VITRO WELL DISCUSSION

UTAH DIVISION OF WATER RIGHTS
UTAH DIVISION OF DRINKING WATER

1. SOURCES OF DATA/ INFORMATION
2. THEORY
3. RESULTS
4. RECOMMENDATIONS

REQUIRED DATA:

- LITHOLOGIC
  - THICKNESS CONFINING LAYERS
  - THICKNESS SHALLOW AQUIFER
- WATER LEVELS
- WELL CONSTRUCTION
- LOCATION WITH RESPECT TO OTHER WELLS
- HYDROLOGIC PARAMETERS
  - T, K, S

SOURCES OF DATA:

- 1987 USGS GROUNDWATER FLOW MODEL (WADELL AND OTHERS)
- TECHNICAL PUBLICATION #87 (REFERRING TO 1983 PUMP TEST DATA)
- HELY AND OTHERS (1971)
- UNPUBLISHED MODEL

SHALLOW AQUIFER

- 80-100 ft well logs
- 73 ft 1987 model
- 39 ft unpublished model

CONFINING LAYERS

- 220 ft well logs
- 70 ft 1987 model
- 32 ft unpublished model
- $K' = 1.55 \cdot 10^{-6}$ ft/s unpublished model
- $K' = 1.23\ 10^{-6}$ ft/s 1987 model
- $K' = 1.43 \cdot 10^{-6}$ ft/s Tech Pub 87
- $K' = 2.9 \cdot 10^{-7}$ ft/s Hely (1971)
- $S \cong 5 \cdot 10^{-5}$ (Walton,)
- $S = .001$ unpublished model

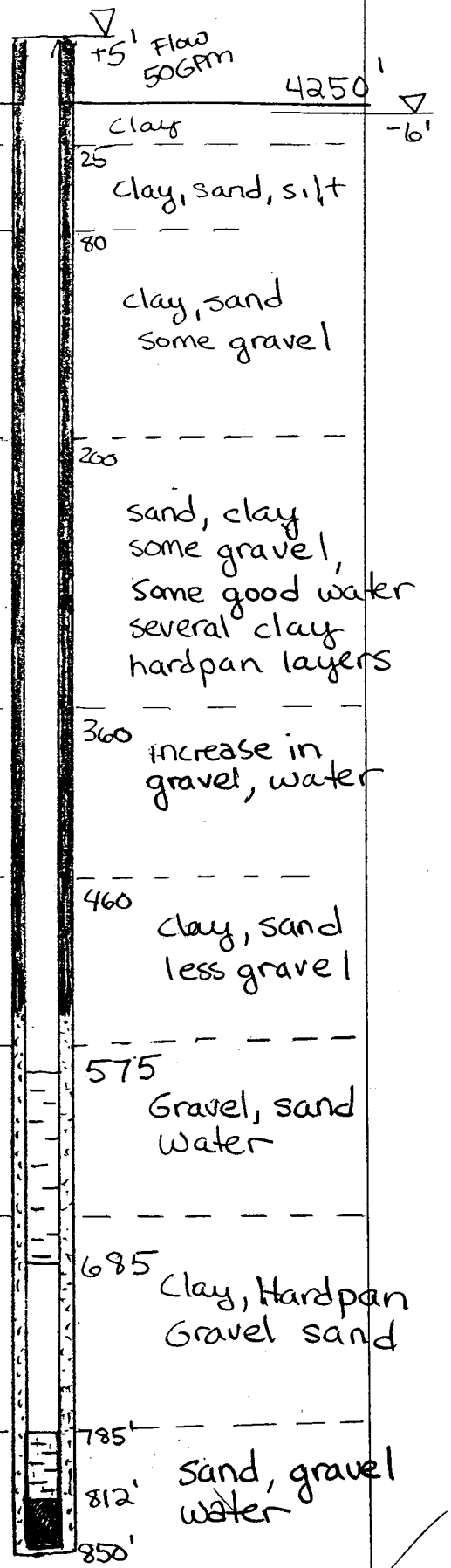
PRINCIPAL AQUIFER

$T = .1736\ ft^2/s$, $S = 1 \cdot 10^{-4}$ } 1987 model

* $T = .0447\ ft^2/s$, $S = 4 \cdot 10^{-4}$ } Tech Pub 87 (1983 Pump Test)

