TRANSMISSIVITY OF THE SNAKE RIVER PLAIN AQUIFER AT THE IDAHO NATIONAL ENGINEERING LABORATORY, IDAHO

By D.J. Ackerman

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09290	meter squared per day
gallon per minute (gal/min)	0.06309	liter per second
gallon per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter
inch (in.)	25.4	millimeter
square mile (mi^2)	2.590	square kilometer

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ABSTRACT

Aquifer-test data of 183 single-well tests at 94 wells in the Snake River Plain aquifer were analyzed to estimate values of transmissivity. Estimates of transmissivity for individual wells ranged from 1.1 to 7.6×10^5 feet squared per day, nearly 6 orders of magnitude. These data were determined in a consistent manner and are useful for describing the distribution of transmissivity at the Idaho National Engineering Laboratory.

The results of type-curve analysis of 37 tests at 26 wells were used to develop a regression relation between specific capacity and transmissivity. This relation, in turn, was used to analyze all specific-capacity data. Values of relative uncertainty for estimated values of transmissivity generally ranged from 0.1 order of magnitude for type-curve analysis to 0.5 order of magnitude for specific-capacity analysis with measured drawdown of less than 0.1 foot.

The values of transmissivity given in this report represent the transmissivity near the test wells and within the test interval. Due to the high degree of heterogeneity of the basalt and the unknown thickness of the aquifer, it is more likely the transmissivity of the whole basalt sequence is different from those values given in this report. Nevertheless, the reported transmissivities are useful, because most of the development of the aquifer at the Idaho National Engineering Laboratory area is limited to the top several hundreds of feet of the aquifer where the test wells are penetrated.

INTRODUCTION

The INEL (Idaho National Engineering Laboratory), which includes about 890 mi^2 of the eastern Snake River Plain in southeastern Idaho (fig. 1), is operated by the U.S. Department of Energy primarily to build, test, and operate nuclear reactors, and to process spent fuel from government-owned reactors. The INEL also supports other government-sponsored projects such as energy, defense, medical, and environmental research. The entire water supply for the INEL is obtained from the Snake River Plain aquifer. Ground water is used at the INEL as the source of noncontact cooling water, process water, and drinking water.

Aqueous chemical and radioactive wastes have been discharged to deep wells and shallow ponds at the INEL since 1952, resulting in the movement of some of these wastes into the Snake River Plain aquifer. Wastes that reach the aquifer move downgradient toward the southern boundary of the INEL. The effects of waste disposal have been investigated by the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, since disposal began.

Purpose and Scope

The purpose of this report is to present a consistently determined set of transmissivity values estimated from aquifer-test and specific-capacity data for the Snake River Plain aquifer at or near the INEL. These transmissivity values are needed for studying ground-water flow at the INEL.

Because of the paucity of multiple-well aquifer tests near the INEL, the scope of this interpretation is limited to single-well tests or specific-capacity data. Much of the data are simply specific capacities, which were used to estimate transmissivities. These estimates are useful for evaluating regional differences in transmissivity and preparing transmissivity maps for use in models of ground-water flow systems (Heath, 1983, p. 60). Single-well tests allow the estimation of transmissivity only; the interpretation of all possible hydrologic properties from

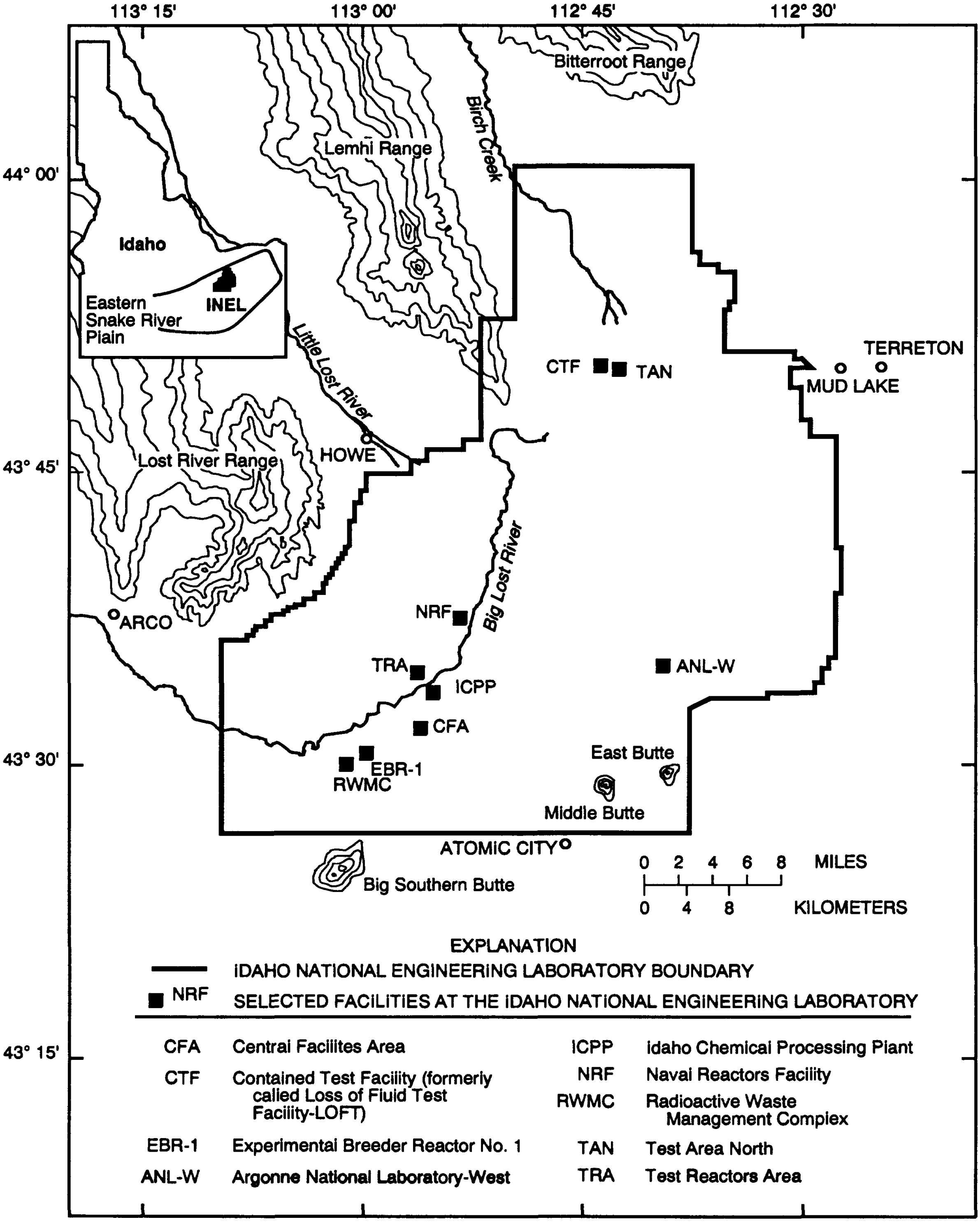


Figure 1.--Location of the Idaho National Engineering Laboratory.

multiple-well tests is not part of the scope of this report.

Data and interpretations are given for 183 tests at 94 wells on and adjacent to the INEL. An estimate of transmissivity is made for the aquifer at each well.

Geohydrologic Setting

The Snake River Plain aquifer at the INEL consists of a layered sequence of basaltic-lava flows and cinder beds intercalated with sedimentary deposits mainly made up of fluvial and lacustrine deposits. Individual lava flows typically are 20 to 25 ft thick and 50 to 100 mi^2 in areal extent. Rubble, clinker zones, fractures, and vesicular zones (collectively referred to as interflow zones) are prevalent near the surfaces of flows. Subsequent lava flows or sedimentary deposits may partly fill fractures and vesicles. The centers of individual flows, especially thick flows, are typically less vesicular and more massive, although they may be characterized by vertical fractures.

The geology and hydrology of the Snake River Plain aquifer at the INEL describe a water-table aquifer of large areal extent (Garabedian, 1989). Well yields are large because of the highly transmissive nature of interflow zones. The aquifer framework results in a complex, heterogeneous, and anisotropic medium at the scale of aquifer tests. If a mathematical treatment is to be workable, certain idealizations regarding homogeneity, well construction, and aquifer extent are imperative.

The effective base of the Snake River Plain aquifer is uncertain but is between 840 and 1,220 ft below land surface--445 and 825 ft below the water table--at one location at the INEL (Mann, 1986, p. 21). The water table at the INEL ranges from about 200 ft below land surface in the north-central part to about 900 ft in the southeastern part. Ground-water levels are relatively stable at the INEL, although they respond to climatic trends and, locally, to recharge from intermittent streams.

Vertical-head gradients are usually less than 0.01 over the first 200 ft and less than 0.02 over the first 550 ft of saturated thickness. Horizontal gradients of the water table generally are from 0.0006 to 0.0004. Ground-water movement is generally toward the southwest. Horizontal velocities have been estimated to be between 5 and 20 ft/d (Robertson and others, 1974, p. 13).

In some areas and at some times, infiltration from intermittent streams and waste ponds has created perched aquifers above the water table of the Snake River Plain aquifer. Results of aquifer tests in perched aquifers are not included in this report. For additional discussions of the geology of the Snake River Plain and the hydrology of the Snake River Plain aquifer, the reader is referred to reports by Garabedian (1989) and Robertson and others (1974).

DESCRIPTION OF AQUIFER-TEST DATA AND WELLS

Transmissivity is a measure of the ability of an aquifer to transmit water to hydraulically downgradient areas and to pumping wells. Transmissivity is defined as the rate at which water of prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohman, 1972, p. 6).

The transmissivity of an aquifer can be estimated from aquifer-test and specific-capacity data. An aquifer test consists of pumping a well at a constant rate for a specified time and measuring the resultant water-level declines in the pumped well and in nearby wells that are not pumped during the testing period. After the pumping is stopped, measurements are made to define the rate of recovery of water levels. The specific capacity of a well, the ratio of the pumping rate to the resultant water-level decline measured in the pumping well, can also be used to estimate transmissivity although there is a lesser degree of certainty when compared with estimates made using aquifer-test data.

Time-drawdown data have been collected at 94 wells at or near the INEL for a variety of purposes, but rarely for the express purpose and design of calculating aquifer properties. Many tests made before 1980 primarily were part of well-acceptance tests for production or injection wells. After 1986, most tests were made for the purpose of obtaining transmissivity estimates but were often constrained by pumping capacity and design.

Records for 183 aquifer tests at 94 wells on or near the INEL (table 1 and figs. 2-5) were reviewed and analyzed. Type-curve analysis was possible for 37 tests at 26 wells. The remaining 146 tests at 80 wells provide little more than specific-capacity data. Because only 5 multiple-well tests at 3 locations are adequate for multiple-well analysis, all data were analyzed as single-well tests.

All methods of analyzing aquifer-test data were developed using simplifying assumptions. When these assumptions are not met, the ability to interpret the data is limited. Improper well construction and test procedures can also diminish the usefulness of the data. Problems in the execution of these aquifer tests that limit the ability to interpret the data are:

1. nonsteady discharge rates;
2. inefficient production wells (well loss);
3. well-bore storage effects;
4. filling of well bores with sediment;
5. decrease in saturated thickness with pumpage;
6. filling and draining of pump columns (small discharge rates coupled with great depths to water);
7. partial penetration effects could not be quantified (effective base of aquifer unknown);
8. lack of record of prior trends in water levels;
9. lack of records of either barometric fluctuations or efficiency;
10. interference from other pumping or injecting wells;
11. observation wells too far from pumping well to clearly quantify the effects of partial penetration, release of water from elastic storage, delayed water-table response, and anisotropy; and
12. insufficient early- or late-time observations of drawdown to fully utilize an applicable method of interpretation.

