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Hydrogeology of an Alluvial Aquifer in the Blue Lake Area, East Multnomah County, Oregon

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Title: Hydrogeology of an Alluvial Aquifer in the Blue Lake Area, East Multnomah County, Oregon.

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This thesis evaluates the hydraulic relationship between the Blue Lake gravel aquifer, the Columbia River, and Blue Lake. Hydrogeology, water levels, and stable isotopes were used to establish these hydraulic relationships.

The Blue Lake gravel aquifer consists of coarse channel deposits of the ancestral Columbia River. The sediments are

predominantly gravel, cobbles, and boulders in a silty to sandy matrix. The clasts are basalt, with lesser amounts of andesite and quartzite. The transmissivity was estimated to be 20,490 m^2/day and the hydraulic conductivity was estimated to be 683 m/day. A deposit of gravel, cobbles, and boulders that is submerged along the south shore of the Columbia River is interpreted to be Blue Lake gravel aquifer sediments, suggesting a hydraulic connection at this location.

Stable isotopes of oxygen and hydrogen were used as natural tracers to determine if water was being contributed to the aquifer from the Columbia River and Blue Lake. There was a pronounced change in isotopic composition of water sampled during a pump test indicating a contribution of water from the river, estimated to be 72% after 22 days of pumping. A small change in isotopic composition occurred in a sample taken near the lake.

Analysis of water level data showed that water levels in the aquifer and those in the Columbia River are not independent of each other. These water levels correlate very well and the response to river stage within the aquifer diminishes with distance. The water levels in Blue Lake and the aquifer were found to be independent of each other.

A strong hydraulic connection exists between the Columbia River and the Blue Lake gravel aquifer. The hydraulic connection of Blue Lake and the aquifer is weak and can only be observed under stressed conditions.

HYDROGEOLOGY OF AN ALLUVIAL AQUIFER IN THE

BLUE LAKE AREA, EAST MULTNOMAH COUNTY, OREGON

by

JAMES MITCHELL WILKINSON

A thesis submitted in partial fufillment of the requirements for the degree of

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TO THE OFFICE OF GRADUATE STUDIES:

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There have been many others among the faculty, students, colleagues, and friends who have contributed to my thesis. I can not express my gratitude enough to the people associated with me through the U.S.G.S. and Portland State University, Geology Department. Through these two entities I have learned so many things.

Finally, I come to my wife, Yaeko, without whose love, support and patience, this thesis would have forever remained a dream. I dedicate this thesis to Yaeko. My accomplishment is hers as much as mine.

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CHAPTER I

INTRODUCTION

LOCATION AND SETTING

The Blue Lake area is located along the southern shore of the Columbia River in east Multnomah County, Oregon (Figure 1). The study area extends from Fairview Lake to the Columbia River and from Taggart Bluff to Campbell Road. These boundaries encompass the known extent of the Blue Lake gravel aquifer (Hartford and McFarland, 1989).

The Blue Lake area is a small part of a much larger area, the Portland Basin, which the Columbia River flows through. The Portland Basin is a northwest trending sediment filled structural depression. The primary sedimentary units are the Sandy River Mudstone, Troutdale Formation, and catastrophic flood deposits. Several other local deposits occur within the Portland Basin to a lesser extent.

The City of Portland operates a well field which serves as a backup municipal water supply. The eastern portion of the well field extends to the Blue Lake area (see Figure 1). A park in the Blue Lake area is operated by Multnomah County and provides picnic and water activities to the public. In addition, there are several residences along the shores of Blue Lake and Fairview Lake. To the east and south of the

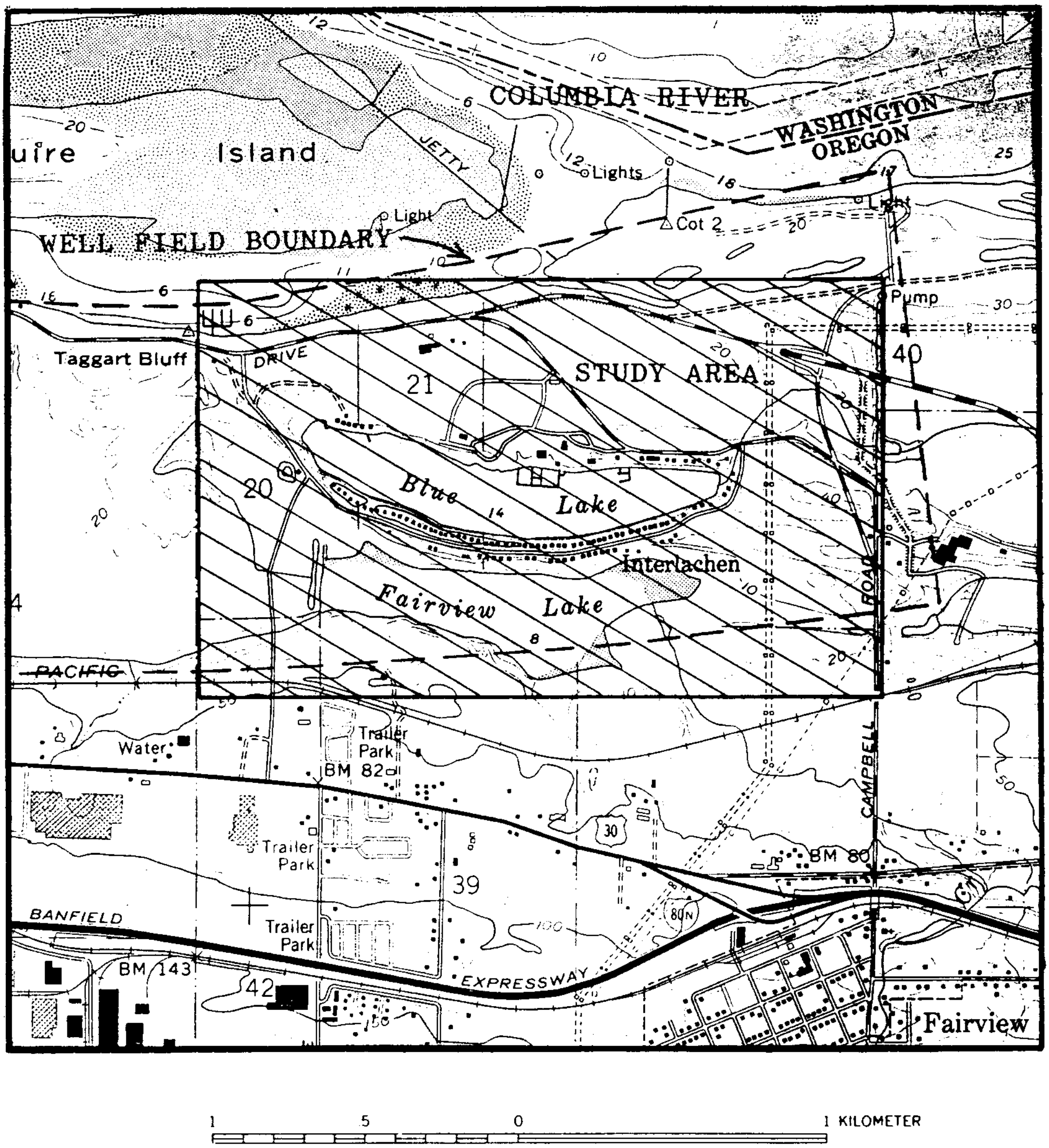


Figure 1. Location of the study area.

study area are some industrial districts. Groundwater south of the study area has been found to contain contaminants and is a source of concern to the City of Portland and other local groundwater users (Malin, 1989; Leighton, 1990; Lindberg, written communication). Land to the west is primarily farmland.

The climate of the study area is generally mild most of the year but can be unseasonably cold in winter due to the proximity of the mouth of the Columbia Gorge. The area receives about 117 to 127 centimeters of rain annually (D. Snyder, written communication) and is moderately drained with some ponding occurring in low lying areas.

PURPOSE AND SCOPE

The Blue Lake gravel aquifer is very productive as a groundwater source. There is the possibility that groundwater withdrawal and contamination in the area could adversely affect the quality and/or quantity of the groundwater. It is important to know the source of the groundwater and the general hydrogeologic characteristics of the aquifer. Successful use, future development, and protection of the aquifer is dependent upon knowledge and understanding of the hydrogeology and hydraulic characteristics of the aquifer.

The proximity of the Columbia River and Blue Lake suggest that there may be a relationship between the aquifer and these water bodies. The goal of this study was to evaluate and establish the relationships of the river and lake to the aquifer. This information will help to provide a better understanding of the hydrogeology of the Blue Lake gravel aquifer.

PREVIOUS WORK

There are several reports which describe the geology and hydrogeology in the Portland vicinity. Of these, there are two published reports which involve work in the Blue Lake area. Hoffstetter (1984) briefly describes the Blue Lake aquifer within his report of the geology of the Portland well field. A more detailed description is contained in a report by Hartford and McFarland (1989). In addition to these reports, there are some unpublished reports of limited distribution done by the City of Portland and by various consulting firms (eg. Landau Associates, Dames and Moore).

Other published reports for the vicinity include those by Griffin and others (1956), Hogenson and Foxworthy (1965), Swanson and others (in press), and Trimble (1963). These reports contain geologic and hydrogeologic descriptions covering the broad region, but not necessarily the Blue Lake gravel aquifer.

CHAPTER II

HYDROGEOLOGY

METHODS OF INVESTIGATION

The Blue Lake gravel aquifer was evaluated using a combination of methods. Initially, literature relevant to the area and subject were reviewed and compiled. Geologic and drillers well logs supplied by the U.S.G.S. were used to provide additional information at well locations in the Blue Lake area. Figure 2 shows the distribution and location of these wells. A well ID cross reference can be found in appendix A. Lithology from the geologic and drillers logs was coded and graphically drafted on a polyester film overlay. Figure 3 shows an example of this procedure. At locations which have both geologic and drillers logs, the lithologic descriptions were compared to examine differences in interpretation. This provided a method of control for interpreting those drillers logs which had no corresponding geologic logs. The lithologic description of the aquifer given in Hartford and McFarland (1989) was compared to the lithology on the graphic plot to determine the interval which represents the aquifer. The elevations of the top and bottom of the aquifer were picked from the graphic plot. An unpublished contour map of the bottom of Blue Lake