$T = .1157\ ft^2/s$, $S = 4 \cdot 10^{-4}$ } Hely (1971)

$T = .1736$, $S = .001$ } unpublished model



* According to Pat Lambert (USGS), the best available information for the area in question is the documentation of an aquifer test conducted in 1983 in Technical Publication No. 87 and 89

THEORY

HANTUSH MODIFIED METHOD (1960) FOR LEAKY CONFINED AQUIFERS, as Described by LOHMAN (1979).

$$T = \frac{Q}{4\pi s} H(u, \beta) \qquad u = \frac{r^2 S}{4Tt} \qquad \beta = \frac{r}{4b}\left(\sqrt{\frac{K' S_s'}{K S_s}}\right)$$

K, K' = hydraulic conductivities of confined aquifer and confining layers

$S_s\ S_s'$ = Specific Storage of main aquifer and confining layers

$S = b S_s$

$S' = b' S_s'$

b, b' = thickness of main aquifer & confining layers

r = distance from pumping well to get drawdown s.

T = transmissivity = Kb.

t = time of Pumping

Q = pumping rate

Simplifying β:

$$\beta = \frac{r}{4b}\left(\sqrt{\frac{K'(S'/b')}{(T/b)(S/b)}}\right) = \frac{r}{b}\left(\frac{K'S'}{b'TS}\right)$$

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Maximum Drawdown at Vitro Well

	Conf Lay					Princ, Aquif	Confin. lay	Princ. Aquif	Confin layer						
	b' (ft)	Q (GPM)	Q (cfs)	t (day)	t (sec)	T (sq ft/s)	K'(ft/s)	S	S'	r(ft)	u	B	H(u,B)	s(ft)	s (interference)**
1987 Model	70	1169	2.61	182.5	1.6E+07	0.1736	1.225E-06	1.0E-04	5E-05	0.42	1.61E-12	2.36E-05	26.63	31.86	
Tech Pub 87*	200	1169	2.61	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	110.82	
Hely (1971)	50	1169	2.61	182.5	1.6E+07	0.1157	2.9E-07	4.0E-04	5E-05	0.42	9.67E-12	8.31E-06	24.79	44.50	
Prelim. Unpublished model	31.7	1169	2.61	182.5	1.6E+07	0.1736	1.55E-06	0.001	0.001	0.42	1.61E-11	5.57E-05	24.32	29.10	

* Thickness of Confining layers based on well logs

Super-posistion of other active wells at vitro well; Tech Pub 87 data (6 month base)

Vitro (1943-1960)	200	1169	2.61	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	110.82	110.82
Davis (SSL)(1955)	200	1026	2.29	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	2024	5.81E-04	7.15E-02	4.2	17.12	17.12
Geneva (1979)	200	228	0.51	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	5346	4.05E-03	1.89E-01	2.8	2.54	2.54
Gr Hunter (4) (1955-1959)	200	6106	13.63	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	7364	7.69E-03	2.60E-01	2.4	58.24	12.00
Tay-Ben (3) (1955-1973)	200	10210	22.79	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	7200	7.35E-03	2.55E-01	2.2	89.26	12.00
Bollinder (SSL)(1975)	200	623	1.39	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	6956	6.86E-03	2.46E-01	2.6	6.43	6.43
2900 South (SSL) (1946)	200	448	1.00	182.5	1.6E+07	0.0447	1.43E-06	4.0E-04	5E-05	2023	5.81E-04	7.15E-02	4.2	7.48	7.48
														291.89	168.39

** interference limitation do not apply to other wells owned by South Salt Lake

interference limitation do not apply to wells with early priority water rights (all but 1 water right in Vitro well are Senior)

Maximum allowable Vitro well flow rate: 60 feet drawdown
(1992 based scenario)