Table 1.--Data on specific-capacity tests of wells at and near the Idaho National Engineering Laboratory

[Locations of wells shown on figures 2, 3, 4, and 5; Date, year-month-day of beginning of test; gal/min, gallon per minute; gal/min/ft, gallon per minute per foot; ?, length of test unknown; Remarks: N, Neuman type-curve analysis; T, Theis type-curve analysis; R, regression analysis; a, multiple well test; b, injection test; c, nearby well pumping; d, decrease in saturated thickness greater than 10 percent; e, before deepening; f, airline measurement of drawdown; g, well developing; h, large barometric change; i, recovery test; j, nearby well injecting; s, drawdown measurable but less than 0.1 foot]

Well identifier	Test number	Date	Length of test, minutes	Discharge, gal/min	Drawdown, feet	Specific capacity, (gal/min)/ft	Remarks
ANP #3 (TAN Disp.)	1	66-09-26	30	420	15.0	2.8×10^{1}	R, b
	2	86-01-14	10	20	>10.0	$<2.0\times10^{0}$	R
	3	87-07-13	75	19.7	12.68	1.6×10^{0}	N
	4	88-01-11	340	37	26.95	1.4×10^{0}	N
ANP #5	1	56-06-15	1,440	418	0.41	1.0×10^{3}	R
	2	56-09-06	1,020	514	0.65	7.9×10^{2}	R
ANP #6	1	56-09-05	1,380	450	0.16	2.8×10^{3}	R
	2	86-01-10	5	45	<0.1	$>4.5\times10^{2}$	R, s
	3	87-07-10	180	42.3	<0.01	$>4.2\times10^{3}$	R, s
ANP #9 (STFA #1)	1	59-07-01	245	142	8.20	1.7×10^{1}	R, g
	2	59-07-17	180	380	15.86	2.4×10^{1}	R, g
	3	59-07-24	60	470	6.40	7.3×10^{1}	R
ARA 2	1	57-09-10	480	1,075	1.38	7.8×10^{2}	R
ARA 3 (GCRE)	1	59-05-20	957	560	0.64	8.8×10^{2}	N
ARBOR TEST 1	1	57-12-27	1,080	403	0.13	3.1×10^{3}	R
AREA-II (NTP Area #2)	1	60-04-22	1,413	510	0.59	8.6×10^{2}	R, h
	2	60-04-23	35	840	0.75	1.1×10^{3}	R
CFA 2	1	51-02-27	193	235	15.30	1.5×10^{1}	N
CPP 1	1	50-12-07	1,080	1,260	2.90	4.3×10^{2}	R
	2	50-12-15	1,440	1,130	1.90	5.9×10^{2}	R
	3	51-03-31	1,409	1,140	1.90	6.0×10^{2}	R, a
	4	51-11-11	1,440	1,940	4.80	4.0×10^{2}	R, a, c
	5	54-11-04	2,700	2,475	5.90	4.2×10^{2}	R, c
	6	81-08-12	760	2,500	4.50	5.6×10^{2}	R
CPP 2	1	51-04-21	1,440	1,030	1.0	1.0×10^{3}	R, b
	2	51-06-29	1,440	1,850	2.70	6.9×10^{2}	R
	3	51-11-11	1,440	1,500	2.40	6.3×10^{2}	R, c
	4	54-11-05	180	1,455	1.30	1.1×10^{3}	R, c
	5	54-11-22	1,440	2,500	3.20	7.8×10^{2}	R, c
	6	81-08-14	720	2,500	2.33	1.1×10^{3}	R
CPP 3 (Disp.)	1	51-09-11	1,440	800	38.10	2.1×10^{1}	R, b
	2	51-09-27	930	800	0.20	4.0×10^{3}	R, b
	3	86-10-02	10	400	62.40	6.4×10^{0}	R, b
	4	86-10-22	32	650	104.20	6.2×10^{0}	R, b
CPP 4	1	83-10-25	1,320	460	113.0	4.1×10^{0}	R, d, e, f
	2	83-11-11	210	520	129.0	4.0×10^{0}	R, d, e, f
	3	83-11-15	1426	520	113.0	4.6×10^{0}	R, d, e, f
EBR I	1	49-08-12	2,880	800	17.0	4.7×10^{1}	N
	2	49-08-12	4,320	483	6.40	7.5×10^{1}	R
EBR II-1	1	58-10-02	2,880	1,025	0.25	4.1×10^{3}	T
	2	88-05-02	163	1,100	1.10	1.0×10^{3}	R, f
EBR II-2	1	58-11-20	2,850	940	8.06	1.2×10^{2}	R
EOCR	1	60-06-27	2,811	920	0.78	1.2×10^{3}	R
FET Disp. #3	1	57-11-23	420	643	4.32	1.5×10^{2}	R
	2	68-05-28	120	900	19.0	4.7×10^{1}	R, b
Fire Sta. #2	1	57-11-04	420	663	7.19	9.2×10^{1}	R
	2	58-11-03	2,880	435	0.58	7.5×10^{2}	R

Table 1.--Data on specific-capacity tests of wells at and near the Idaho National Engineering Laboratory--Continued

Well identifier	Test number	Date	Length of test, minutes	Discharge, gal/min	Drawdown, feet	Specific capacity, (gal/min)/ft	Remarks
Highway #3	1	67-10-16	15	350	>54.0	<6.5x10^{0}	R
	2	67-10-16	?	316	<54.0	>5.9x10^{0}	R
IET #1 Disp. (ANP #4)	1	86-01-13	10	30	4.0	7.5x10^{0}	R
	2	87-07-09	120	20.2	2.35	8.6x10^{0}	N
LOFT Prod. #1 (FET 1)	1	58-04-17	960	1,830	12.05	1.5x10^{2}	T, a
LOFT Prod. #2 (FET 2)	1	58-05-03	960	1,820	16.10	1.1x10^{2}	R, a
LPTF Disp.	1	57-06-20	1,440	615	55.47	1.1x10^{1}	T
MTR Test	1	86-01-15	10	26	<0.1	>2.6x10^{2}	R, s
	2	87-07-01	100	26.1	0.02	1.3x10^{3}	R, s
NPR Test	1	86-01-23	15	29	<0.1	>2.9x10^{2}	R, s
	2	87-06-09	150	25.7	0.28	9.2x10^{1}	R
NRF #1	1	50-07-26	120	1,010	57.0	1.8x10^{1}	R, e
	2	50-08-03	1,452	1,010	62.30	1.6x10^{1}	R, e
	3	50-11-17	726	1,410	0.49	2.9x10^{3}	R
	4	57-03-27	1,793	2,300	2.0	1.2x10^{3}	R, f
NRF #2	1	51-06-11	1,440	1,245	4.80	2.6x10^{2}	R, i
	2	51-08-03	2,880	1,430	0.50	2.9x10^{3}	R
	3	57-02-19	2,880	2,610	1.29	2.0x10^{3}	R
NRF #3	1	56-08-24	2,880	1,242	4.83	2.6x10^{2}	R
	2	57-03-25	2,760	2,160	15.16	1.4x10^{2}	R
OMRE	1	57-03-22	900	314	116.71	2.7x10^{0}	R
P & W #1	1	57-08-09	1,440	570	0.36	1.6x10^{3}	R
P & W #2	1	57-09-06	1,440	550	0.57	9.6x10^{2}	R
	2	87-06-12	180	34.3	0.02	1.7x10^{3}	R, s
P & W #3	1	57-11-14	1,440	630	4.54	1.4x10^{2}	R
PSTF Test	1	57-12-20	1,440	714	10.71	6.7x10^{1}	R
QAB	1	82-02-13	57	5	47.0	1.1x10^{-1}	N
RWMC Prod.	1	74-11-23	1,440	412	5.50	7.5x10^{1}	R
S5G test	1	63-11-08	2,880	600	<0.1	>6.0x10^{3}	R, s
Site 6	1	59-11-04	1,423	616	25.09	2.5x10^{1}	R
Site 14	1	56-09-11	1,440	419	0.81	5.2x10^{2}	R
	2	87-06-16	180	10.5	<0.01	>1.1x10^{3}	R, s
Site 19	1	60-06-09	360	520	21.60	2.4x10^{1}	R, e
	2	60-08-01	1,235	520	17.60	3.0x10^{1}	R, e
	3	60-09-26	1,440	600	2.20	2.7x10^{2}	R
	4	86-01-16	10	26	<0.1	>2.6x10^{2}	R, s
	5	87-06-24	120	27.4	0.08	3.4x10^{2}	R, s
SPERT #1	1	56-01-11	240	377	21.14	1.8x10^{1}	R
SPERT #2 (SPERT IV)	1	60-04-13	1,441	540	0.90	6.0x10^{2}	R
TAN #1 (ANP #1)	1	53-04-16	1,658	1,066	7.75	1.4x10^{2}	T
	2	53-04-30	360	1,325	11.86	1.1x10^{2}	T, a
	3	53-07-20	1,235	1,719	11.50	1.5x10^{2}	R, a
	4	53-08-31	1,440	1,130	10.0	1.1x10^{2}	R, j
	5	87-11-17	215	1,050	5.92	1.8x10^{2}	T, a
TAN #2 (ANP #2)	1	53-08-31	1,440	1,130	28.70	3.9x10^{1}	R, b, c
	2	53-11-12	4,320	1,220	21.30	5.7x10^{1}	T, a
	3	87-11-18	240	1,010	7.67	1.3x10^{2}	T, a
TRA Disp.	1	86-02-04	15	27	<0.1	>2.7x10^{2}	R, s
	2	87-07-29	60	24.2	0.05	4.8x10^{2}	R, s
TRA #1 (MTR 1)	1	50-03-27	1,230	1,160	0.54	2.1x10^{3}	R, a
	2	50-05-26	4,320	810	0.34	2.4x10^{3}	R, a
	3	57-07-20	1,060	3,990	3.81	1.0x10^{3}	T, a
	4	57-07-22	2,880	3,940	3.33	1.2x10^{3}	T, a
	5	68-03-28	57	3,300	2.06	1.6x10^{3}	R

Table 1.--Data on specific-capacity tests of wells at and near the Idaho National Engineering Laboratory--Continued