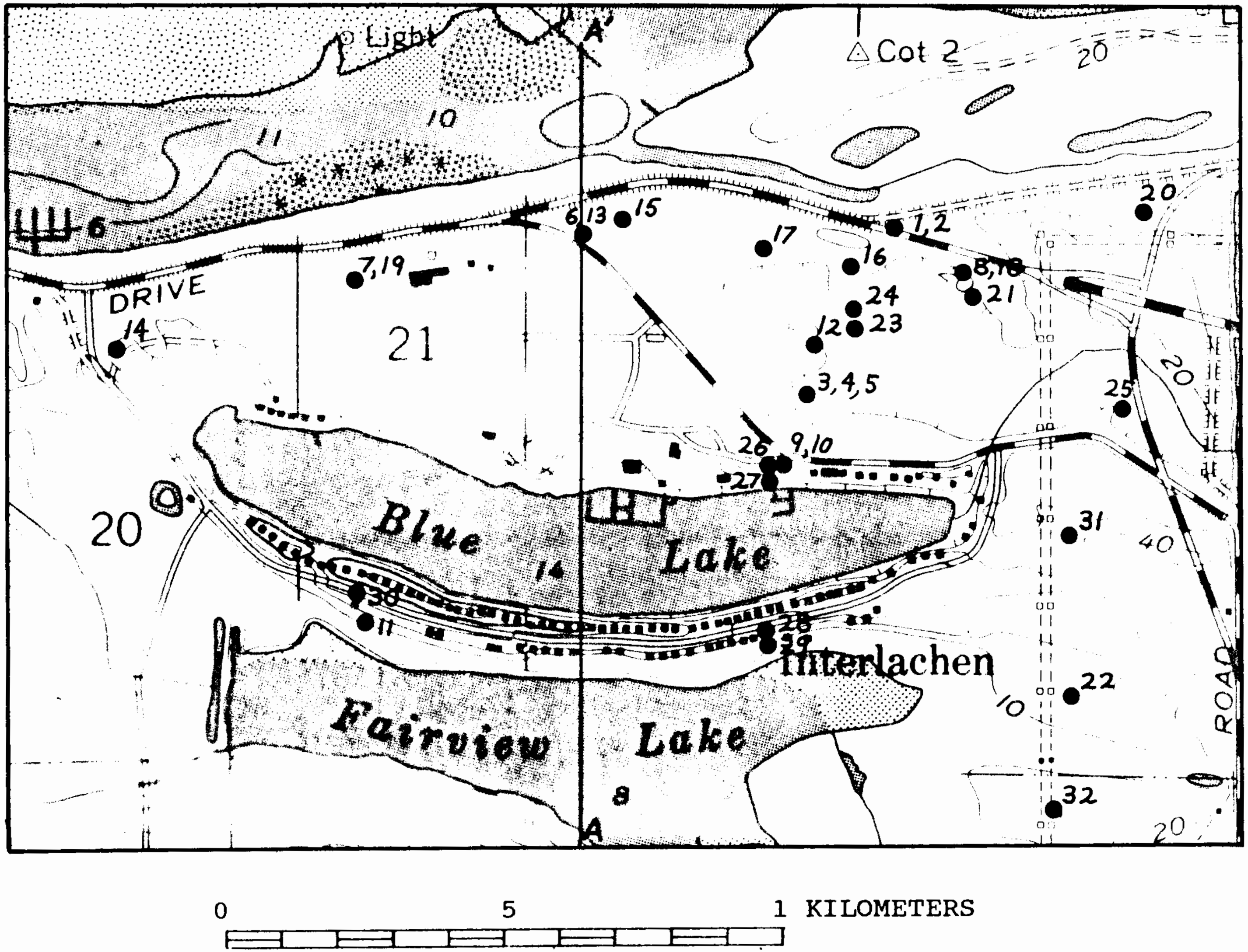
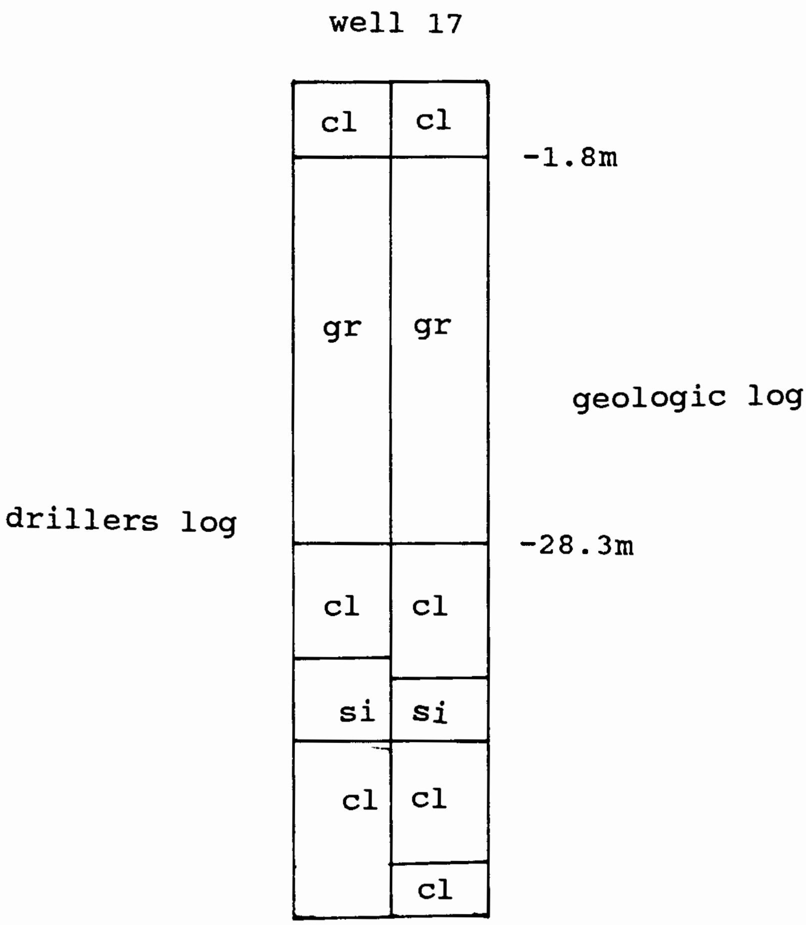


Figure 2. Well locations and identification.



EXPLANATION

cl	clay
gr	gravel
si	silt

1cm = 6m

Figure 3. Example of geologic and drillers lithologies.

(McFarland, written communication) provided additional control for estimating the altitude of the top of the aquifer below Blue Lake. These data were combined with those of Hartford and McFarland (1989) and contoured to create modified maps of the top and bottom of the aquifer.

The City of Portland provided discharge and drawdown data for a pump test at well 19 in August 1990. These data were used to calculate the hydraulic characteristics of the aquifer. Distance versus drawdown (see Figure 6) and time versus drawdown (see Figure 4, 5) were plotted and the resulting parameters were used to calculate transmissivity, storage coefficient, and hydraulic conductivity. The following relationships from Heath (1982) were used for distance versus drawdown:

$$T=2.3Q/(2\pi s) \qquad (1)$$

$$S=2.25Tt/r_0^2 \qquad (2)$$

where T is transmissivity in square meters per day, Q is discharge in cubic meters per day, s is drawdown over one log cycle in meters, t is time of measurement in days since pumping started, and r_0 is the distance in meters (x intercept at drawdown = 0). For time versus drawdown, the following relationships were used from Heath (1982):

$$T=2.3Q/(4\pi s) \qquad (3)$$

$$S=2.25Tt_0/r^2 \qquad (4)$$

where t_0 is x intercept at drawdown = 0 in days and r is the distance from the pumping well to the observation well in meters. Hydraulic conductivity is calculated using

$$K=T/b \qquad (5)$$

where K is the hydraulic conductivity in meters per day and b is the thickness of the aquifer in meters (Heath, 1982).

Elevations above or below sea level are with respect to the National Geodetic Vertical Datum of 1929.

BLUE LAKE GRAVEL AQUIFER

Lithology and Extent

Lithologic data and descriptions recorded on drillers and geologic well logs provided data about the Blue Lake gravel aquifer sediments. Data from these well logs indicate that the sediments consist of 65% to 90% gravel to cobble size clasts with some boulders in a matrix of clayey to sandy silt based on the size classification given in Fetter (1988). The concentration of gravel to cobble size clasts is predominantly 75% to 85% throughout the sediments. Although the clast size varies, most are from fine gravel (6 mm) to small cobble (100 mm) size with cobbles up to 152 mm and boulders up to 355 mm reported.

Data from geologic logs indicate that the composition of the clasts is 60% to 90% basalt, with up to 30% andesite, and up to 30% quartzite. There are also minor amounts of other metamorphic rocks and occasional pieces of sandstone reported in the geologic logs. The average composition is 75% to 85% basalt, 15% to 20% andesite, and 10% quartzite.

The matrix varies from clayey silt to sand. Most descriptions are sandy silt to silty sand with some lesser amounts of coarse sand. Thin lenses of clay are reported in some of the wells at varying depths. There is no evidence of cementing in the aquifer.

The sediments of the aquifer are present at many well locations within the Blue Lake area. The westernmost occurrence of Blue Lake gravel sediments is at well 14 (see Figure 2 for location). The easternmost occurrence is at wells 20 and 25, and the southernmost occurrence is at well 27. All wells located within the boundary delineated by wells 14, 20, 25 and 27 penetrate the aquifer sediments. Drillers and geologic well logs for wells farther east and west were examined and no trace of the aquifer sediments was found. There is a submerged deposit of gravel, cobbles, and boulders along the south shore of the Columbia River just east of Taggart Bluff which is the only outcrop of aquifer sediments observed.

Geologic logs were used to pick the top and bottom extent of the aquifer based on one or more changes in sediment characteristics. These characteristics are cementation, size distribution, and lithology. Table I summarizes the results.

Hydraulic Characteristics

In August 1990, the City of Portland conducted a pump test at well 19. The screened interval for well 19 is

TABLE I

TOP AND BOTTOM ELEVATIONS FOR THE BLUE LAKE GRAVEL AQUIFER

WELL ID	ELEVATION OF AQUIFER (METERS) TOP	BOTTOM
1	-3.0	-70.7
2	-3.0	-70.7
3	0.9	-32.0
4	0.9	-32.0
5	0.9	-32.0
6	1.0	-52.1
7	1.8	-28.3
8	-2.4	-69.5
9	6.7	-36.0
10	6.7	-36.0
12	-0.6	-31.4
13	1.0	-52.1
14	3.0	-16.5
15	-0.9	-
16	-0.3	-
17	0.0	-50.9
18	-1.5	-
19	-0.6	-29.3
20	-19.5	-
21	0.0	-
23	-0.9	-
24	-0.9	-36.3
25	0.3	-
26	3.4	-
27	3.4	-

exclusively within the Blue Lake gravel aquifer. Well 19 was pumped at a rate of 37,900 m^3/day for 22 days (August 7 - 29). Water levels at two locations, wells 6 and 9 (see Figure 2), were monitored by the City of Portland during the pump test. Pumping was halted on August 18 for a day due to technical problems. The data from the pump test were selected from the period of pumping prior to August 18 and are shown in Table II. Wells 6 and 9 are approximately 427

TABLE II

DRAWDOWN DATA FOR AUGUST 1990 PUMP TEST

TIME SINCE PUMPING STARTED (DAYS)	DRAWDOWN (METERS) Well 6	Well 9
0.68	0.49	0.27
1.02	0.55	0.34
1.70	0.61	0.43
2.05	0.64	0.46
2.67	0.70	0.52
3.75	0.73	0.55
4.74	0.79	0.61
5.74	0.94	0.73
6.87	1.01	0.82
7.73	0.98	0.85

meters and 844 meters away from well 19, respectively.

The data in table II are shown in Figures 4 and 5 as plots of time versus drawdown. Logarithmic best fit lines are projected back to the point of no drawdown and the corresponding times were used for calculating transmissivities and storage coefficients. Figure 6 shows the data plotted as distance versus drawdown for the successive measurement times. Logarithmic best fit lines are projected through the data out to the point of no drawdown and the corresponding distances were used for transmissivity and storage coefficient calculations. Calculations were made using equations 1 and 2 for distance versus drawdown and equations 3 and 4 for time versus drawdown. These calculated values are summarized in Table III.

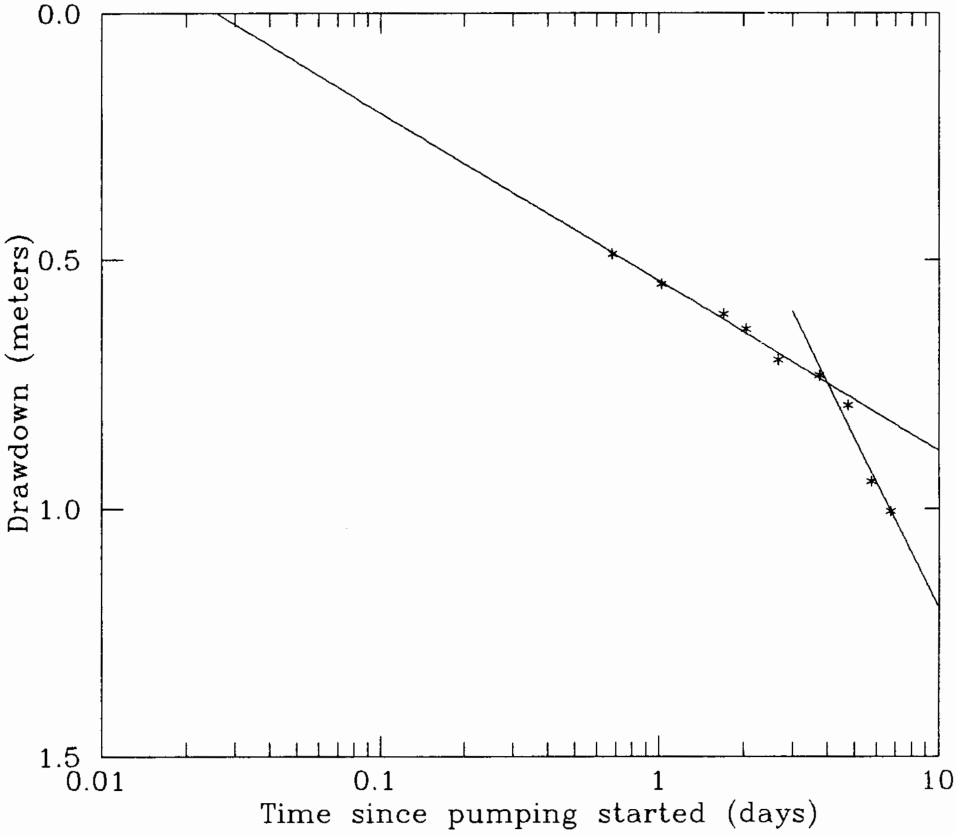


Figure 4. Time vs. drawdown plot of the August 1990 pump test data for well 6.

