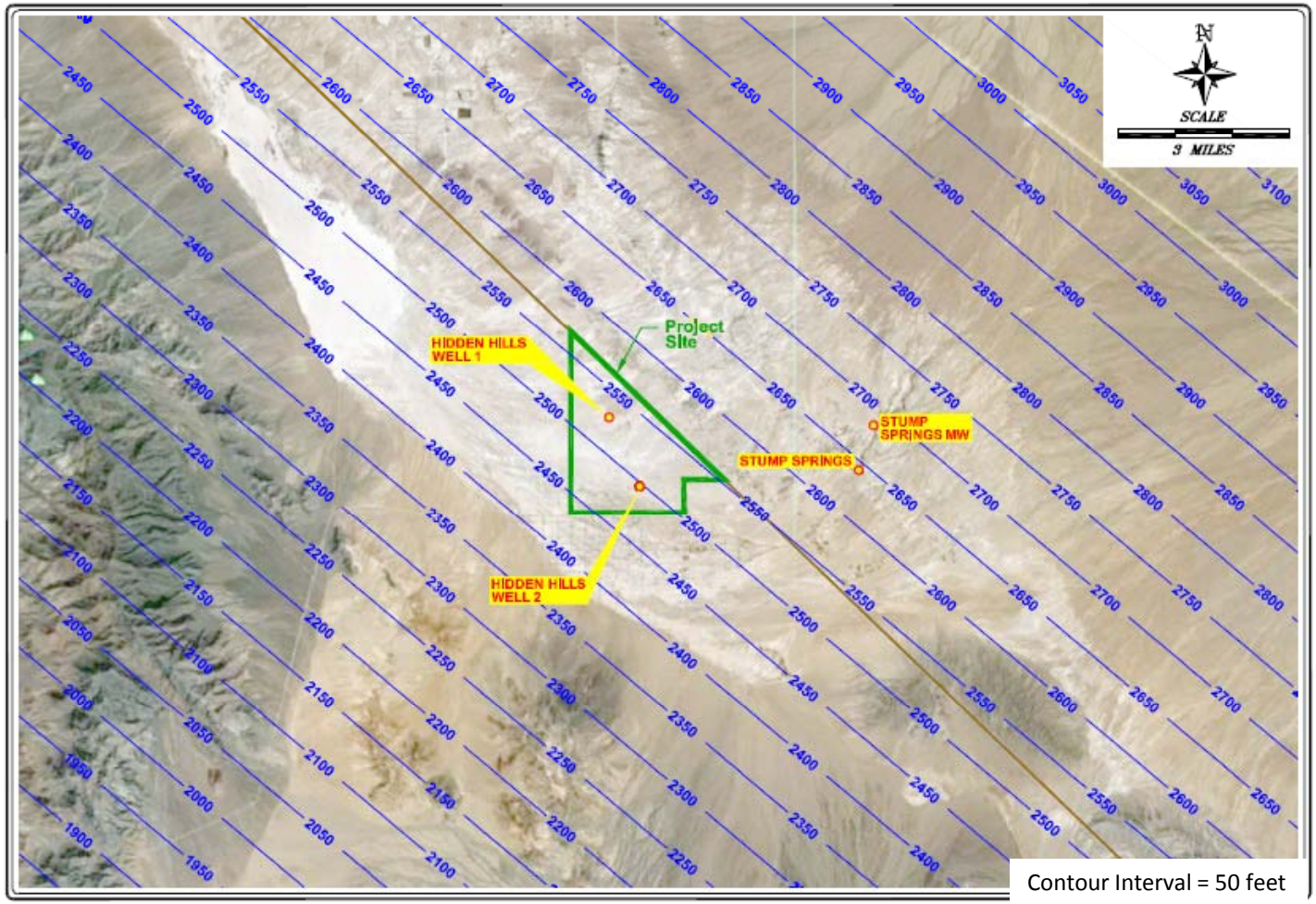
- Predicts drawdown will extend no more than about 1500 feet after 25 years
- Yields an estimated Transmissivity of about 6,000 gpd/ft

CEC Staff Assumed No Gradient and No Leakance and Half Actual Aquifer Transmissivity