Well identifier	Test number	Date	Length of test, minutes	Dis-charge, gal/min	Draw-down, feet	Specific capacity, (gal/min)/ft	Remarks
TRA #2 (MTR 2)	1	51-01-22	1,440	750	61.0	1.2×10^{1}	R
	2	51-03-17	1,200	800	61.0	1.3×10^{1}	R
	3	52-10-28	4,384	590	53.50	1.1×10^{1}	R
TRA #3 (ETR 1)	1	57-06-07	2,880	4,350	1.99	2.2×10^{3}	N, a
	2	67-11-15	32	3,200	0.76	4.2×10^{3}	R
	3	68-02-29	52	3,900	1.27	3.1×10^{3}	R
TRA #4 (ETR 4)	1	68-05-02	57	1,700	2.60	6.5×10^{2}	R
WS-INEL #1	1	79-01-25	1,412	68	20.50	3.3×10^{0}	N
	2	86-01-18	7	30	4.20	7.1×10^{0}	R
	3	87-06-04	240	26.7	6.39	4.2×10^{0}	N
9	1	87-07-30	350	18.7	0.04	4.7×10^{2}	R, s
11	1	89-09-13	240	16.7	<0.01	$>1.7\times10^{3}$	R, s
12	1	50-08-29	660	535	4.90	1.1×10^{2}	R
14	1	89-09-14	210	15.9	0.08	2.0×10^{2}	R, s
17	1	89-09-20	260	31.8	8.70	3.7×10^{0}	N
24	1	52-08-26	?	350	4.0	8.8×10^{1}	R
	2	53-04-15	11	420	3.07	1.4×10^{2}	R
	3	88-01-14	60	7.6	0.03	2.5×10^{2}	R, s
30	1	53-04-27	960	250	0.10	2.5×10^{3}	R, s
31	1	53-07-10	1,140	280	1.70	1.6×10^{2}	R
37	1	87-07-07	120	7.6	0.05	1.5×10^{2}	R, s
40	1	87-07-28	60	6.4	0.01	6.4×10^{2}	R, s
43	1	87-07-29	60	6	0.01	6.0×10^{2}	R, s
51	1	87-06-26	120	5.4	0.15	3.6×10^{1}	R
57	1	87-06-24	120	5	0.02	2.5×10^{2}	R, s
58	1	86-01-17	10	26	<0.1	$>2.6\times10^{2}$	R, s
	2	87-06-18	120	25.3	0.08	3.2×10^{2}	R, s
76	1	86-01-17	5	26	<0.1	$>2.6\times10^{2}$	R, s
	2	87-06-10	120	24.9	0.02	1.2×10^{3}	R, s
82	1	87-06-26	130	8.8	0.02	4.4×10^{2}	R, s
	2	87-07-01	120	5.6	<0.01	$>5.6\times10^{2}$	R, s
83	1	87-06-15	150	6	0.44	1.4×10^{1}	N
86	1	87-08-04	150	19	3.39	5.6×10^{0}	N
87	1	87-07-14	121	2.3	0.13	1.8×10^{1}	R
	2	88-10-18	170	6	0.38	1.6×10^{1}	N
88	1	84-09-13	60	5	24.50	2.0×10^{-1}	N, d
	2	87-07-08	270	5	28.60	1.7×10^{-1}	N, d
89	1	87-07-21	210	4.5	6.32	7.1×10^{-1}	N
	2	87-07-22	240	4.5	6.69	6.7×10^{-1}	N
90	1	87-07-15	105	4.3	0.53	8.1×10^{0}	R
97	1	86-01-22	5	32	<0.1	$>3.2\times10^{2}$	R, s
	2	87-06-30	120	27.4	0.05	5.5×10^{2}	R, s
98	1	86-01-21	15	31	<0.1	$>3.1\times10^{2}$	R, s
	2	87-06-05	120	18.3	0.03	6.1×10^{2}	R, s
99	1	86-01-23	15	29	<0.1	$>2.9\times10^{2}$	R, s
	2	87-06-30	90	24.5	0.03	8.2×10^{2}	R, s
100	1	87-06-17	180	18	0.13	1.4×10^{2}	R
101	1	86-01-29	60	12	<0.1	$>1.2\times10^{2}$	R, s
	2	87-07-02	150	8.5	0.50	1.7×10^{1}	R
103	1	80-12-22	2,790	96	<0.1	$>9.6\times10^{2}$	R, s
	2	87-06-22	120	21.5	0.02	1.1×10^{3}	R, s
104	1	80-12-06	1,890	21	50.70	4.1×10^{-1}	R
	2	80-12-15	1,681	20	50.20	4.0×10^{-1}	R
	3	86-01-27	20	24	>35.0	$<6.9\times10^{-1}$	R
	4	87-06-01	150	16.2	23.45	6.9×10^{-1}	N

Table 1.--Data on specific-capacity tests of wells at and near the Idaho National Engineering Laboratory--Continued

Well identifier	Test number	Date	Length of test, minutes	Discharge, gal/min	Drawdown, feet	Specific capacity, (gal/min)/ft	Remarks
105	1	81-01-05	2,880	63	<0.1	>6.3×10^{2}	R, s
	2	87-06-29	150	19	0.03	6.3×10^{2}	R, s
106	1	81-01-12	2,855	95	0.10	9.5×10^{2}	R, s
	2	86-01-25	10	24	<0.1	>2.4×10^{2}	R, s
	3	87-06-11	180	21.9	0.03	7.3×10^{2}	R, s
107	1	81-06-11	1,100	120	<0.1	>1.2×10^{3}	R, s
	2	87-07-06	110	5.4	0.01	5.4×10^{2}	R, s
108	1	80-12-29	2,490	90	<0.1	>9.0×10^{2}	R, s
	2	87-06-23	120	20.5	0.02	1.0×10^{3}	R, s
109	1	87-07-31	329	16.3	0.02	8.2×10^{2}	R, s
110	1	87-07-16	135	4.4	0.04	1.1×10^{2}	R, s
111	1	85-11-05	100	26	18.80	1.4×10^{0}	R
	2	87-05-20	140	14.2	11.0	1.3×10^{0}	N
112	1	85-11-01	30	26	<0.1	>2.6×10^{2}	R, s
	2	87-05-26	120	24.8	0.05	5.0×10^{2}	R, s
113	1	85-11-01	30	26	<0.1	>2.6×10^{2}	R, s
	2	87-06-01	120	24.6	0.02	1.2×10^{3}	R, s
114	1	85-11-04	40	6.2	16.30	3.8×10^{-1}	N
	2	87-05-21	190	8.4	26.24	3.2×10^{-1}	R
115	1	85-11-05	145	18	14.40	1.3×10^{0}	N
	2	87-05-22	130	15	14.02	1.1×10^{0}	N
	3	87-05-27	180	17.1	14.70	1.2×10^{0}	N
116	1	85-11-07	60	24	9.10	2.6×10^{0}	N
	2	87-05-29	209	20.7	8.10	2.6×10^{0}	N
117	1	87-12-17	140	7.2	20.25	3.6×10^{-1}	N, d
119	1	87-12-16	90	3.2	68.81	4.7×10^{-2}	R, d
120	1	87-12-15	60	21.1	0.02	1.4×10^{3}	R, s

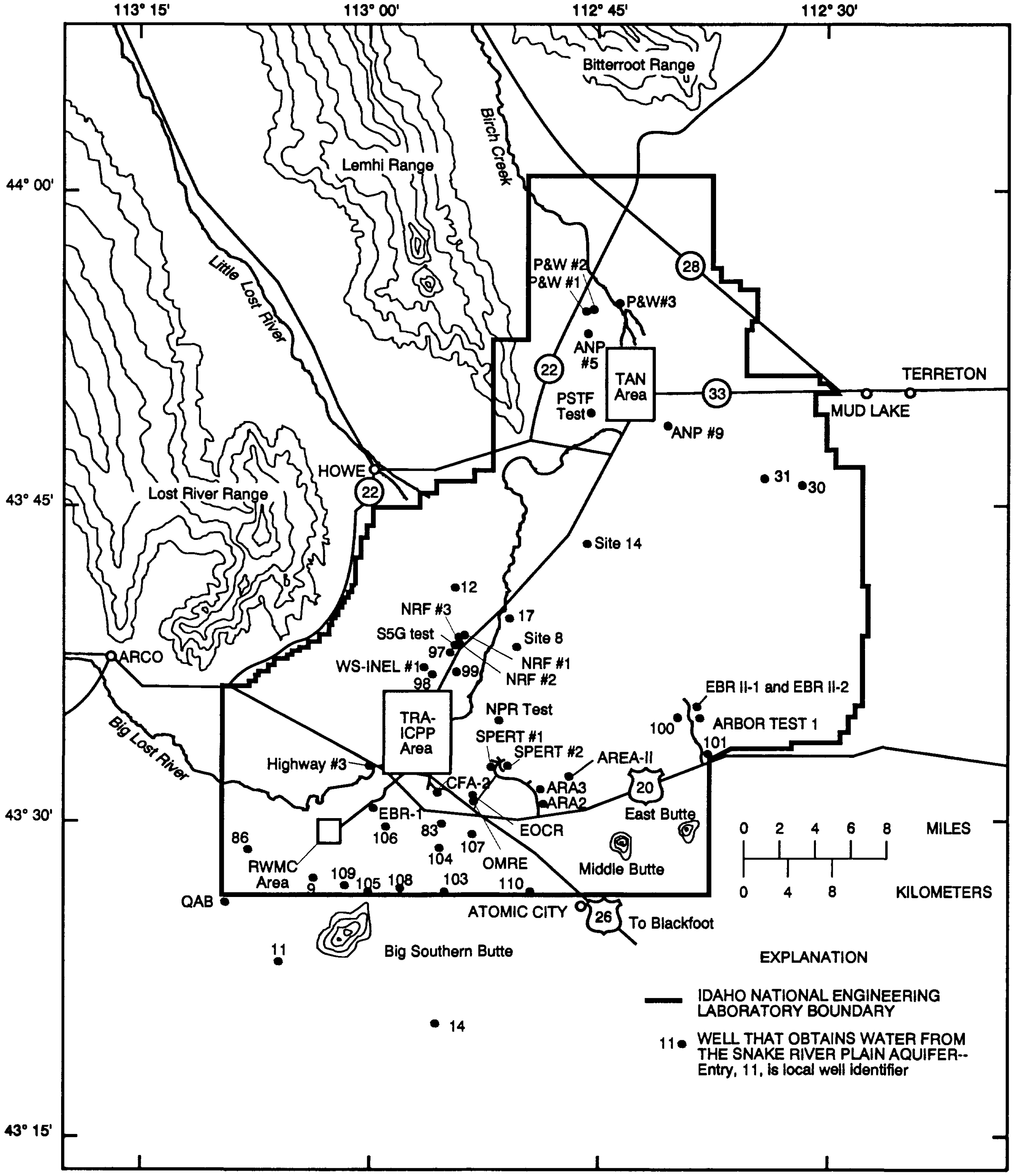


Figure 2.--Locations of wells with aquifer tests at and near the Idaho National Engineering Laboratory.