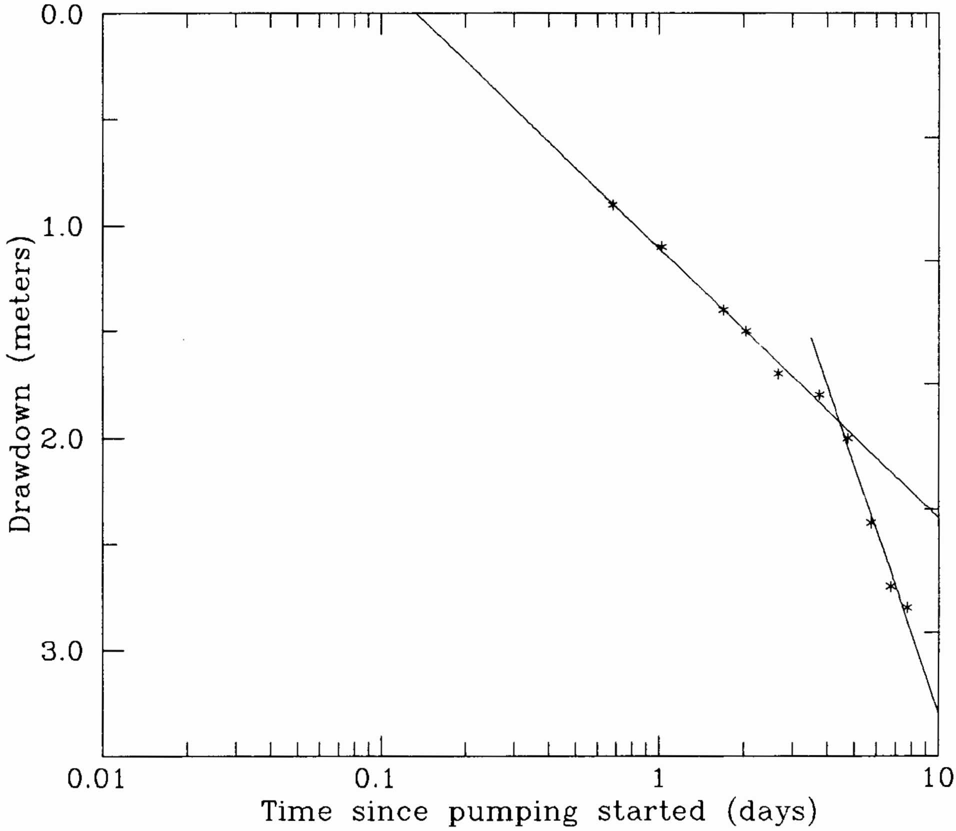


Figure 5. Time vs. drawdown plot of the August 1990 pump test data for well 9.

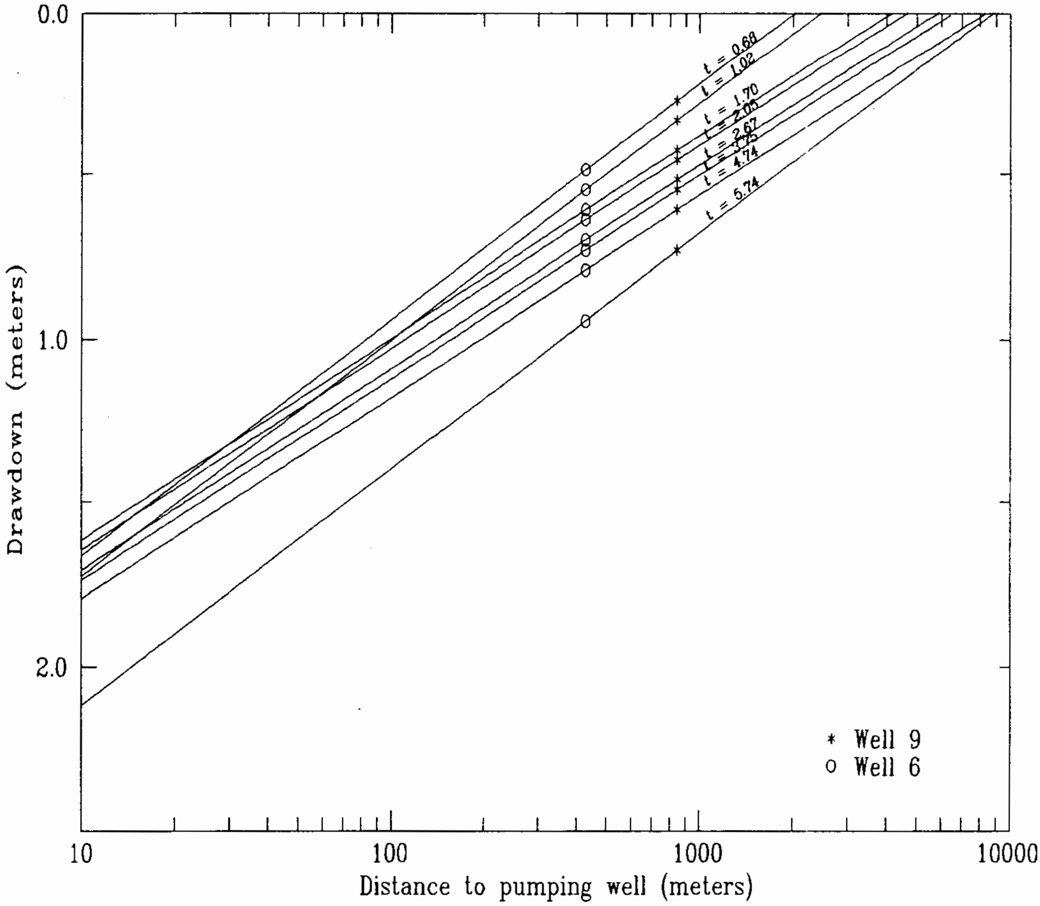


Figure 6. Distance vs. drawdown plot of the August 1990 pump test data.

TABLE III

CALCULATED VALUES OF TRANSMISSIVITY AND STORAGE COEFFICIENT

TRANSMISSIVITY (M^2/day)	STORAGE COEFFICIENT	COMMENTS
20,410	0.006	well 6 (figure 4)
17,880	0.007	well 9 (figure 5)
19,270	0.007	t=0.68 (figure 6)
19,270	0.007	t=1.02 (figure 6)
22,480	0.005	t=1.70 (figure 6)
22,480	0.005	t=2.05 (figure 6)
21,630	0.005	t=2.67 (figure 6)
22,480	0.004	t=3.75 (figure 6)
22,480	0.004	t=4.74 (figure 6)
19,270	0.003	t=5.74 (figure 6)

Figures 4 and 5 show a break in slope at about 4 days. this change in hydraulic conditions represents a known bias and therefore values of transmissivity calculated from this point and later were not used for the average. The remainder of the values were used to calculate the average transmissivity. An average value of 20,490 m^2/day for transmissivity was used to calculate hydraulic conductivity. Based on a thickness of 30 meters at well 19, a hydraulic conductivity of 683 m/day was calculated. Assuming an average thickness of 38 meters within the aquifer, the hydraulic conductivity is 560 m/day.

ADJACENT UNITS

Recent Alluvium (Qal)

These sediments include overbank deposits and current channel deposits of the Columbia River. The overbank deposits are part of the Columbia River flood plain and are up to 10 meters thick in the study area. The lithology of the overbank deposits is described by Hartford and McFarland (1989) as silty clay to sandy silt which is unsaturated.

The channel deposits are described by Hoffstetter (1981) as the Columbia River Sands Formation. These deposits are medium sands of quartz and basalt composition with interbedded thin beds of gravel, silt, and clay (Hoffstetter, 1981). The unit is up to 91 meters thick and overlies the Blue Lake gravel aquifer in well 20 (see figure 2)

(Hoffstetter, 1981).

Troutdale Sandstone Aquifer (TSA)

The Troutdale sandstone aquifer is a coarse vitric sandstone with lenses and beds of conglomerate, sand, and silt (Swanson and others, in press). In the Blue Lake area, this unit crops out and forms a ridge between Blue Lake and Fairview Lake (see Figure 9). It has a dip of 12 to 14 degrees to the south (Hartford and McFarland, 1989) and is interpreted by Swanson (1986) as a homoclinal feature. It consists of moderate to well sorted, angular to sub-rounded, indurated basaltic glass (Hartford and McFarland, 1989). Wells completed in this unit have been tested at rates up to 9.5 m^3/min. (Swanson and others, in press).

Confining unit (CU)

The confining unit is described as confining unit 2 by Hartford and McFarland (1989) and Swanson and others (in press). It underlies the Troutdale sandstone aquifer and is encountered at depth in some of the wells in the Blue Lake area. Geologic logs for wells 14 and 19 indicate that it is composed of clay with silt and sand lenses and is described by Willis (1978) as a leaky confining layer. These sediments are interpreted to be lacustrine by Trimble (1963).

Sand and Gravel Aquifer (SGA)

The sand and gravel aquifer is the lowermost unit encountered in the Blue Lake area (see Figure 9). Data from well logs in the Blue Lake area indicate that this unit is predominantly fine sand. It is described by Swanson and others (in press) as composed of silty sand, clay, sand, and sandy gravel. Hartford and McFarland (1989) describe the upper unit of the sand and gravel aquifer as being partially eroded in the Blue Lake area, exposing a finer grained facies. Swanson and others (in press) reports that this aquifer is very productive and has been tested at rates up to 11.4 m^3/min.

DISCUSSION

A comparison of geologic and drillers well logs for locations in the Blue Lake area shows that interpretations of the geologists and drillers are very similar. Differences exist mostly in the interpretation of grain size and cementation in units adjacent and below the Blue Lake gravel aquifer. Hartford and McFarland (1989) describe the Blue Lake gravel aquifer as coarse channel deposits of the ancestral Columbia River. This paleochannel has eroded into the Troutdale Formation and subsequently filled with coarse flood deposits. This suggests that the aquifer sediments are late Pleistocene in age corresponding with the catastrophic floods described by Bretz and others (1956). Mundorff

(1964) describes an aquifer with very similar characteristics on the north side of the Columbia River in the Camas, Washington area. These descriptions are consistent with those found in the geologic and drillers well logs.

The sediments in the adjacent units are all fine grained, ranging from the clayey silt in the confining unit to the medium sand in the Troutdale Sandstone aquifer. This is a sharp contrast to the clast supported coarse gravel and cobble deposits of the Blue Lake gravel aquifer. The aquifer sediments are easily distinguishable from the adjacent units.

The elevations of the top and bottom of the aquifer (see Table I) were compared to those presented by Hartford and McFarland (1989). These data were found to be in general agreement for locations common to their work and this study.

Figure 7 shows the elevation of the top of the aquifer, modified from Hartford and McFarland (1989). A notable high of 6.7 meters is present along the east side of the north shore of Blue Lake. From that area the elevation decreases gently to the northwest and more sharply to the south and northeast.