Nearly 10 feet of drawdown at Stump Springs

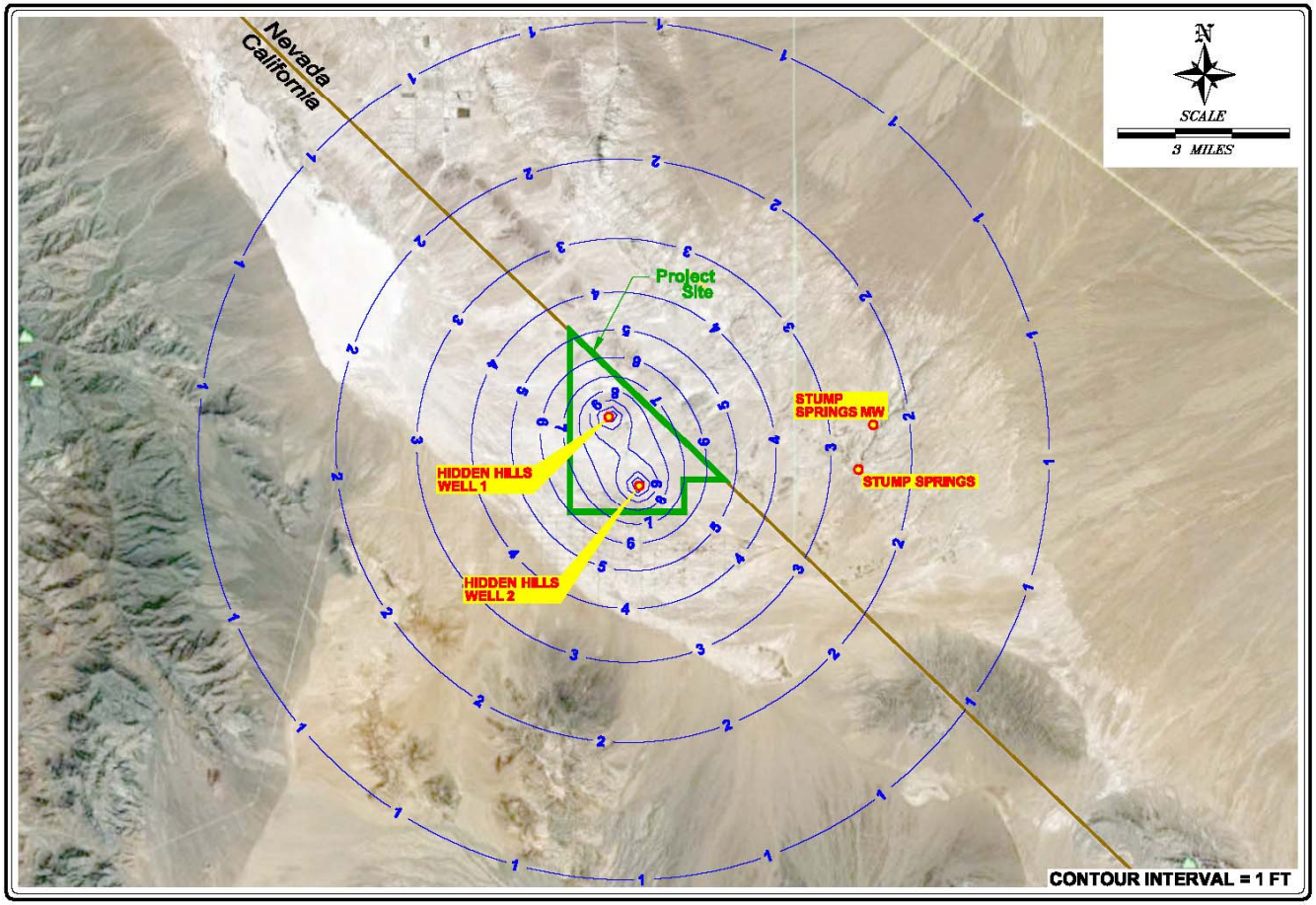
Simulated Gradient (No Pumpage)



Cardno ENTRIX | PROJECT NAME: BRIGHTSOURCE ENERGY HIDDEN HILLS | DWG. NUMBER: 33153001je1
PROJECT NUMBER: 33153001.00 | DATE: 06/12/12

FIGURE 1. ESTIMATED BASELINE HEADS IN THE AREA OF THE PROJECT SITE WITH NO PUMPAGE.

Hidden Hills Pumping (No Gradient or Leakance)



Cardno ENTRIX	PROJECT NAME: BRIGHTSOURCE ENERGY HIDDEN HILLS	DWG. NUMBER: 33153001je1
	PROJECT NUMBER: 33153001.00	DATE: 06/12/12

FIGURE 2. DRAWDOWN BASED ON 25 YEARS OF PUMPAGE BY HIDDEN HILLS ONLY, WITH NO LEAKANCE REPRESENTED.