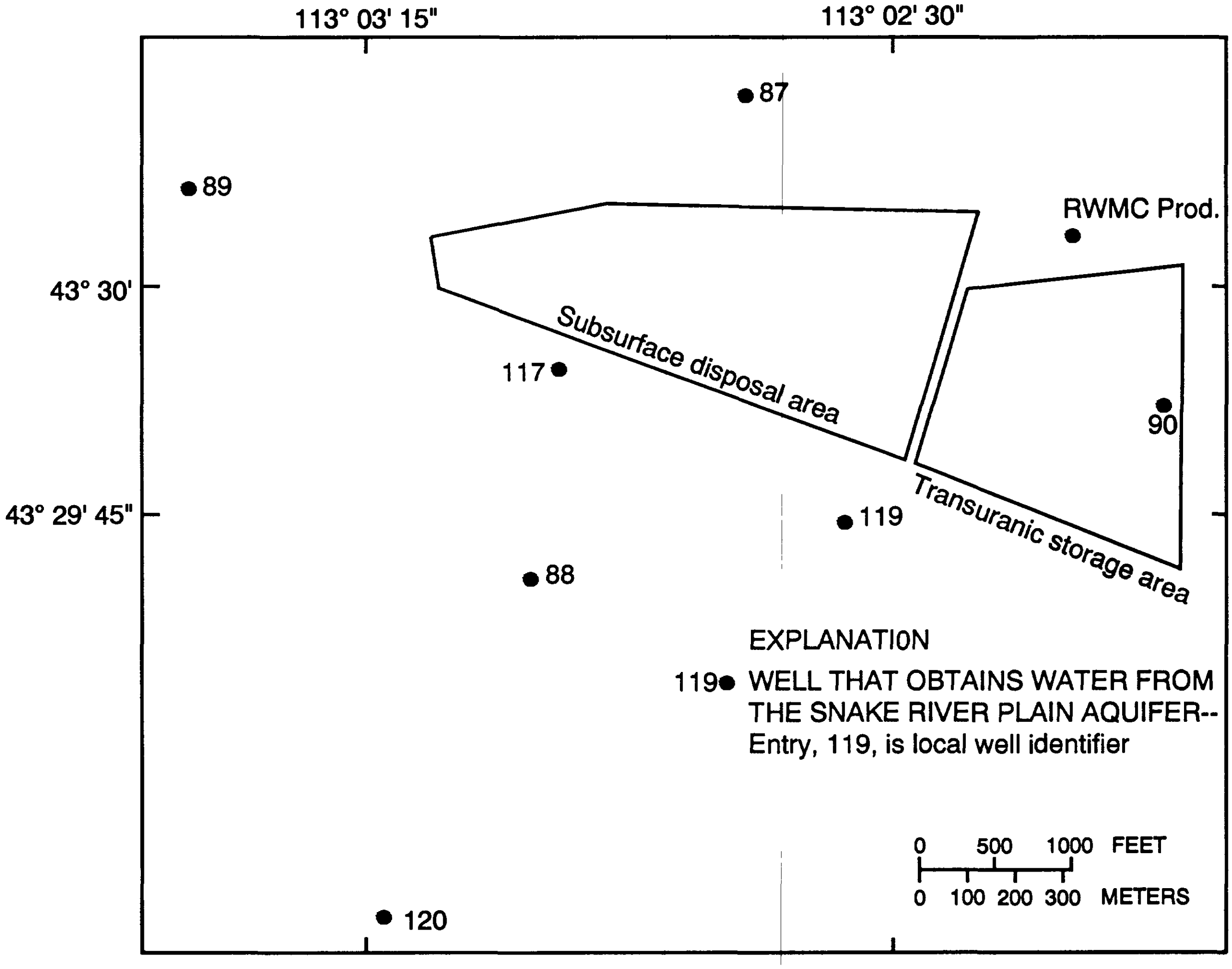


Figure 3.--Locations of wells with aquifer tests at and near the Radioactive Waste Management Complex.

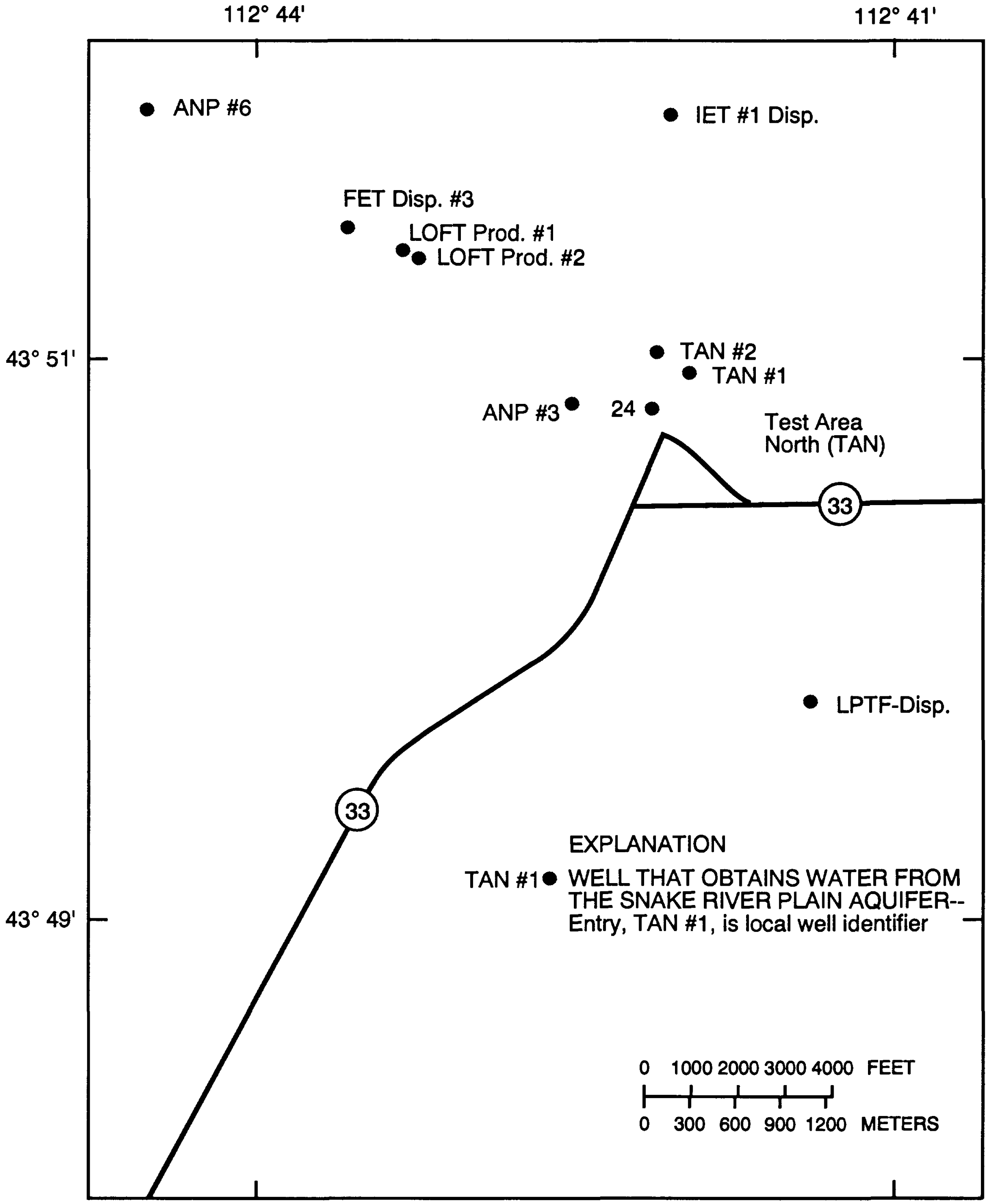


Figure 4.--Locations of wells with aquifer tests at and near the Test Area North.

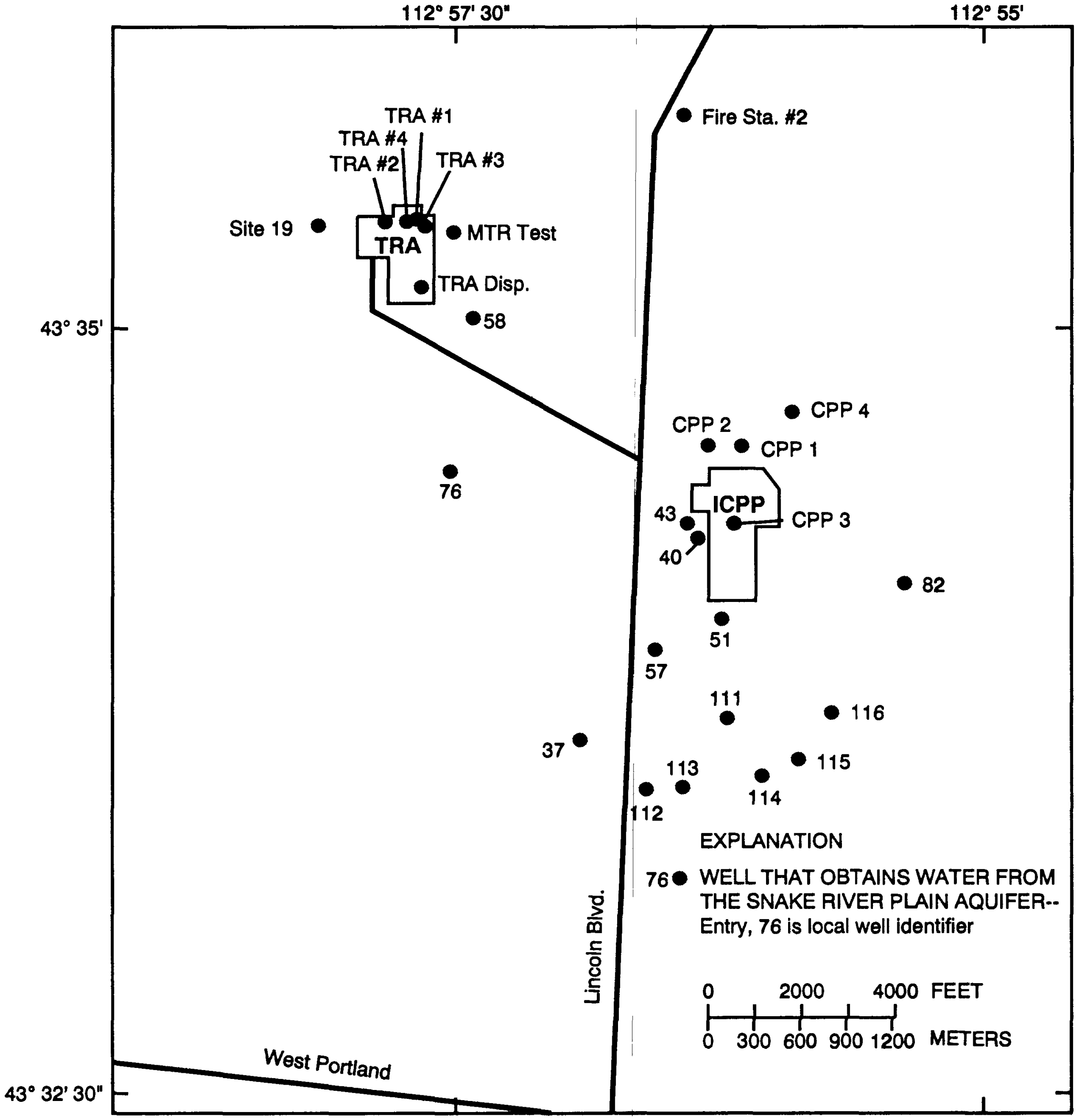


Figure 5.--Locations of wells with aquifer tests at and near the Test Reactors Area-Idaho Chemical Processing Plant.

Production wells at the INEL generally are constructed using 16 in. or larger casing grouted in place near the water table. Below the water table, perforated or torch-cut steel casing is hung in the open hole. In some wells, a gravel pack is also placed around the perforated casing. Pre-made screens are rarely used at the INEL.

Construction of most observation wells usually is similar to that of production wells, except that casing diameters are smaller and most completions are open hole below the water table. Depth of penetration below the water table usually is less for observation wells than for production wells. Construction and completion data for all but 15 of the wells can be found in a report by Bagby and others (1984); data for the other wells can be obtained from the U.S. Geological Survey's INEL Project Office.

Production wells are equipped with pumps capable of producing from 50 to more than 1,000 gal/min. Observation wells are equipped with pumps capable of producing 1 to 40 gal/min. For most wells, the pumping rate is limited by the size of pump that will fit in the well.

Water levels in wells generally were measured with electric tapes or wetted steel tapes. Occasionally, response was recorded with a float-actuated continuous water-level recorder. The resolution of water levels and accuracy of drawdown was usually about 0.01 ft but was sometimes 0.1 ft. For a few tests, which were noted, air-line measurements with a precision of no more than 0.1 ft were used.

Most measurements of discharge less than 50 gal/min were made by observations of total flow on an inline meter. Some observations and checks on the flow meter were made by bucket and stopwatch. Most observations of discharge more than 50 gal/min were made using an orifice method or an inline flow meter.