Super-posistion of other active wells using 1992 average flow rate at vitro well (6 month base)

	b' (feet)	Q (GPM)	Q (cfs)	t (day)	t (sec)	Princ, Aquif T (sq ft/s)	Confin. la K'(ft/s)	Princ. Aquif S	Confin layer S'	r(ft)	u	B	H(u,B)	s(ft)	s (inter-ference limits)
Vitro	200	255	0.57	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	24.20	24.20
Davis (SSL)	200	1178	2.63	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2024	5.81E-04	7.15E-02	4.2	19.66	19.66
Geneva	200	0	0.00	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	5346	4.05E-03	1.89E-01	2.8	0.00	0.00
Gr Hunter (4)	200	291	0.65	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7364	7.69E-03	2.60E-01	2.4	2.78	2.78
Tay-Ben (3)	200	1640	3.66	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7200	7.35E-03	2.55E-01	2.2	14.33	12.00
Bollinder (SSL)	200	139	0.31	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	6956	6.86E-03	2.46E-01	2.6	1.43	1.43
2900 South (SSL)	200	0	0.00	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2023	5.81E-04	7.15E-02	4.2	0.00	0.00
															60.08

Maximum allowable Vitro well flow rate: 60 feet drawdown
(Maximum Flow Rates)

	b' (feet)	Q (GPM)	Q (cfs)	t (day)	t (sec)	Princ, Aquif T (sq ft/s)	Confin. la K'(ft/s)	Princ. Aquif S	Confin layer S'	r(ft)	u	B	H(u,B)	s(ft)	s (with inter-ference limits)
Vitro Well alone, pumping alone for 6 months															
Tech Pub 87 data	200	636	1.42	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	60.29	
Super-posistion of maximum flow rates of other active wells at vitro well; (6 month base)															
Vitro	200	157	0.35	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	14.86	14.86
Davis (SSL)	200	314	0.70	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2024	5.81E-04	7.15E-02	4.2	5.23	5.23
Geneva	200	228	0.51	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	5346	4.05E-03	1.89E-01	2.8	2.54	2.54
Gr Hunter (4)	200	6106	13.63	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7364	7.69E-03	2.60E-01	2.4	58.24	12.00
Tay-Ben (3)	200	10210	22.79	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7200	7.35E-03	2.55E-01	2.2	89.26	12.00
Bollinder (SSL)	200	623	1.39	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	6956	6.86E-03	2.46E-01	2.6	6.43	6.43
2900 South (SSL)	200	448	1.00	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2023	5.81E-04	7.15E-02	4.2	7.48	7.48
															60.55

Maximum allowable Vitro well flow rate: 80 feet drawdown
(1992 based scenario)

Super-posistion of other active wells using 1992 average flow rate at vitro well (6 month base)

	b' (feet)	Q (GPM)	Q (cfs)	t (day)	t (sec)	Princ, Aquif T (sq ft/s)	Confin. la K'(ft/s)	Princ. Aquif S	Confin layer S'	r(ft)	u	B	H(u,B)	s(ft)	s (inter-ference limits)
Vitro	200	466	1.04	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	44.16	44.16
Davis (SSL)	200	1178	2.63	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2024	5.81E-04	7.15E-02	4.2	19.66	19.66
Geneva	200	0	0.00	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	5346	4.05E-03	1.89E-01	2.8	0.00	0.00
Gr Hunter (4)	200	291	0.65	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7364	7.69E-03	2.60E-01	2.4	2.78	2.78
Tay-Ben (3)	200	1640	3.66	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7200	7.35E-03	2.55E-01	2.2	14.33	12.00
Bollinder (SSL)	200	139	0.31	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	6956	6.86E-03	2.46E-01	2.6	1.43	1.43
2900 South (SSL)	200	0	0.00	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2023	5.81E-04	7.15E-02	4.2	0.00	0.00
															80.03