Simulated Pumping at Hidden Hills With Leakance

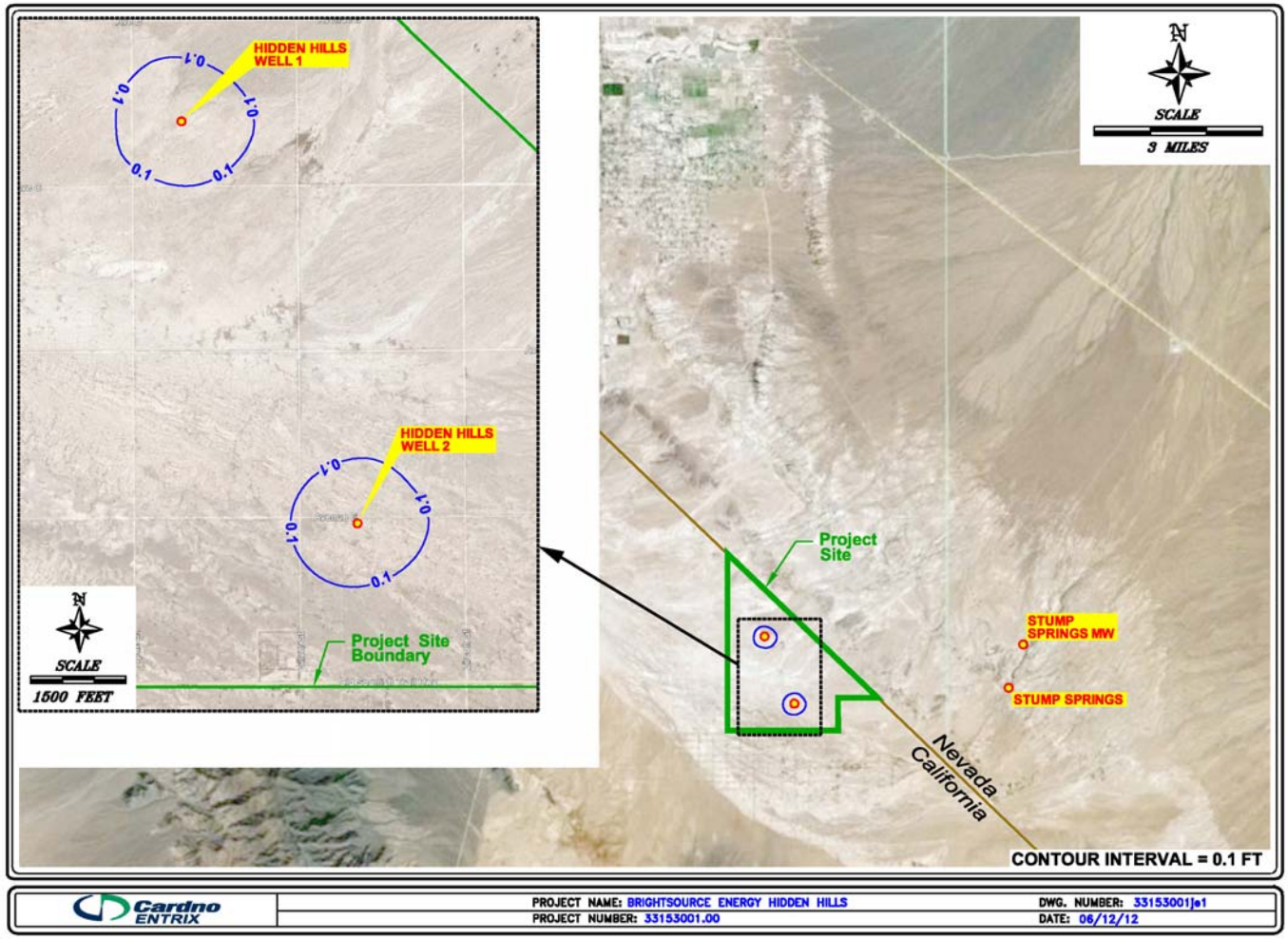


FIGURE 3. DRAWDOWN (0.1–FOOT CONTOUR) BASED ON 25 YEARS OF PUMPAGE BY HIDDEN HILLS ONLY, WITH LEAKANCE REPRESENTED.

Summary

- The pumping test data demonstrated that the aquifer can easily support the project
- Pumping represents about 8% of normal flow beneath site
- The test data clearly showed that the aquifer receives recharge from leakance
- CEC staff assumed a flat aquifer with no recharge (not representative of site conditions)
- Regional flow and recharge from leakance must be considered to match pumping test data
- No drawdown will propagate to springs from the Hidden Hills site
- No significant drawdown is expected at any private wells.
- Earlier models did not reflect aquifer properties as they are now understood.

Question & Answer