Names and locations of wells are given in tables 1 and 2 and on figures 2-5. The well identifier used for reference between tables and figures is a form of the local name in use at the INEL. Some wells are referred to by

Table 2.--Estimates of transmissivity from tests of wells at and near the Idaho National Engineering Laboratory

[Locations of wells shown on figures 2, 3, 4, and 5; ft^2/d, feet squared per day; Relative uncertainty in orders of magnitude; Well depth, below land surface; Water level, at beginning of test below land surface; Penetration, below water table]

Well identifier	Trans-missivity, ft^2/d	Relative uncer-tainty	Test num-ber	Local well number	Well depth, feet	Water level, feet	Penetra-tion, feet	Perforated or open interval, feet below land surface
ANP #3	3.0×10^1	0.1	4	06N 31E 13CAB1	310	195	115	180-244, 269-305
ANP #5	1.5×10^5	0.4	1	07N 31E 33DCD1	395	291	104	296-316, 332-390
ANP #6	5.0×10^5	0.4	1	06N 31E 10ACC1	305	214	91	211-256, 266-296
ANP #9	6.6×10^3	0.4	3	06N 32E 26CDB1	681	220	461	577-677
ARA 2	1.1×10^5	0.4	1	02N 30E 12ADB1	787	606	181	620-643, 664-706, 725-768
ARA 3	2.1×10^4	0.1	1	02N 30E 01BDB1	1,340	593	747	700-1,340
ARBOR TEST 1	5.6×10^5	0.4	1	03N 32E 13DCA1	790	673	117	680-730, 737-787
AREA-II	1.2×10^5	0.4	1	03N 31E 35DCA1	881	666	215	667-722, 742-814, 844-876
CFA 2	1.7×10^2	0.1	1	02N 29E 01DBB1	681	472	209	521-651, 661-681
CPP 1	7.3×10^4	0.4	6	03N 30E 19BCB1	585	456	129	460-485, 527-577
CPP 2	1.6×10^5	0.4	6	03N 29E 24ADA1	605	457	148	458-483, 551-600
CPP 3	7.6×10^5	0.4	2	03N 30E 19CBC1	598	451	147	490-593
CPP 4	2.5×10^2	0.4	3	03N 30E 19BAC1	700	445	255	445-700
EBR I	1.3×10^3	0.1	1	02N 29E 09CAA1	1,075	596	479	600-1,075
EBR II-1	5.2×10^5	0.1	1	03N 32E 13BBD2	745	635	110	643-743
EBR II-2	1.1×10^4	0.4	1	03N 32E 13BBD3	753	630	123	650-750
EOCR	1.8×10^5	0.4	1	02N 30E 05DDD1	1,237	484	753	1,051-1,237
FET Disp. #3	1.5×10^4	0.4	1	06N 31E 11CDC1	300	199	101	175-295
Fire Sta. #2	1.0×10^5	0.4	2	03N 29E 12DDB1	516	420	96	427-467, 501-511
Highway #3	$>3.3\times10^2$	>0.5	1	03N 29E 33BAD1	750	538	212	650-750
IET #1 Disp.	1.6×10^2	0.1	2	06N 31E 12ACD1	324	207	117	219-319
LOFT Prod. #1	3.1×10^4	0.1	1	06N 31E 14ABB1	340	201	139	230-330
LOFT Prod. #2	1.1×10^4	0.4	1	06N 31E 14ABB2	461	202	259	209-448
LPTF Disp.	3.5×10^3	0.1	1	06N 32E 22CCA1	315	206	109	190-309
MTR Test	2.0×10^5	0.4	2	03N 29E 14ADD1	588	451	137	447-588
NPR Test	8.6×10^3	0.4	2	03N 30E 16DDD1	600	456	144	500-535
NRF #1	5.1×10^5	0.4	3	04N 30E 30AAD1	535	363	172	394-478, 485-530
NRF #2	3.4×10^5	0.4	3	04N 30E 30ADA1	528	365	163	373-397, 422-448, 497-523
NRF #3	2.9×10^4	0.4	1	04N 30E 30AAD2	546	365	181	485-543
OMRE	1.3×10^2	0.4	1	02N 30E 08AAA1	941	479	462	534-636, 919-938
P & W #1	2.5×10^5	0.4	1	07N 31E 28CAC1	432	315	117	322-372
P & W #2	1.4×10^5	0.4	1	07N 31E 28DAB1	386	309	77	310-361, 363-380
P & W #3	1.4×10^4	0.4	1	07N 31E 26BBC1	406	304	102	322-401
PSTF Test	5.9×10^3	0.4	1	06N 31E 21DCC1	320	206	114	190-309
QAB	3.0×10^0	0.1	1	01N 28E 03CDB1	1,115	767	348	1,036-1,074
RWMC Prod.	6.8×10^3	0.4	1	02N 29E 18ADC1	683	571	112	625-635, 590-610
S5G test	$>1.2\times10^6$	>0.5	1	04N 30E 30ADB	600	370	230	393-600
Site 6	1.8×10^3	0.4	1	04N 30E 26CCA1	523	351	172	366-461
Site 14	6.7×10^4	0.4	1	05N 31E 28CCC1	717	263	454	535-717
Site 19	3.1×10^4	0.4	3	03N 29E 14BCB1	865	467	398	472-512, 533-572, 594-614, 762-862
SPERT #1	1.2×10^3	0.4	1	03N 30E 34BAD1	653	457	196	482-652
SPERT #2	8.0×10^4	0.4	1	03N 30E 34ACB1	1,217	465	752	950-1,217
TAN #1	2.9×10^4	0.1	5	06N 31E 13ACD1	365	204	161	200-355
TAN #2	1.6×10^4	0.1	2	06N 31E 13ACC1	345	212	133	235-335
TRA Disp.	6.2×10^4	0.4	2	03N 29E 14DBD1	1,275	460	815	512-697, 930-1,070, 1,183-1,268
TRA #1	7.3×10^5	0.1	4	03N 29E 14ACD1	600	456	144	481-581
TRA #2	7.9×10^2	0.4	1	03N 29E 14ACB1	772	457	315	496-571, 558-567, 572-772
TRA #3	1.0×10^5	0.1	1	03N 29E 14ADB1	597	456	141	470-497, 518-592
TRA #4	8.7×10^4	0.4	1	03N 29E 14ACD3	975	458	517	887-970
WS-INEL #1	3.7×10^2	0.1	3	03N 29E 01ABC1	595	385	210	362-595

Table 2.--Estimates of transmissivity from tests of wells at and near the Idaho National Engineering Laboratory--Continued

Well identifier	Trans-missivity, ft^2/d	Relative uncer-tainty	Test num-ber	Local well number	Well depth, feet	Water level, feet	Penetra-tion, feet	Perforated or open interval, feet below land surface
9	5.9×10^4	0.4	1	02N 28E 35AAC1	632	604	28	604-632
11	$>7.0\times10^4$	>0.5	1	01N 29E 30BBD1	752	652	100	673-703
12	1.1×10^4	0.4	1	04N 30E 07ADB1	692	325	367	587-692
14	2.2×10^4	0.4	1	01S 30E 15BCA1	751	715	36	715-751
17	4.4×10^2	0.1	1	04N 30E 22BDD1	497	352	145	399-497
24	1.4×10^4	0.4	2	06N 31E 13DBB1	326	218	108	255-325
30	4.3×10^5	0.4	1	05N 33E 13BDC1	405	265	140	276-290, 300-317, 360-405
31	1.7×10^4	0.4	1	05N 33E 10CDC1	428	251	177	285-428
37	1.6×10^4	0.4	1	03N 29E 25CAA1	572	466	106	507-572
40	8.7×10^4	0.4	1	03N 29E 24DAD1	483	451	32	456-483
43	8.0×10^4	0.4	1	03N 29E 24DAD2	676	451	225	451-676
51	2.9×10^3	0.4	1	03N 30E 30BBB1	659	455	204	475-659
57	2.8×10^4	0.4	1	03N 29E 25ABD1	732	459	273	477-732
58	3.7×10^4	0.4	2	03N 29E 14DDA1	503	453	50	218-503
76	1.9×10^5	0.4	2	03N 29E 23ADC1	718	466	252	457-718
82	5.6×10^4	0.4	1	03N 30E 19DDC2	700	446	254	470-570, 593-700
83	9.0×10^2	0.1	1	02N 29E 13AAA1	752	495	257	516-752
86	3.0×10^2	0.1	1	02N 28E 21BBB1	691	645	46	48-691
87	8.5×10^2	0.1	2	02N 29E 18BDA1	673	586	87	586-673
88	1.3×10^1	0.1	2	02N 29E 18CCD1	662	576	87	587-662
89	4.9×10^1	0.1	2	02N 28E 13ADD1	646	590	56	590-646
90	4.9×10^2	0.4	1	02N 29E 17CBC1	609	578	31	578-609
97	7.1×10^4	0.4	2	04N 30E 31ABD1	510	379	131	388-510
98	8.1×10^4	0.4	2	03N 29E 01DBB1	505	398	107	407-505
99	1.1×10^5	0.4	2	03N 30E 06ACD1	450	387	63	303-450
100	1.4×10^4	0.4	1	03N 32E 14CDD1	750	671	79	662-750
101	1.2×10^3	0.4	2	03N 32E 36ADD1	865	770	95	750-865
103	1.6×10^5	0.4	2	02N 30E 31CBC1	760	579	181	575-760
104	1.4×10^1	0.1	4	02N 29E 24DAD1	700	552	148	550-700
105	8.5×10^4	0.4	2	02N 29E 33DCC1	800	666	134	400-800
106	1.0×10^5	0.4	3	02N 29E 15CBA1	760	583	177	400-760
107	7.0×10^4	0.4	2	02N 30E 16CCA1	690	476	214	270-690
108	1.5×10^5	0.4	2	02N 29E 35CCC1	760	604	156	400-760
109	1.1×10^5	0.4	1	02N 29E 31CDC1	800	618	182	600-800
110	1.1×10^4	0.4	1	02N 30E 35DAD1	780	566	214	580-780
111	2.2×10^1	0.1	2	03N 30E 30BCC1	600	463	132	440-600
112	6.4×10^4	0.4	2	03N 29E 25DCA1	563	467	96	432-563
113	1.9×10^5	0.4	2	03N 29E 25DDB1	564	467	97	445-564
114	1.0×10^1	0.1	1	03N 30E 30CBD1	562	462	100	440-562
115	3.2×10^1	0.1	2	03N 30E 30CAA1	581	458	123	440-581
116	1.5×10^2	0.1	2	03N 30E 30ACC1	580	453	127	400-580
117	1.4×10^1	0.1	1	02N 29E 18CBD1	655	581	74	581-655
119	1.1×10^0	0.4	1	02N 29E 18DCB1	705	600	105	600-705
120	2.2×10^5	0.4	1	02N 29E 19BCB1	705	611	94	611-705

more than one local name (for instance ANP #3 is sometimes called TAN Disp. or Tan Disposal). Table 1 lists one or more alternate names in parentheses where multiple names are used to identify a specific well. A second local well identifier, the local well number, also is given in table 2. This identifier is derived from the township, range, and section location of the well and is useful for plotting map locations and for cross-reference with other data bases. For an explanation of the well numbering system and an example of another useful data base for the project area, see Bagby and others (1984, p. 12).