Figure 8 shows the elevation of the bottom of the aquifer, modified from Hartford and McFarland (1989). The bottom of the aquifer shows a distinct deepening trend to the east. The minimum depth encountered was 70.7 meters at wells 1 and 2. The pattern formed by the contours and the easterly dip indicate an east-west aligned trough, dipping to the east.

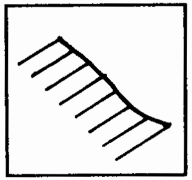
The southern and western extent of the aquifer follows the ridge of Troutdale Sandstone from the south side of Blue Lake to Taggart Bluff to the northwest (Hartford and McFarland, 1989). As noted by Hartford and McFarland (1989), the eastern extent is not clearly defined due to a lack of available data.

Figure 9 is a north-south oriented hydrogeologic section. The ridge-forming Troutdale Sandstone can be seen bounding the aquifer to the south of Blue Lake. The northern extent projects to just north of the south shore of the Columbia River, where the submerged gravel, cobble, and boulders were observed. The Columbia River Sands described by Hoffstetter (1981) are interpreted to project below the Columbia River, terminating the Blue Lake gravel aquifer to the north.

Drawdown data are shown plotted with a Theis type curve in Figures 10 and 11. The estimated transmissivities and storage coefficients are 17,740 m^2/day and .008 respectively for well 6, and 16,760 m^2/day and .009 respectively for well 9. The lack of early data for the time immediately after pumping started make this data less than adequate for use. The deviation from the curve at about 4 days is small but pronounced for both wells. This corresponds to the break in

EXPLANATION

Contour interval 2 m. Dashed where inferred.



Area where unit not present.

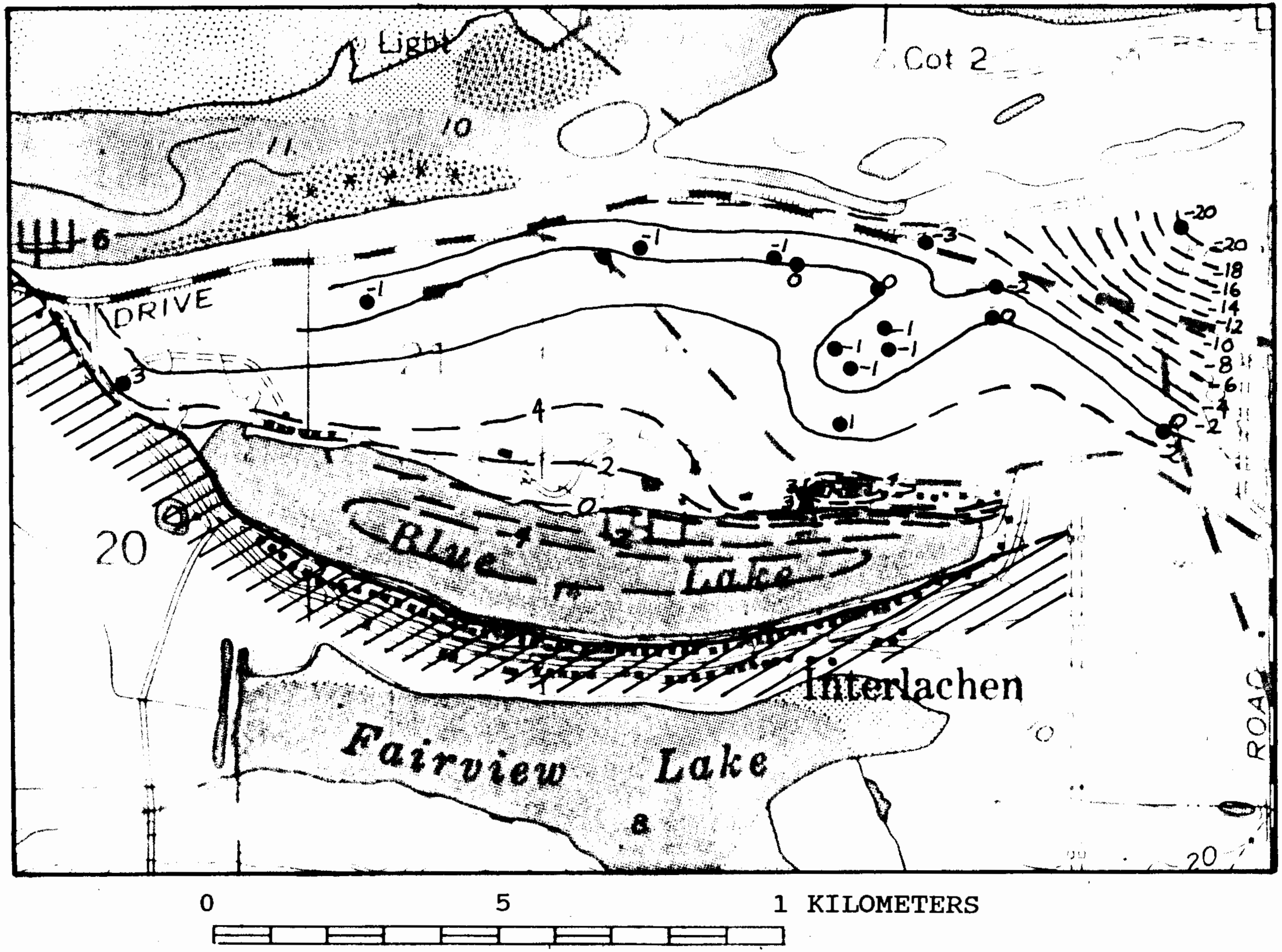
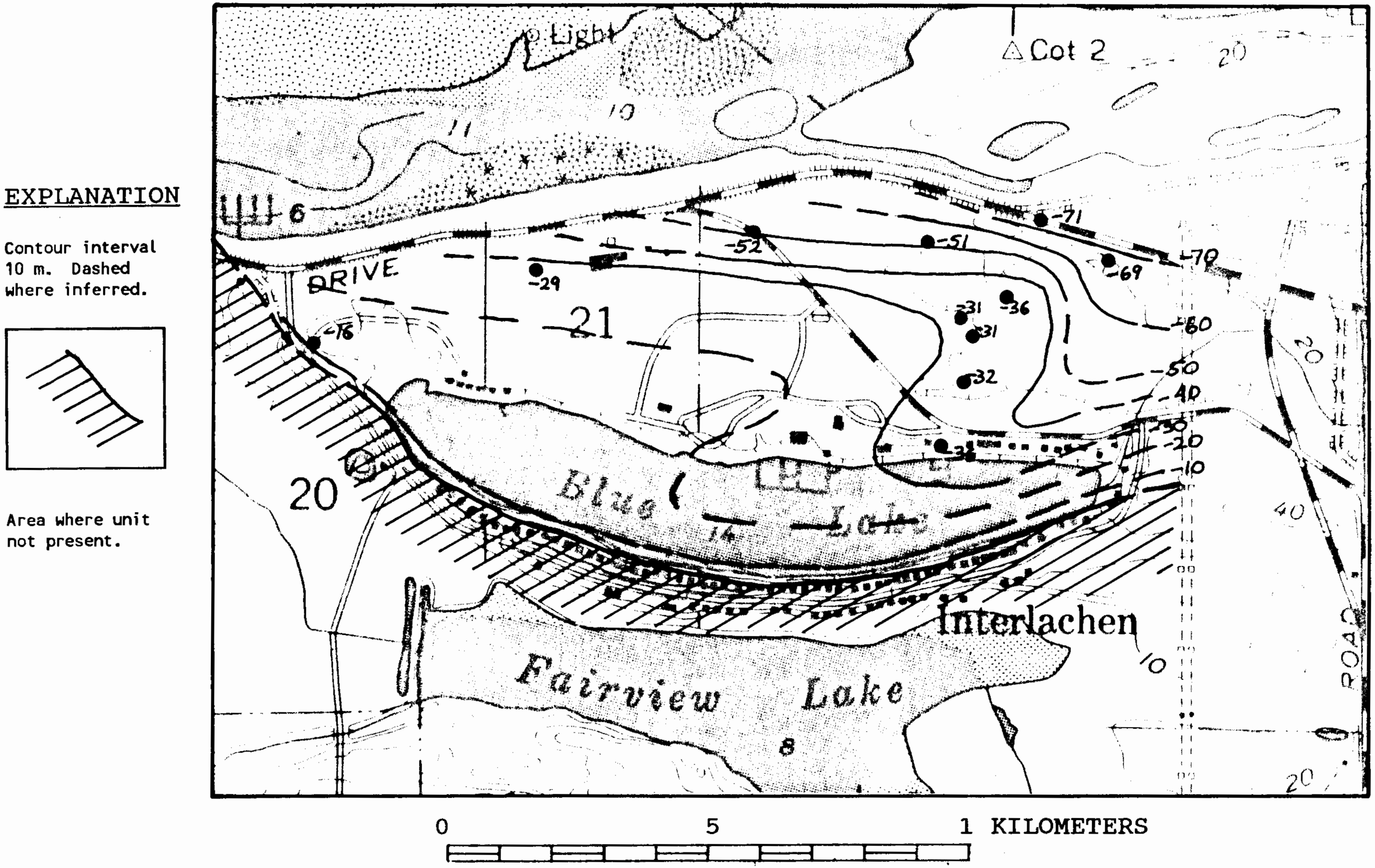
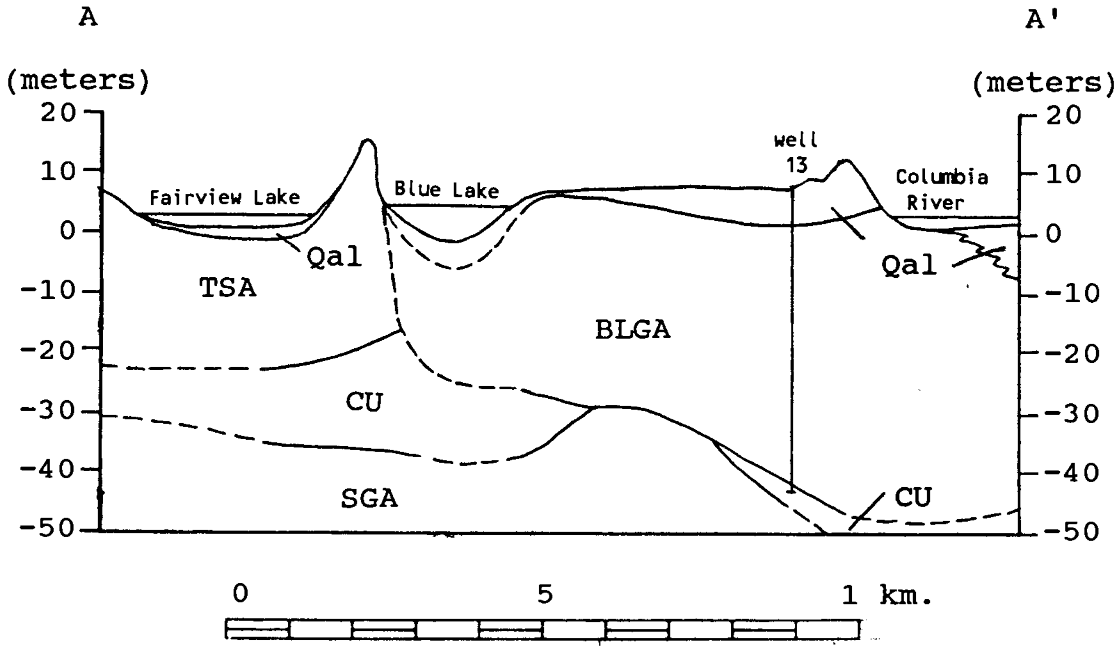


Figure 7. Contour map of the top of the Blue Lake gravel aquifer, modified from Hartford and McFarland (1989).



<u>Figure 8.</u> Contour map of the bottom of the Blue Lake gravel aquifer, modified from Hartford and McFarland, (1989).