Maximum allowable Vitro well flow rate: 80 feet drawdown
(Maximum Flow Rates)

	b' (feet)	Q (GPM)	Q (cfs)	t (day)	t (sec)	Princ, Aquif T (sq ft/s)	Confin. la K'(ft/s)	Princ. Aquif S	Confin layer S'	r(ft)	u	B	H(u,B)	s(ft)	s (with inter-ference limits)
Vitro Well, pumping alone for 6 months															
Tech Pub 87 data	200	844	1.89	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	80.04	
Super-posistion of maximum flow rates of other active wells at vitro well; (6 month base)															
Vitro	200	363	0.81	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	0.42	2.50E-11	1.48E-05	23.85	34.39	34.39
Davis (SSL)	200	314	0.70	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2024	5.81E-04	7.15E-02	4.2	5.23	5.23
Geneva	200	228	0.51	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	5346	4.05E-03	1.89E-01	2.8	2.54	2.54
Gr Hunter (4)	200	6106	13.63	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7364	7.69E-03	2.60E-01	2.4	58.24	12.00
Tay-Ben (3)	200	10210	22.79	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	7200	7.35E-03	2.55E-01	2.2	89.26	12.00
Bollinder (SSL)	200	623	1.39	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	6956	6.86E-03	2.46E-01	2.6	6.43	6.43
2900 South (SSL)	200	448	1.00	182.5	1.58E+07	0.0447	1.43E-06	4.0E-04	5E-05	2023	5.81E-04	7.15E-02	4.2	7.48	7.48
															80.08

RECOMMENDATIONS

- LIMIT DRAWDOWN TO 80 FT BELOW GROUND SURFACE
- LIMIT DIVERSION RATE TO 1.0 CFS
- RE-EVALUATE AS ADDITIONAL DATA BECOMES AVAILABLE

REQUIREMENTS

- ANALYZE INTEGRITY OF WELL CONSTRUCTION
- INSTALL FLOW AND TOTALIZING METER
- DESIGN MONITORING PLAN
  - WATER LEVELS
  - WATER QUALITY
  - WITHDRAWALS
  - FLOW RATE
- OBTAIN APPROVAL FROM BOTH DIVISION OF DRINKING WATER AND DIVISION OF WATER RIGHTS

Example Calculation:

6 months @ 2.61 cfs using Tech Pub 87 data at well site

$$T = \frac{Q}{4\pi s} H(u, \beta)$$

$$s = \frac{Q}{4\pi T} H(u, \beta)$$

$Q = 2.61$ cfs

$r_w = 0.42$ ft (radius well)

$t = 6$ mo $= 1.58 \cdot 10^7$ s $\quad K' = 1.43 \cdot 10^{-6}$ ft/s

$T = .0447$ ft^2/s $\quad b' = 200$ ft

$S = 4 \cdot 10^{-4} \quad S' = 5 \cdot 10^{-5}$

$$u = \frac{r^2 S}{4Tt} \qquad u = \frac{(.42')^2 (4 \cdot 10^{-4})}{4(.0447 \text{ ft}^2/\text{s})1.58 \cdot 10^7 \text{ s}} \qquad u = 2.50 \cdot 10^{-11}$$

$$\beta = \frac{r}{4}\left(\frac{K' S'}{b' T S}\right)^{1/2} \qquad \beta = \frac{(.42 \text{ ft})}{4}\left(\frac{(1.43 \cdot 10^{-6} \text{ ft/s})(5 \cdot 10^{-5})}{(200 \text{ ft})(.0447 \text{ ft}^2/\text{s})(4 \cdot 10^{-4})}\right)^{1/2}$$

$$\beta = 1.49 \cdot 10^{-5}$$

$H(u, \beta) \cong W(u)$ when $\beta \to 0$ approaches Theis Curve

Theis Curve

$$s = \frac{Q}{4\pi T} W(u) \quad \text{since } \beta \to 0 \qquad s = \frac{2.61 \text{ ft}^3/\text{s}}{4\pi (.0447 \text{ ft}^2/\text{s})}(23.85)$$