ANALYSIS OF AQUIFER-TEST DATA

The interpretation of the response of water levels in wells to pumping withdrawals is the most common method of determining hydrologic properties of aquifers. In general, the drawdown, s, in a pumped well or an observation well is measured at regular intervals during constant-rate pumping and is compared with predicted drawdowns from well-hydraulics equations. A large number of combinations of aquifer conditions, geometry, and aquifer-test designs can be accommodated by various analytical and graphical methods. However, a survey of the various analytical treatments reveals the similarity of time-drawdown response for differing aquifer conditions. Interpretations of hydrologic properties are therefore not unique because of differences in analytical assumptions, complications introduced by field conditions, and uncertainty in hydrologic conditions.

The methods of analysis for aquifer-test data at the INEL were chosen on the basis of the conceptualization of the aquifer system. The analytical treatments were applied as uniformly as possible while remaining consistent with the conceptual model and assumptions of the analysis method to increase the significance of comparisons of results.

The analytical treatment chosen as most representative of the aquifer was that of Neuman (1972, 1974, 1975) for an anisotropic, unconfined aquifer considering delayed (water-table) gravity response, vertical components of flow, specific storage, specific yield, and partial penetration. Neuman's solution reproduces the typical response of a water-table aquifer as indicated on time-drawdown curves (Freeze and Cherry, 1979, p. 326). The method of Neuman was advanced from the work of Boulton (1954 and 1963), and uses a graphical method of solution involving type-curve matching. The type curves given by Neuman (1975) include as a subset the type curves most commonly used in aquifer-test analysis, those of Theis (in Lohman, 1972, p. 17).

The Theis method has an advantage of greater mathematical simplicity; however, it also has the disadvantage of simplifying some of the physics of the aquifer. For unconfined aquifers, the more rigorous treatments of boundary conditions and more complete consideration of hydrologic properties used by Neuman are preferred from a theoretical standpoint. Aquifer-test data support type-curve matches with both the Theis and Neuman methods of analysis.

Other methods could have been chosen for analysis of these data. Some methods and the reasons for not choosing them were:

The Thiem equation (in Lohman, 1972, p. 11) was not used because it requires steady-state and isotropic conditions.

The Jacob straight-line (or semilogarithmic) method (in Lohman, 1972, p. 19) as modified for use with the conditions to which Neuman's method apply (Neuman, 1975, p. 331) could not be used for nearly all of the data at the INEL because the early-time data were poor or not discernible from intermediate-time data. More will be said concerning early-, intermediate-, and late-time response in the section on type-curve analysis by the Neuman method.

The type-curve analysis methods of Boulton (1963) and Stallman (in Lohman, 1972, p. 35) were probably adequate for the purpose of this study but were not as rigorous or flexible as those of Neuman.

Numerical-model analysis, such as used by Linder and Reilly (1983) or Prince and Schneider (1989), is perhaps the most rigorous method and can account for field conditions most accurately. However, data were not sufficient to use this method efficiently.

Four methods were used to estimate transmissivity from drawdown data for the single-well tests at the INEL. Two methods of type-curve analysis were used to analyze the most complete tests. The type curves used were those of Neuman (1975) and Theis (in Lohman, 1972, p. 15). Two simple analytical methods were used to analyze all other tests, the specific-capacity method and a regression method. The simplest method was to estimate transmissivity from specific capacity by use of a simple linear-regression equation. The estimates of transmissivity calculated from type curve analysis were regressed with corresponding specific capacities. Transmissivity was estimated for all remaining wells by application of the linear-regression equation. Transmissivity was also calculated from specific capacity for some wells using the method described by Theis and others (1963, p. 331-341).

The transmissivity derived by any of these methods from a single-well test has a wider confidence interval than a transmissivity derived by more rigorous analysis of a properly-designed and well-executed multiple-well aquifer test. Comparison of estimates of transmissivity determined from data at observation wells with those determined from data at the pumping well indicated a possible bias of 0.5 to 1.5 orders of magnitude with an average bias of about 1 order of magnitude. The single-well tests gave smaller values.

Type-Curve Analysis

Field data were matched with theoretical type curves to determine aquifer transmissivity. The type curves used were those of Neuman (1975, as given in Freeze and Cherry, 1979, fig. 8.12) for fully penetrating wells in an anisotropic unconfined aquifer. A distinctive S-shaped curve with three distinct segments results (fig. 6) when drawdown and time for an aquifer test in an unconfined aquifer are plotted on a logarithmic coordinate scale graph. During the first or early-time segment, which only covers a very

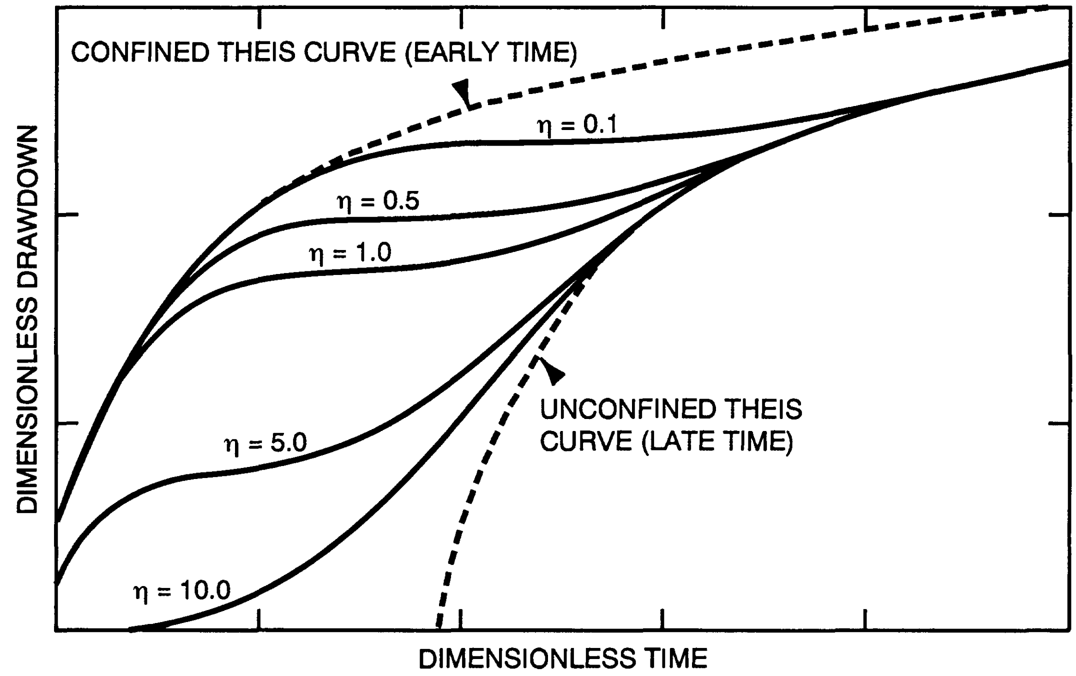


Figure 6.--Relation of drawdown and time for a well completed in an unconfined aquifer considering the effects of delayed gravity response and vertical components of flow. Both scales are logarithmic. The dimensionless parameter, η, relates anisotropy, radius, and aquifer thickness. Modified from Neuman (1972, fig. 8).

short period, the aquifer shows a typical confined response. Water is released from storage as a result of aquifer compaction and the expansion of water. The time-drawdown response may follow a Theis nonequilibrium type curve for a typical confined aquifer storage coefficient. During the second or intermediate time segment, a definite departure from the Theis curve results in response to the effects of water delivered to the well by dewatering at the water table. This decrease in the rate of drawdown is called either delayed gravity response, delayed yield, or delayed drainage. This intermediate response may produce a definite flat or nearly horizontal part of the curve.

Given enough time, a third segment may be recognized after the effects of delayed gravity response have dissipated. During the third or late-time segment, time-drawdown response will gradually start to follow the Theis nonequilibrium type curve for an unconfined aquifer. Neuman's curves reproduce all three segments of the time-drawdown response and allow the determination, with adequate field data, of horizontal and vertical hydraulic conductivity, specific (elastic) storage, and specific yield. Because aquifer thickness and effective radius are unknown, the analysis of time-drawdown data can yield only transmissivity and the dimensionless parameter η related to anisotropy, aquifer thickness, and effective radius. Freeze and Cherry (1979) use the notation η, which is used in this report; Neuman (1975) used β for the same parameter.

The type curves given by Neuman are for fully penetrating wells. Neuman (1975) has provided a computer program to develop additional theoretical curves for partially penetrating wells. Because data were lacking for aquifer thickness and effective radius of the pumping well, the special curves were not developed.

For the single-well aquifer tests at the INEL, most time-drawdown data complete enough for analysis showed the first two segments of the typical delayed gravity response in an unconfined aquifer. An example of the response and interpretation is given on figure 7. The data for 27 tests at 20 wells matched type curves with a value of η between 0.001 and 0.4,

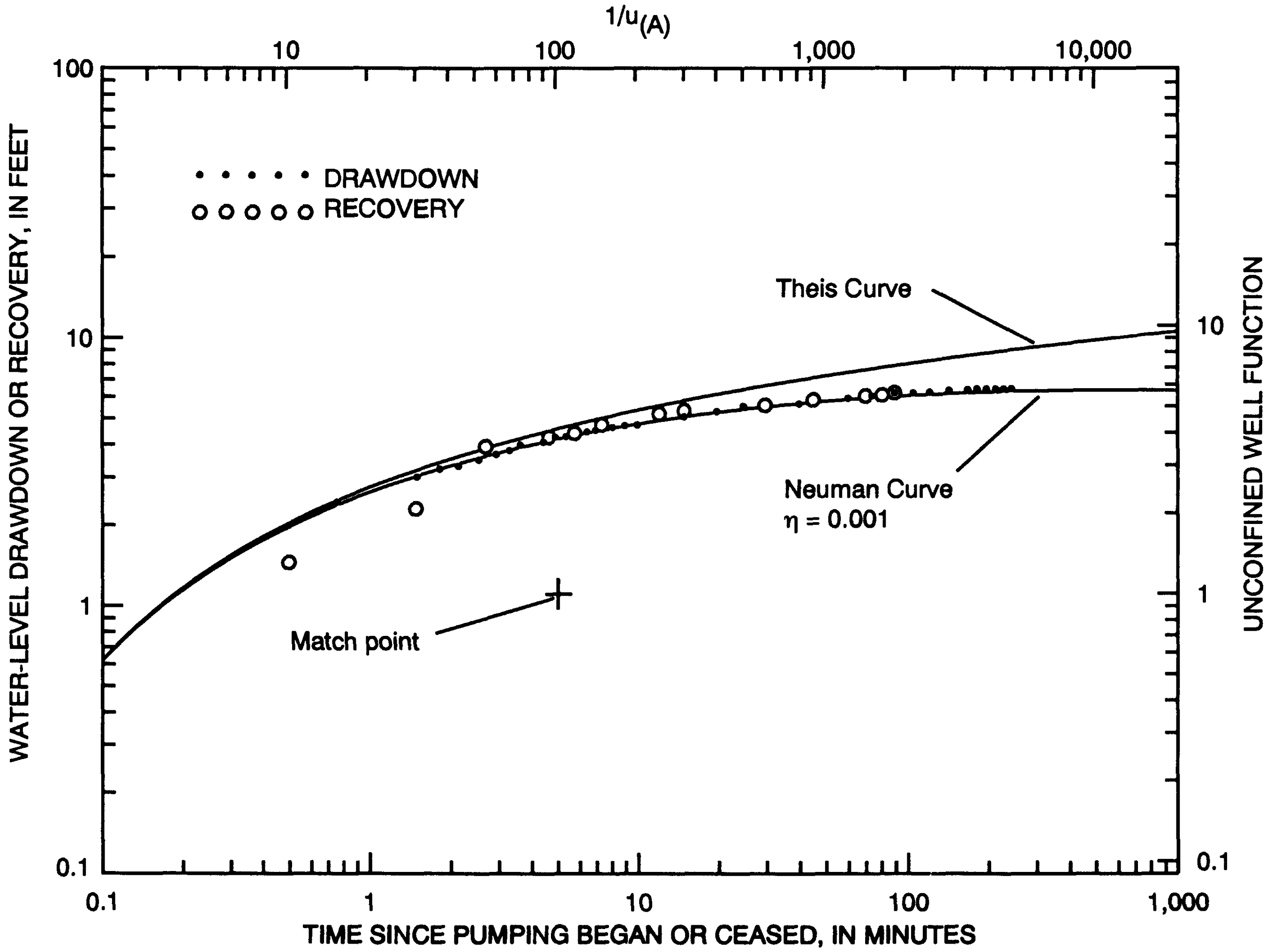


Figure 7.--Relation of observed drawdown to drawdown computed using Neuman's (1975) delayed gravity response method. Well is 03N 29E 01ABC1, WS-INEL #1. Date of test is June 4, 1987.

generally between 0.004 and 0.1. The time-drawdown data for 10 tests at 6 wells, however, did not show a definite flat segment for intermediate time response. These data can be best matched to the Theis segment of the type curves. Those tests for which transmissivity was calculated by the type-curve method are noted on table 1.