EXPLANATION

BLGA	Blue Lake Gravel Aquifer
Qal	Recent Alluvium
TSA	Troutdale Sandstone Aquifer
CU	Confining Unit
SGA	Sand and Gravel Aquifer

Figure 9. North-south hydrogeologic section through the Blue Lake area.

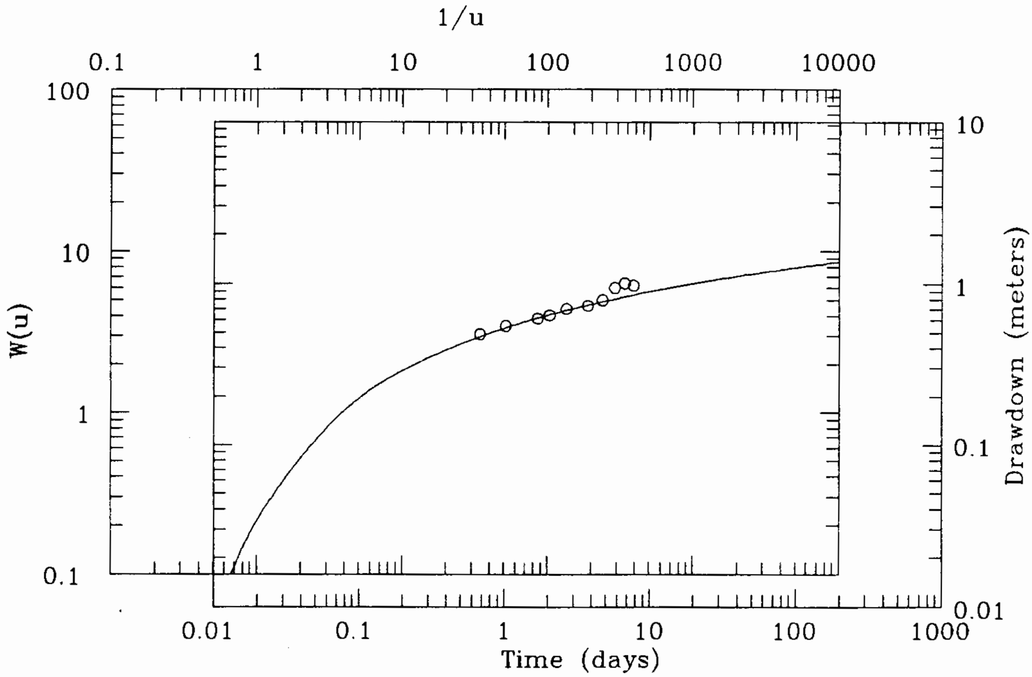


Figure 10. Drawdown data for well 6 with Theis type curve.

slope shown in Figures 4 and 5. This condition is indicative of an impermeable boundary being sensed (Driscoll, 1986; Heath, 1982).

The distance to the hydraulic boundary can be calculated using the relationship

$$r_i=r_o(t_i/t_o)^{1/2} \tag{6}$$

where r_i is the distance from the observation well to the image well, r_o is the distance from the observation well to the pumping well, t_i is the time at which a drawdown s_i caused by the image well at the observation well, and t_o is the time at which a drawdown of s_o is caused by the real

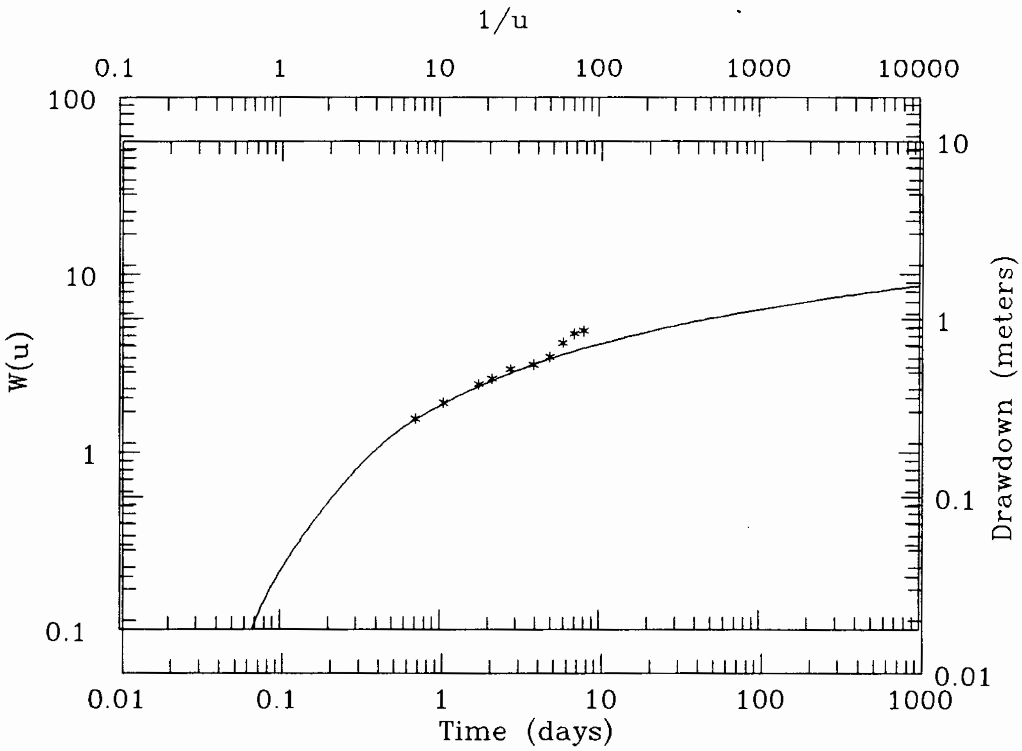


Figure 11. Drawdown data for well 9 with Theis type curve.

pumping well at the observation well (Heath, 1982). Equation 6 assumes $s_i = s_o$. Since the boundary is halfway between the observation well and the image well, the distance of the boundary becomes $r_i/2$ from a point halfway from the pumping well to the observation well (Heath, 1982). Based on these assumptions and conditions, the hydraulic boundary is calculated to be approximately 5,000 meters away. This distance is a hydraulic distance which is influenced by other hydraulic conditions and therefore does not represent the true distance. The relationship of the aquifer to the Columbia River shown in Figure 9 suggests that there may be a strong recharge boundary influencing the hydraulic conditions.

Assuming a recharge influence from the Columbia River, the boundary is probably much closer than 5,000 meters and represents the TSA.

The City of Portland has conducted several pump tests in the Blue Lake gravel aquifer from which hydraulic conductivities from 600 to 900 m/day have been estimated (W. McFarland, personal communication). The expected range of values for gravels is about 100 to 6,000 m/day (Heath, 1982). Values of 560 to 683 m/day calculated from the August 1990 pump test data are consistent with previous estimates and the expected range.

CHAPTER III

STABLE ISOTOPE ANALYSIS

METHODS OF INVESTIGATION

The traditional method of determining the relationship between an aquifer and a surface water body involves comparing water levels to determine the hydraulic gradient and measuring discharge along a stream. Another method is the use of naturally occurring stable isotopes as a natural tracer. This method can be used independently from traditional methods as a tool for corroborating or refuting hypotheses based on the traditional approach. In this study, stable isotopes of hydrogen and oxygen were used to determine the hydraulic relationship between the Blue Lake gravel aquifer and two surface water bodies, the Columbia River and Blue Lake. The two questions addressed are: 1) Is the Blue Lake gravel aquifer hydraulically connected to the Columbia River and/or Blue Lake?, and 2) What is the contribution of the Columbia River and Blue Lake to the pumping wells?

In March 1990, the City of Portland conducted a pump test, pumping five production wells (wells 12, 13, 17, 18, 19; see Figure 2 for locations) at a combined rate of 118 m^3/min. All of these wells are completed in the Blue Lake gravel aquifer. This provided an opportunity to collect water samples for stable isotope analysis under stressed hydraulic conditions.

Before, during and after this test, water samples were collected from the production wells (wells 12, 13, 17, 18, 19), observation wells (wells 1, 2, 3, 4, 5, 9, 10), the Columbia River, the Sandy River, and Blue Lake (see figure 2). Samples were collected with U.S.G.S. equipment and supplies by U.S.G.S. personnel including myself.

The procedure for sampling was developed by laboratory personnel at the Portland U.S.G.S. office. Prior to sampling at each observation well, the well was purged and the pH, specific conductance, and temperature of the effluent was monitored. Samples were taken after these parameters had stabilized and been recorded. A pneumatic pump using nitrogen was used for pumping water from the area adjacent to the well screen. Samples were collected by filling 50 ml glass bottles and sealing them with polyseal caps to minimize any effects from headspace. Samples taken from the production wells were collected directly from outlets at the wells. Samples collected from the Columbia River, Sandy River, and Blue Lake were obtained with a bailer lowered to a depth equal to half of the total depth at the collection location. These samples were also collected in 50 ml glass bottles with polyseal caps. Samples selected for analysis were sent to the U.S.G.S. Water Quality Laboratory in Menlo

Park, California where concentrations of oxygen^{18} and deuterium were determined using mass spectrometry (K. McCarthy, personal communication). The data are expressed as per mil values of the isotopic ratios D/H and $^{18}O/^{16}O$ relative to standard mean ocean water (SMOW) (Craig, 1961). The isotopic ratios are defined as

$$\delta^{18}O(\text{per mil})=(((^{18}O/^{16}O)_{sample}/(^{18}O/^{16}O)_{SMOW})-1)1000 \qquad (7)$$

$$\delta D(\text{per mil})=(((^{2}H/^{1}H)_{sample}/(^{2}H/^{1}H)_{SMOW})-1)1000 \qquad (8)$$

for concentrations of ^{18}O, ^{16}O, ^{2}H, ^{1}H.

The pump test of August 1990 provided another opportunity for sample collection. Samples were collected daily at the pumping well (well 19) for the 22 day duration of the test. The collection procedure was the same as that used in March and selected samples were analyzed by the same laboratory and procedure.

RESULTS

The results of the analysis of the water samples are shown in Table IV. The standard deviations of the reported data are 0.1 per mil for oxygen^{18} and 1.5 per mil for deuterium.

DISCUSSION

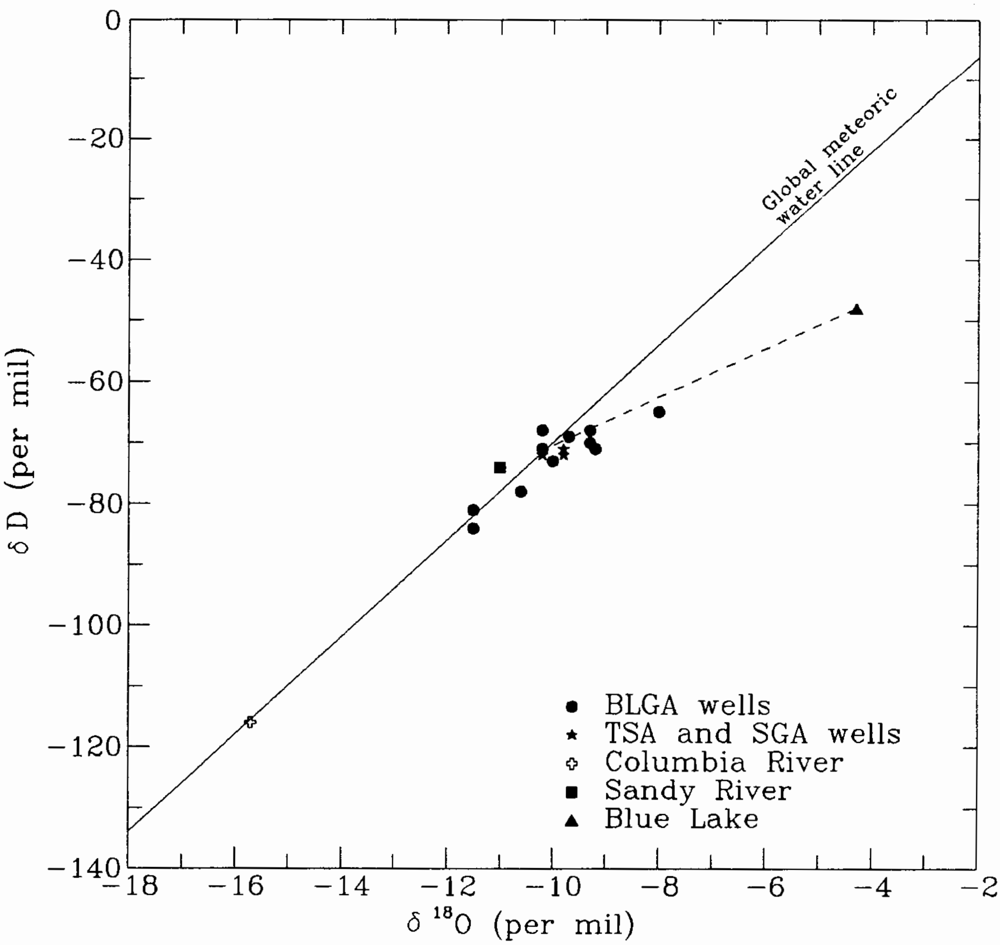
Figure 12 shows isotopic compositions of samples collected prior to the initiation of the pump test, relative to the global meteoric water line (Craig, 1961). The isotopic