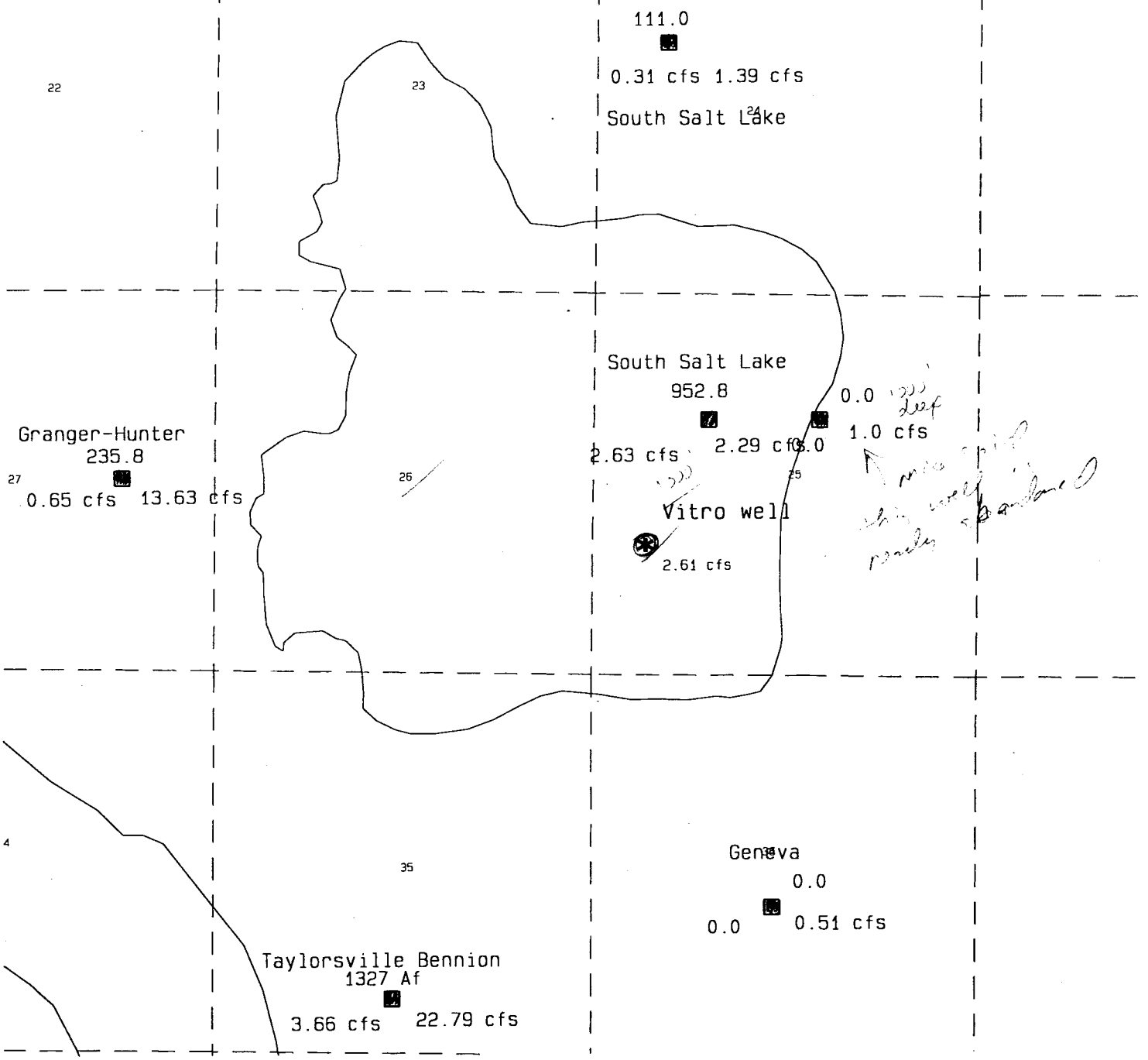
$W(u) \cong 23.85$

Table 8.1

Freeze + Cherry

$$\boxed{s = 110.8 \text{ feet}}$$

1992 Water use and Maximum Potential flow in Vitro Area



1992 Water Use (AF)

1992 Avg Flow
(6 mo period)

Maximum flow