Specific-Capacity Method

The specific-capacity method was used to estimate transmissivity from single-well tests. The advantages of this method are its simplicity and flexibility. The method does not require as much data as type-curve methods. However, the results may only represent the transmissivity near the tested wells. Nevertheless, due to the wide distribution of these types of data, it is useful for studying of ground-water flow in the INEL area.

One of the most common and useful types of data available for the description of the hydrologic properties of the Snake River Plain aquifer at the INEL is the specific capacity of wells. Specific capacity is an expression of the productivity of a well and is commonly expressed as the ratio of the pumping rate, Q, in gallons per minute, to the total measured drawdown, s_T, in feet. The total drawdown, s_T, in a pumped well is the sum of all or some of the following components, which depend on well construction and hydrologic conditions:

> the drawdown s (aquifer loss), in hydraulic head in the aquifer at the well screen or borehole boundary due to laminar flow of water through the aquifer; plus the drawdown s_{wL} (well loss), due to turbulent flow of water through the screen or well face and inside the casing into the pump intake; plus the drawdown s_p, due to partial penetration of the aquifer by the pumped well, plus the drawdown s_d, due to dewatering part of the aquifer, plus or minus the drawdown or buildup s_b, due to boundaries of the aquifer, minus the buildup s_r, due to recharge boundaries of the aquifer.

Stated as an equation (Walton, 1970, p. 311),

$$s_T = s + s_{wL} + s_p + s_d \pm s_b - s_r. \qquad (1)$$

In general, aquifer loss is by far the largest component of total drawdown. With proper design of aquifer tests and construction of wells, aquifer loss becomes the only measurable term.

Specific capacity can be used as the basis for estimating transmissivity by assuming values for hydrologic constants of the aquifer and well (Theis and others, 1963, p. 332, equation 1). The equation, modified here to allow for different units, is:

$$T = 15.32(Q/s)(-0.577 - \ln\{r^2S/4Tt\}) \qquad (2)$$

where Q/s = specific capacity of a well, in gallons per minute per foot of drawdown;

r = effective radius of the pumped well in feet;

S = storage coefficient, dimensionless;

T = transmissivity, in feet squared per day; and

t = time of the specific-capacity test, in days.

Because transmissivity is on both sides of the equation, an iterative process was used to solve the equation.

To solve the equation with the available data, the storage coefficient and effective radius of the well must be estimated. Uncertainties in the storage coefficient and the effective radius result in differences in the estimate of transmissivity because both parameters are within the logarithmic term of equation 2. The effective radius was assumed to be the drilled diameter of the well below the water table. This assumption may result in too large an estimate of transmissivity if the effective radius is larger. Storage coefficients of 0.1 and 0.01 were used. When applied to data that followed the Theis curve, 10 tests at 6 wells, the method generally gave values within 0.2 orders of magnitude of the value from type-curve analysis.

A simple linear-regression analysis was used to empirically predict transmissivity from specific capacity. Because the data take on values covering nearly 6 orders of magnitude, the regression analyses were performed on logarithmic-transformed values. The logarithmic-transform procedure minimized the overweighting of the largest values. The resulting regression equation relating transmissivity from type-curve analyses to specific capacity with a correlation coefficient of 0.97 ($r^2 = 0.94$) is:

$$\text{Log } T = 1.1853 \text{ Log } Q/s + 1.6087 \qquad (3)$$

or

$$T = (Q/s)^{1.1853} \times 40.62. \qquad (4)$$

The data and relation are shown on figure 8.

Estimates of transmissivity from specific-capacity data calculated from equations 3 or 4 were compared with corresponding estimates of transmissivity determined from type-curve analysis. The residuals were evenly distributed (fig. 9) and had a maximum, minimum, and average of 0.78, -0.70, and 0.00 orders of magnitude, respectively. The values from equations 3 or 4 generally were less than 0.4 orders of magnitude different from those determined by the type-curve analysis.

RESULTS OF AQUIFER-TEST ANALYSES

Analyses of aquifer-test data by the type-curve method were used to judge the relative accuracy of estimates of transmissivity from the specific-capacity data. Because the data span nearly 6 orders of magnitude, 0.05 to more than 6,000 (gal/min)/ft for specific capacity and 1.1 to more than 1.2×10^6 ft^2/d for transmissivity, uncertainties are expressed as orders of magnitude. This method of expressing uncertainty is a convenient normalization of data with a wide range of values. To convert the uncertainty to engineering units, subtract or add the uncertainty to the logarithm of the value and take the antilogarithm.

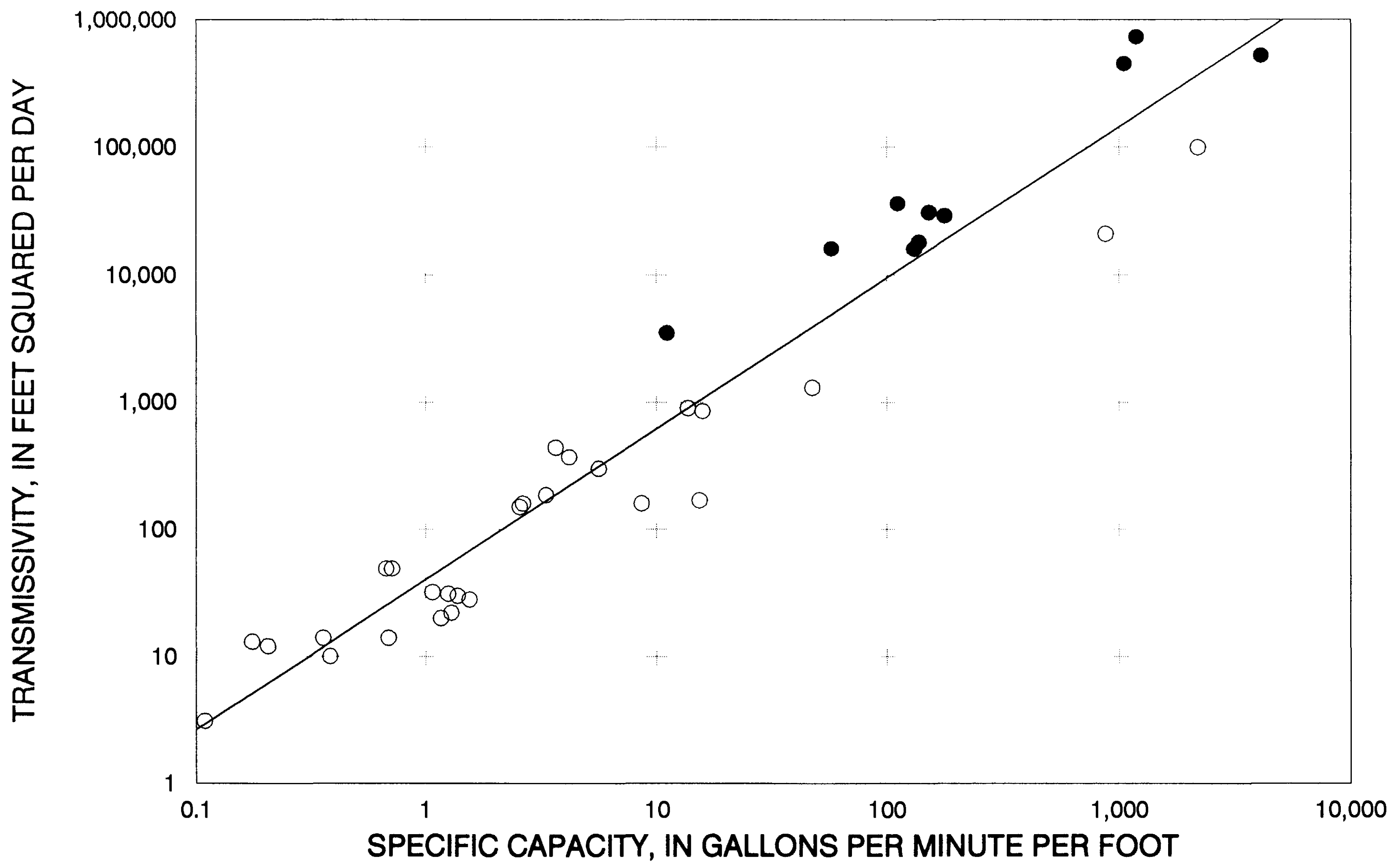


Figure 8.--Transmissivity estimates from specific-capacity data. Solid symbols are Theis type-curve data; open symbols are Neuman type-curve data. Regression equation is: Transmissivity = specific capacity $^{1.1853}$ × 40.62.