TABLE IV

OXYGEN[18] AND DEUTERIUM VALUES FOR WATER SAMPLES COLLECTED IN MARCH AND AUGUST 1990 (RELATIVE TO SMOW)

Well ID	Sample Date	$\delta^{18}O$ (per mil)	δD (per mil)
19	03/05/90	-10.6	-78.0
	03/11/90	-12.9	-99.0
	08/10/90	-12.2	-94.0
	08/13/90	-12.5	-100.0
	08/16/90	-12.7	-102.0
	08/19/90	-12.8	-102.0
	08/22/90	-13.5	-106.0
	08/25/90	-13.6	-106.0
	08/29/90	-13.9	-109.0
13	03/05/90	-11.5	-84.0
	03/12/90	-13.2	-100.0
17	03/05/90	-11.5	-81.0
	03/12/90	-12.8	-98.0
1	03/02/90	-9.2	-71.0
	03/14/91	-11.4	-85.0
2	03/06/90	-10.2	-71.0
	03/14/90	-10.1	-75.0
18	03/05/90	-10.0	-73.0
	03/12/90	-10.0	-77.0
12	03/05/90	-9.7	-69.0
	03/11/90	-9.4	-68.0
3	03/02/90	-9.3	-68.5
4	03/02/90	-10.2	-67.5
	03/14/90	-8.3	-68.0
5	03/02/90	-9.8	-72.0
	03/09/90	-10.2	-75.0
9	03/02/90	-9.3	-70.0
	03/09/90	-9.8	-68.0
10	03/02/90	-8.0	-65.0

compositions of samples from the aquifer and the Sandy River form a cluster along the meteoric water line. The water of the Columbia River is significantly depleted in the heavy isotopes relative to local waters. The isotopic composition of Blue Lake appears to represent a point on an evaporation trajectory (Craig, 1961; Domenico and Schwartz, 1990) origi-



<u>Figure 12.</u> Initial composition of oxygen^{18} and deuterium before pumping.

nating from the cluster. Well 10, a shallow well adjacent to Blue Lake, has a water sample isotopic composition which falls along the Blue Lake evaporation trajectory. These initial values establish the isotopic signatures which characterize the different water sources.

Figure 13 shows initial and subsequent isotopic compositions in selected wells. All of these water samples show a significant shift in isotopic composition after

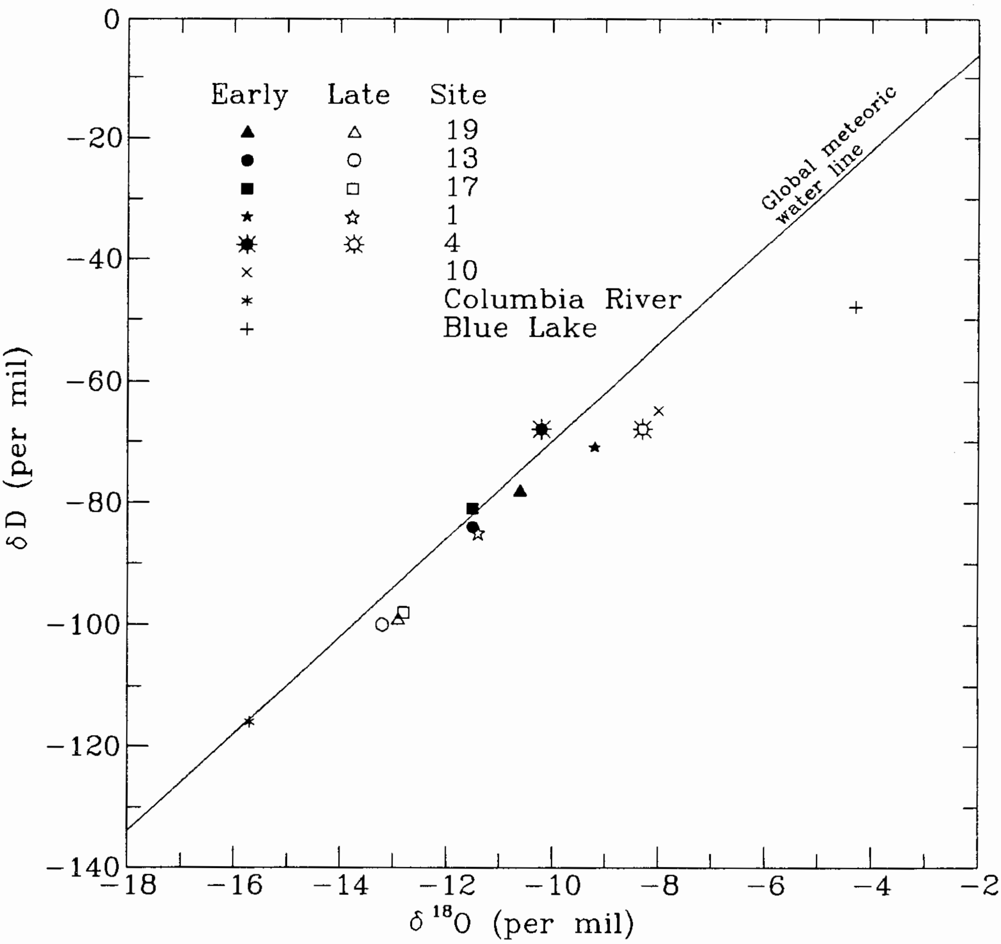


Figure 13. Initial vs. late compositions of oxygen^{18} and deuterium for selected locations.

pumping started. All of those which shifted toward the Columbia River are from wells proximal to the river. The sample which shifted in the general direction of Blue Lake is from well 4, located closer to Blue Lake, and suggests that the pumping drew the aquifer - Blue Lake transition zone closer to that well.

Assuming that the initial contribution of the river to the well is zero, and the isotopic composition of the Columbia River is constant, the percent contribution of water from the Columbia River to the pumping wells can be estimated using simple mixing theory. The relationship is

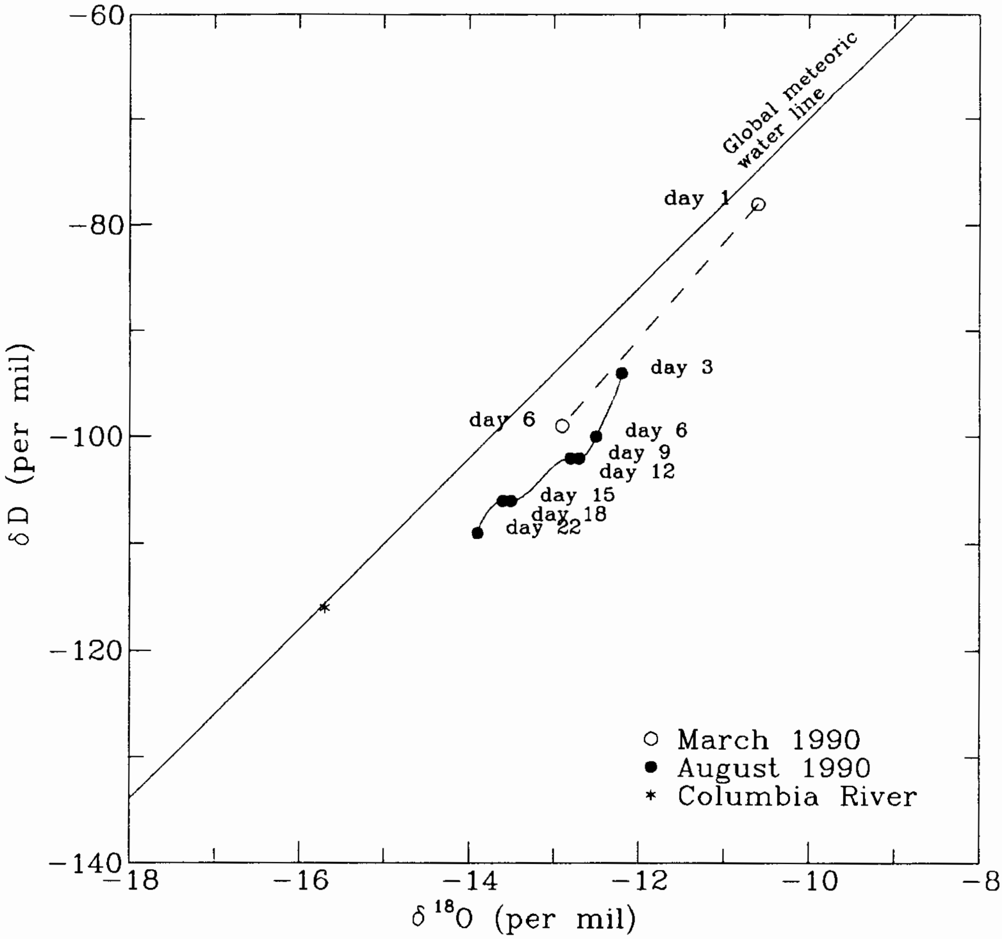
$$PR_{\upsilon} = 100(C_{\iota}-C_{\upsilon})/(C_{\iota}-CR) \quad (7)$$

where PR_{υ} is the percent river contribution at time t, C_{ι} is the initial composition of the groundwater at the well, C_{υ} is the composition of the well water at time t, and CR is the composition of the Columbia River.

The Sandy River is a relatively local drainage and the river water is representative of local meteoric water. The isotopic compositions of aquifer water samples are homogeneous as shown by the clustering in Figure 12. The isotopic composition of the Sandy River falls within this same cluster, indicating the aquifer water is of local origin. The Columbia River is a regional river which drains approximately 622,600 km^2. This drainage basin is inland to the north and east of the study area. The depleted isotopic composition of the Columbia River is characteristic of higher latitudes and inland regions (Domenico and Schwartz, 1990). The isotopic composition of the Columbia River is a composite of many sources and any one source is assumed to have an insignificant effect. Therefore the isotopic composition of the Columbia River is assumed to be constant.

Calculations were made using equation 7 based on these assumptions. Discharge from well 19 showed the largest percent contribution of river water with about 50% after six days. Well 13 had a 45% contribution from river water and well 17 had a 38 percent contribution after seven days. Water sampled from observation well 1 two days after pumping stopped showed a 33% contribution of river water. Although the δD value in observation well 4 remained constant, the $\delta^{18}O$ value shows a 2 per mil enrichment, suggesting about a 28% contribution of water from Blue Lake. The constant δD value at well 4 suggests that enough Columbia River water influenced the sample to hold the value steady. The amount of Columbia River water was probably relatively small, less than 10%.

The results of the analysis of samples collected in August (well 19) are shown in Figure 14 with data from March for the same well superimposed on it. As in March, the isotopic composition shifted toward the composition of the Columbia River. Although a sample was not collected prior to pumping in August, a comparison of data from day 6 for August and March shows very similar compositions. One notable difference is that the August data are slightly enriched in $\delta^{18}O$ values compared to March data. Although Blue Lake was not sampled during August, it is not unreasonable to assume a seasonal enrichment in heavy isotopes. The shift in the August data suggests a small contribution of Blue Lake water, probably less than 10%. An estimate of percent contribution from the river can be calculated based on the assumptions that the isotopic composition of the



<u>Figure 14.</u> Oxygen^{18} and deuterium compositions with respect to time for well 19.

Columbia River is nearly constant and that the initial isotopic composition of water in well 19 is nearly identical to that of March. The estimated contribution is calculated to be about 72% water from the Columbia River after 22 days of pumping.

Figures 15 and 16 show the isotopic values of $\delta^{18}O$ and δD with respect to time. The isotopic composition of well 19 water did not reach a point of equilibrium after 22 days

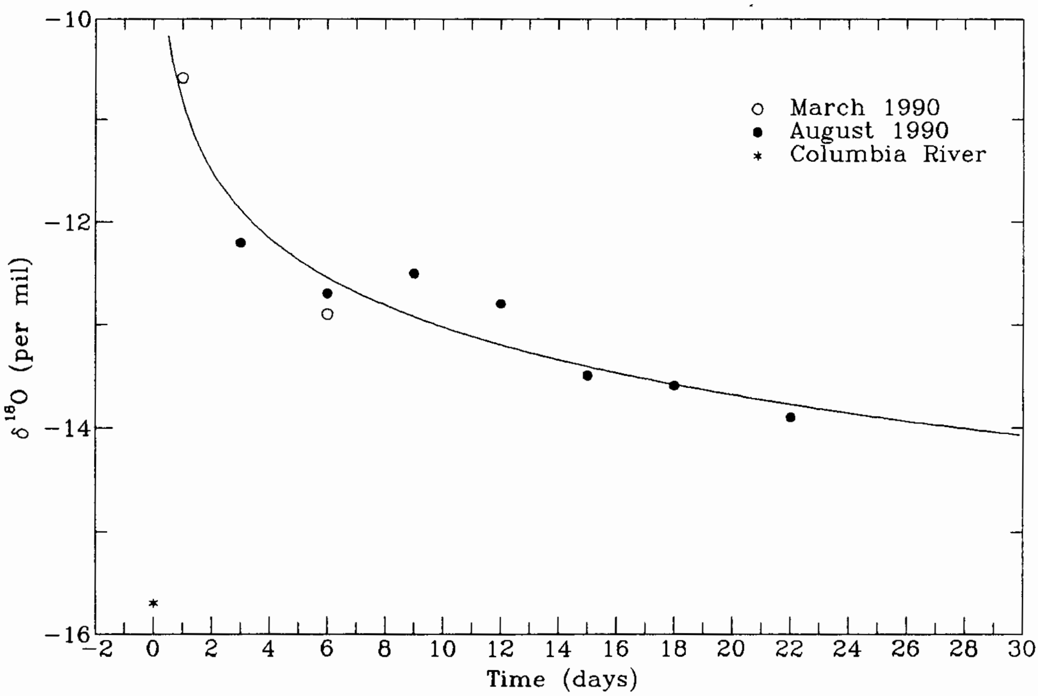


Figure 15. Oxygen^{18} vs. time, well 19.

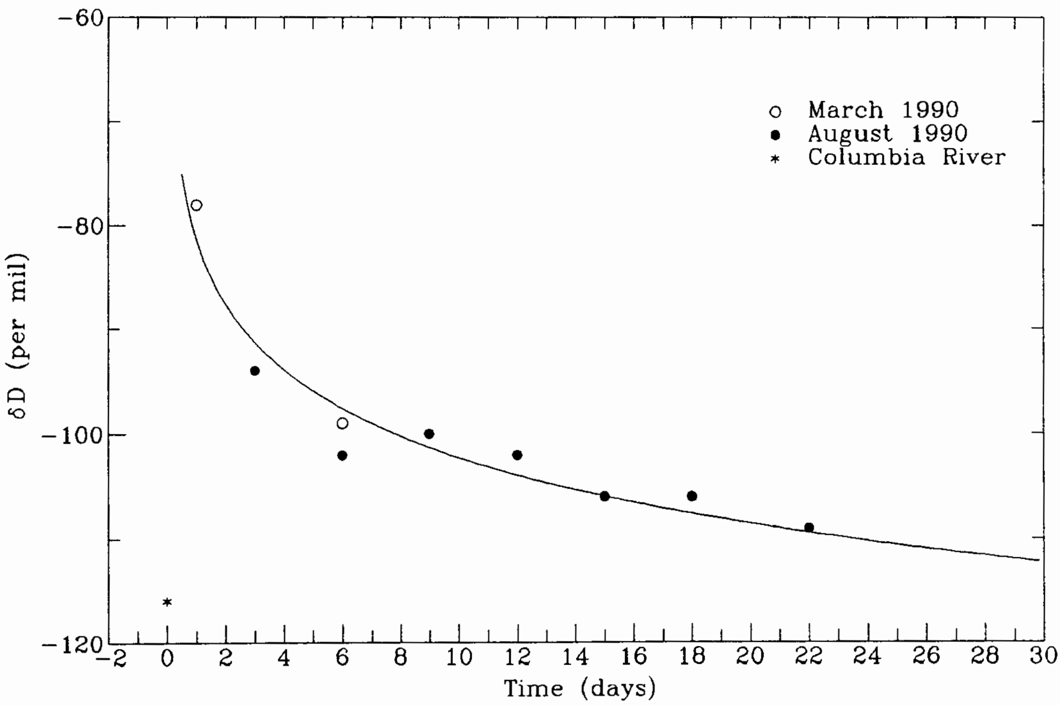


Figure 16. Deuterium vs. time, well 19.

of pumping. It is assumed that the isotopic composition will reach an equilibrium point at some point in time. By evaluating the components separately and projecting the trends with respect to time, a range of percent contribution can be established using the same relationship outlined earlier. These data can then be combined to give an estimated contribution at the projected point of equilibrium.

The trend of the data appears to be exponential, therefore an exponential best fit line was applied to the data and projected beyond 22 days. Equilibrium was arbitrarily chosen as the point at which the change is less than 0.3% of the isotopic value for the same period of time for both components. Using these parameters, a range of 73% to 94% is estimated. By using $\delta^{18}O$ and δD values from this equilibrium point, an estimated contribution can be calculated. Using these projected values a contribution of about 82% water from the Columbia River can be expected after 30 days of pumping.

CHAPTER IV

WATER LEVEL ANALYSIS

METHODS OF INVESTIGATION

Water levels in the Blue Lake area were monitored to determine the relationships of the Blue Lake gravel aquifer, Blue Lake, and the Columbia River. Barometric pressure and precipitation were also monitored.

The U.S.G.S. supplied a Campbell Scientific Incorporated model CR21 digital recorder for recording the water level in the aquifer. It utilized a float and counterweight attached to a ten turn precision linear potentiometer. The circumference of the pulley on the potentiometer was 30.5 centimeters, giving the apparatus a 3 meter range of motion for water levels. The recorder was programmed to record the instantaneous water level at 30 minute intervals. The potentiometer has a rated accuracy of $\pm$1.0%. The sensitivity of the apparatus was 6 millimeters. A frame was constructed to which the potentiometer apparatus was mounted. The frame was clamped to the well casing and the digital recorder enclosed in an airtight container. The entire assembly fit inside the well vault.

A water level recorder was installed in well 6 (see Figure 2 for location) in October, 1990. An additional recorder was installed in well 4 in January, 1991. Both recorders monitored water levels continuously until April, 1991 when they were removed. Both sites were visited semi-monthly to download data and manually measure the water level with a steel tape. The difference between actual and recorded water levels was calculated and used as a correction factor for the recorded data. Elevations at the top of the wells had been previously surveyed by U.S.G.S. personnel and reference the National Geodetic Vertical Datum of 1929.

The water stage in the Columbia River was obtained from the U.S.G.S. in 30 minute intervals from October, 1990 until April, 1991. The source of the data is a water stage recorder located on the Columbia River at Washougal, Washington (river mile 122.9). The datum for this recorder is along a variable Columbia River datum. Blue Lake is adjacent to river mile 118.

A microbarograph located at the U.S.G.S. in Portland, Oregon was the source of barometric pressure data. The microbarograph is a drum recorder which monitors barometric pressure continuously. The paper record was digitized to convert it to digital format in 30 minute intervals from October, 1990 until April, 1991. The microbarograph was monitored and found to have a timing error of no more than 10 minutes per week. Correction of barometric pressure for altitude was unnecessary because absolute magnitude was not used.

Values for precipitation were obtained from the National Weather Service in digital format. These were daily totals as measured at the Portland International Airport.

The water level in Blue Lake was not recorded. It is generally maintained at an elevation of 4.6 meters with a seasonal fluctuation of 0.3 meters (Hoffstetter, 1981).

A subset of data was selected from the overall data based on continuity. From this subset of data, water levels in the aquifer were cross-correlated with each other and with the Columbia River using the computer program CROSS. A listing of CROSS can be found in Appendix C. Precipitation and barometric pressure were examined visually.

RESULTS

Data for the month of February, 1991 were selected for analysis because they contain uninterrupted records of data for all five parameters, wells 4 and 6 water levels, Columbia River water level, barometric pressure, and precipitation. The data can be found in Appendix B. A correction factor was obtained by calculating the difference in recorded and measured water levels in the aquifer. This correction factor was applied to the aquifer water level data to obtain true water level elevations.

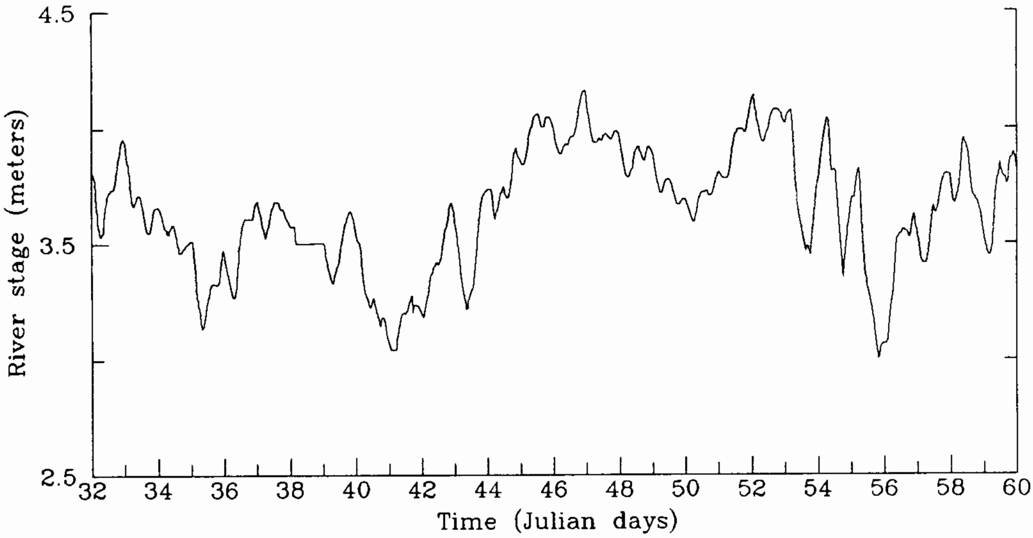
DISCUSSION

The data are shown in Figures 17, 18, 19, 20, and 21.