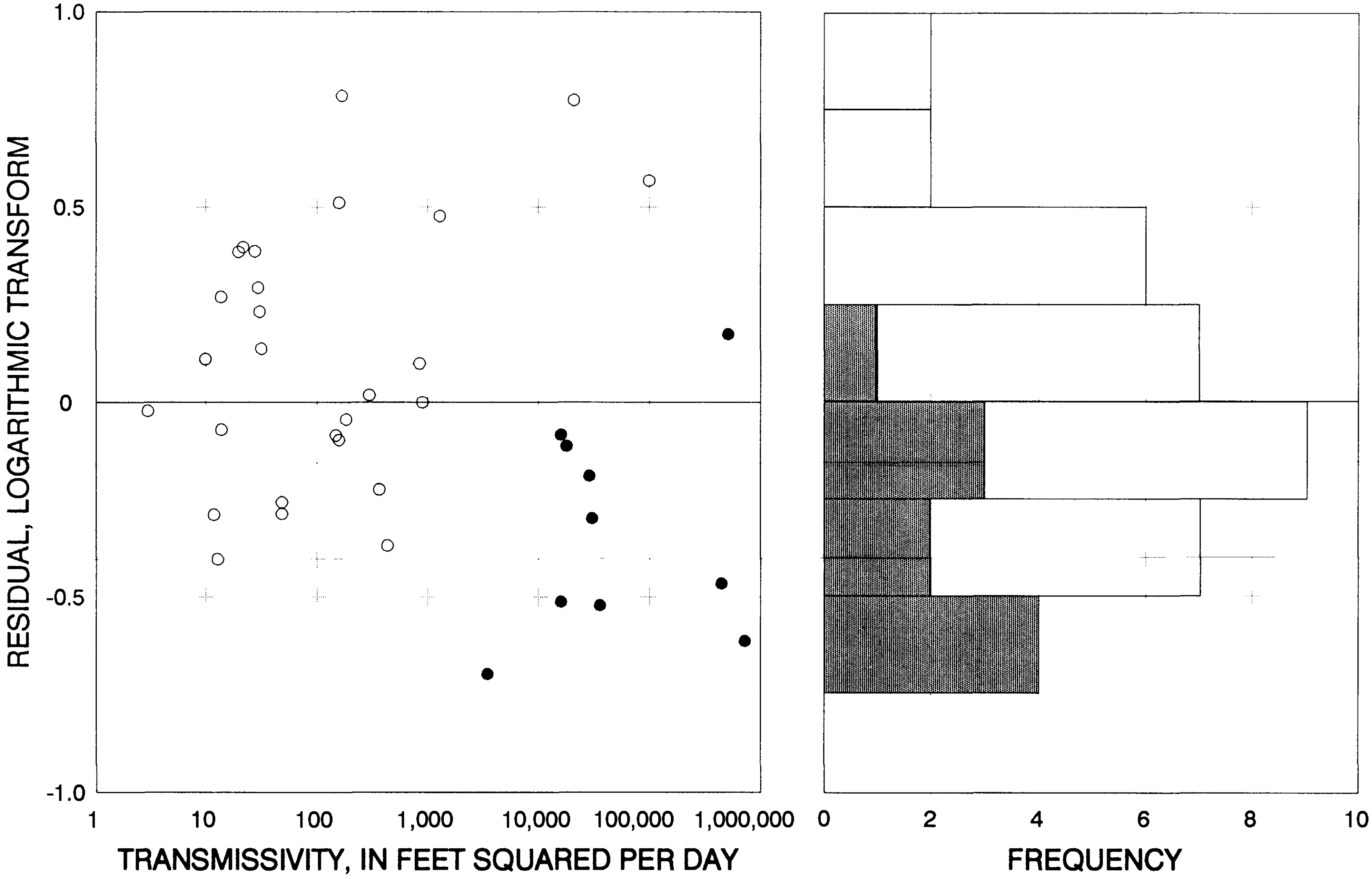


Figure 9.--Residuals of transmissivity predicted by simple linear-regression analysis. Solid symbols and bars are Theis type-curve data, open symbols and bars are Neuman type-curve data.

For those tests where data were insufficient to use the type-curve method, the established regression equation of transmissivity and specific capacity was used to estimate transmissivity. If the drawdown was less than the limit of detection for the measurement method used, it is listed in table 1 as less than (<) the detection limit. Specific capacity and transmissivity calculated from these values are given as greater than (>) values. Similarly, drawdowns larger than could be measured are listed as greater than the last measured value. Specific capacities from "greater than" drawdowns are given as less than values. Only three tests (table 2) with drawdowns less than the detection limit were used for transmissivity estimates.

The estimates of transmissivity in table 2 were chosen as the best or most representative of type-curve analysis or from specific-capacity data at individual wells. The tests listed in table 2 are cross-referenced by test number to those of table 1. The specific-capacity methods for estimating transmissivity could have been used for those tests having time-drawdown data that followed the Theis curve. The specific-capacity method was not applicable to all specific-capacity data, offered no improvement in accuracy, and was not used for final estimates published in table 2.

On the basis of the repeatability of transmissivity determinations for individual wells and on the agreement between type-curve and specfic-capacity data analyses, relative uncertainties tabulated for estimates of transmissivity were assigned by inspection as follows:

- ±0.1 order of magnitude, type-curve analysis;
- ±0.4 order of magnitude, specific-capacity analysis, drawdown greater than 0.1 ft;
- ±0.5 order of magnitude, specific-capacity analysis, drawdown observed less than or equal to 0.1 ft;
- >±0.5 order of magnitude, specific-capacity analysis, drawdown less than detection limit.

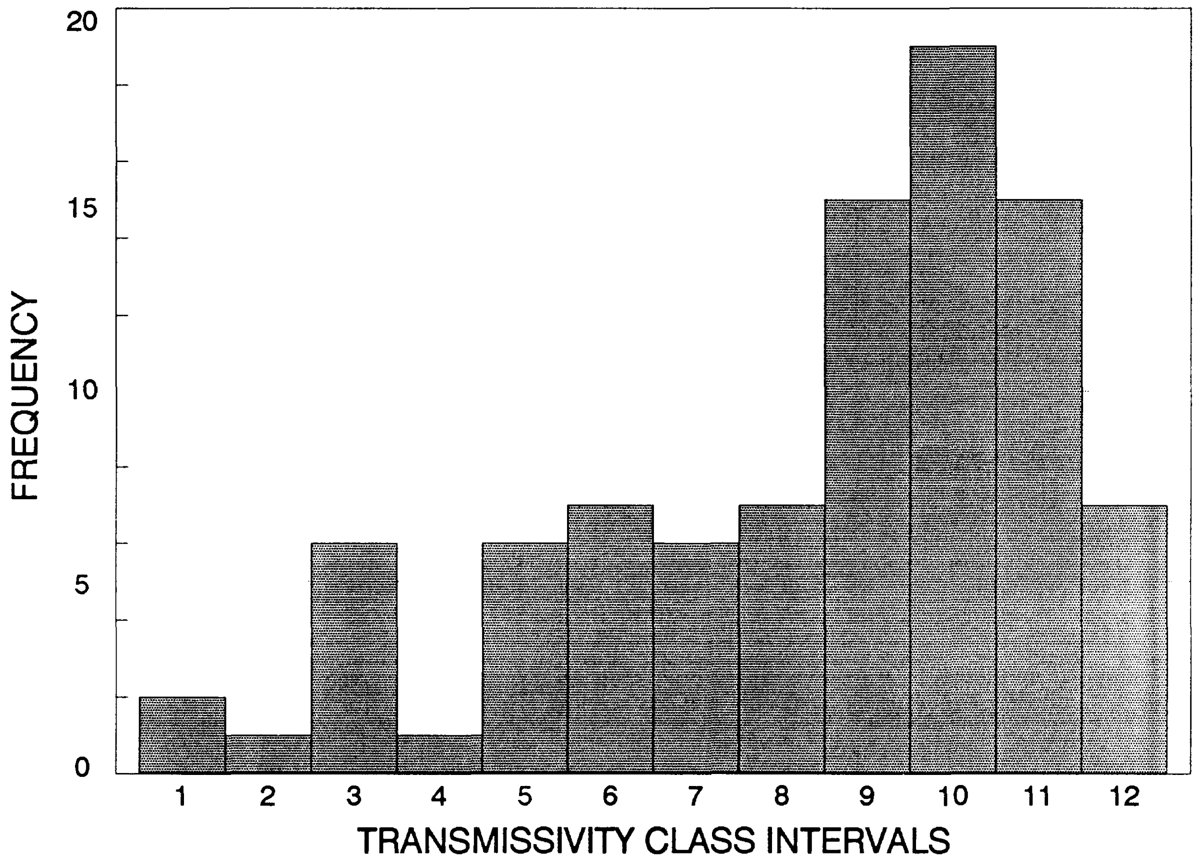
The range, distribution, and estimates of central tendency for transmissivity estimates are shown on figure 10 and table 3 for locations with definite (not based on drawdown less than detection limit) values. The transmissivity estimates span a range of nearly 6 orders of magnitude (1.1 to 7.6×10^5 ft²/d) with a negatively skewed distribution. Most measures of central tendency are close to 6×10^4 ft²/d. Because of the complex nature of individual well completions, no attempt was made to present a hydraulic conductivity. A rough estimate of hydraulic conductivity can be made by dividing the transmissivity by the penetration of the well below the water table (table 2). The range of penetrations was 28 to 807 ft and the arithmetic mean 190 ft. Most values were between 50 and 250 ft. The range of values for hydraulic conductivity calculated using penetration and estimated transmissivity was nearly 6 orders of magnitude (8.6×10^{-3} to 5.5×10^3 ft/d). These values are consistent with the hydraulic conductivity of fractured basalts and lava flows as given by Heath (1983, p. 13), and Freeze and Cherry (1979, table 2.2).

Table 3.--Central tendencies of transmissivity estimates

[ft^2/d, feet squared per day]

Number of observations	[1]91
Range of values	[1]1.1 - 760,000 ft^2/d
Measures of central tendency	
Arithmetic mean	93,000 ft^2/d
Root mean square	180,000 ft^2/d
Geometric mean	9,600 ft^2/d
Median	25,000 ft^2/d
Mode	60,000 ft^2/d

[1]Does not include three observations with greater than values, Highway #3, S5G test, and 11.



EXPLANATION

Units are feet squared per day; intervals are 0.5 order of magnitude wide.

Class interval	Center of interval	Extremes of interval		
1	2	1.1	-	3.6
2	6	3.6	-	11
3	20	11	-	36
4	60	36	-	110
5	200	110	-	360
6	600	360	-	1,100
7	2,000	1,100	-	3,600
8	6,000	3,600	-	11,000
9	20,000	11,000	-	36,000
10	60,000	36,000	-	110,000
11	200,000	110,000	-	360,000
12	600,000	360,000	-	1,100,000

Figure 10.--Distribution of estimated transmissivity at and near the Idaho National Engineering Laboratory.

The large range of values for transmissivity or hydraulic conductivity has profound implications concerning flow in the Snake River Plain aquifer at the INEL. Parts of the aquifer having a hydraulic conductivity of about 8 ft/d would be more than 2 orders of magnitude less permeable than parts of the aquifer with the greatest hydraulic conductivity. In like manner, that same part of the aquifer would be more than 2 orders of magnitude more permeable than the parts of the aquifer with the smallest hydraulic conductivity. Heath (1983, p. 24) stated that aquifers are 1 to 3 orders of magnitude more permeable than confining beds. If a criterion of 2 orders of magnitude difference in hydraulic conductivity is sufficient to differentiate aquifers and confining beds, then some parts of the aquifer may be at once an aquifer and a confining bed relative to flow in other parts of the aquifer.

The estimates of transmissivity provided in this report were determined in a consistent manner and are useful for describing the three dimensional distribution of aquifer properties. Such information is useful for evaluating regional differences in transmissivity of ground-water flow systems. Because the values were not determined from properly designed and well-executed multiple-well tests, they are only of limited use for estimating well-field performance.

SUMMARY

Aquifer-test data of 183 single-well tests at 94 wells in the Snake River Plain aquifer were analyzed to estimate values of transmissivity. Estimates of transmissivity for individual wells ranged from 1.1 to 7.6×10^5 ft^2/d, nearly 6 orders of magnitude. These data were determined in a consistent manner and are useful for describing the distribution of transmissivity at the INEL.

The results of type-curve analysis of 37 tests at 26 wells were used to develop a regression relation between specific capacity and transmissivity. This relation, in turn, was used to analyze all specific-capacity data. An estimate of transmissivity is made for the aquifer at each well. Values of relative uncertainty for estimated values of transmissivity generally ranged from 0.1 order of magnitude for type-curve analysis to 0.5 order of magnitude for specific-capacity data analysis with measured drawdown of less than 0.1 ft. Because of the paucity of adequate multiple-well aquifer tests the scope of interpretation is limited to single-well tests or specific-capacity data.

The values of transmissivity given in this report represent the transmissivity near the test wells and within the test interval. Due to the high degree of heterogeneity of the basalt and the unknown thickness of the aquifer, it is more likely the transmissivity of the whole basalt sequence is different from those values given in this report. Nevertheless, the reported transmissivities are useful, because most of the development of the aquifer at the INEL area is limited to the top several hundreds of feet of the aquifer where the test wells are penetrated.

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