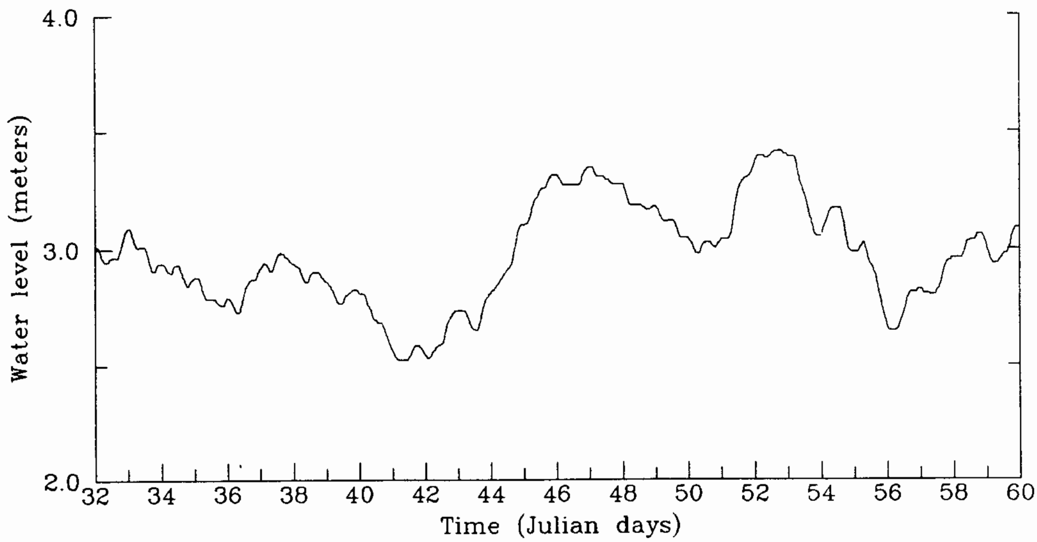
These figures show that there are some very obvious trends among the data sets. The strongest obvious effect on aquifer water levels is the Columbia River stage.

The Columbia River stage shows a considerable amount of fluctuation and periodicity (Figure 17). The period of the fluctuation is about two cycles per day, suggesting a strong tidal effect. The same tidal fluctuations can be seen to a lesser degree in the water level data of well 6 (Figure 18). Water level data of well 4 does not appear to be strongly influenced by tides (Figure 19). Instead it has the appearance of an averaged Columbia River stage. Any effects of local barometric pressure (Figure 20) and precipitation (Figure 21) appear to be overshadowed by the influence of the Columbia River.

The data for water levels in the aquifer and the Columbia River were analyzed using cross-correlation to determine the strength of the relationship and the offset in time phase. Figure 22 shows a plot of the correlation coefficient for water levels in well 6 and the Columbia River. The correlation for this relationship is 0.96. The significance of the correlation coefficient can be tested statistically to determine the independence of the two data sets. The null hypothesis states that the two data sets are independent, random sequences (Davis, 1986). Based on the standard t-test, the null hypothesis is rejected for a significance level of 0.1%. Therefore, the two data sets



<u>Figure 17.</u> **Columbia River stage, February, 1991.**



<u>Figure 18.</u> **Water levels in well 6, February, 1991.**

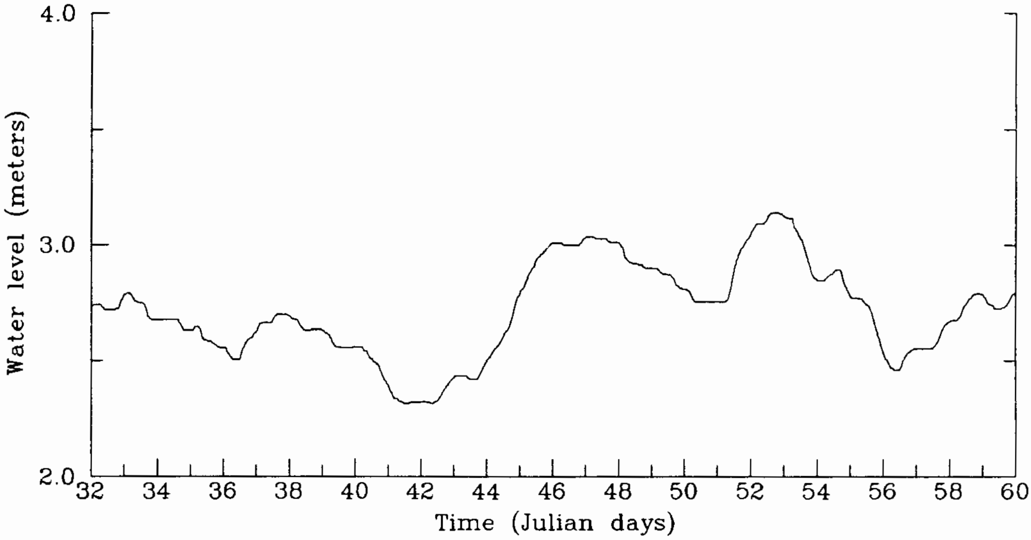


Figure 19. Water levels in well 4, February, 1991.

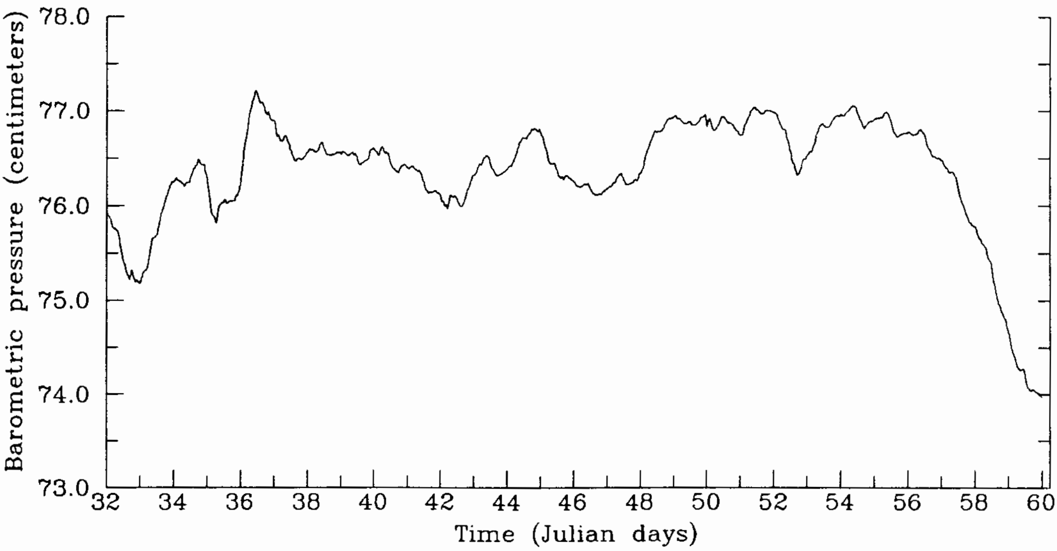


Figure 20. Barometric pressure, February, 1991.

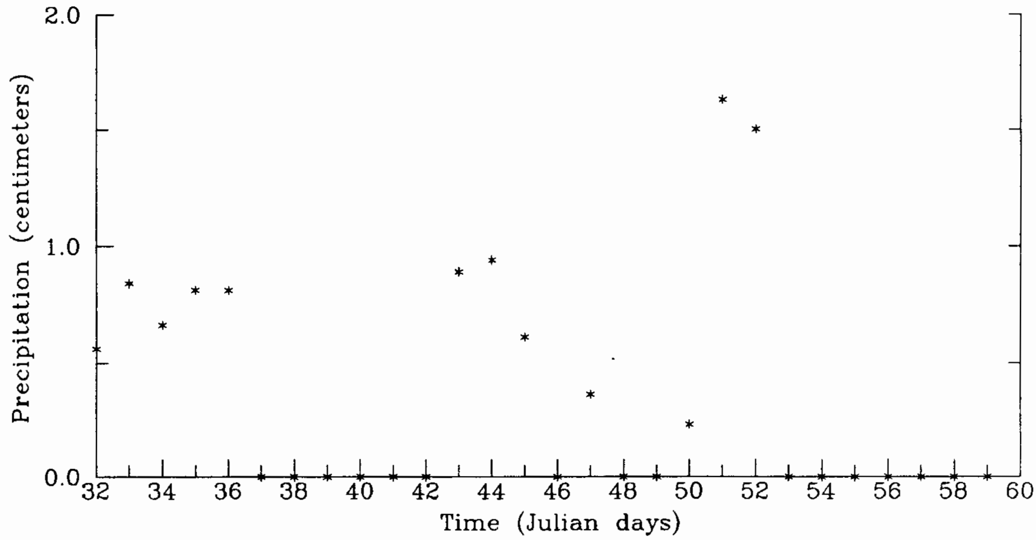


Figure 21. Precipitation, February, 1991.

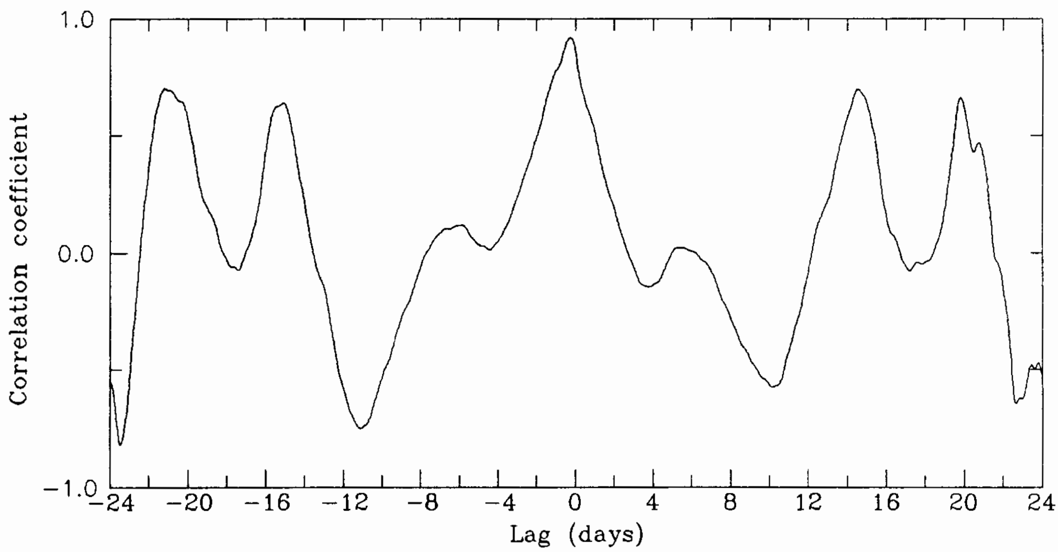


Figure 22. Correlogram for water levels in well 6 and the Columbia River.

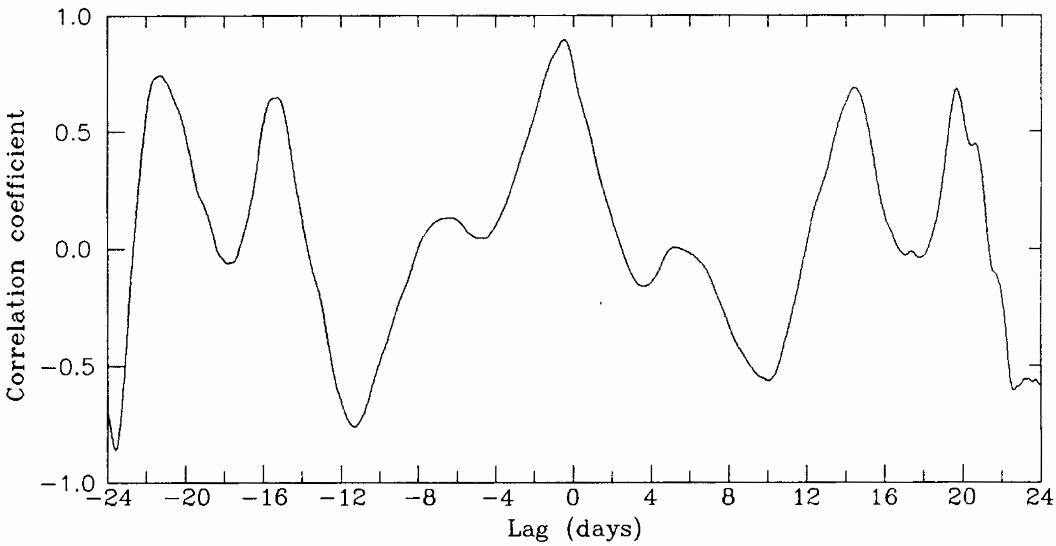
are not independent and the correlation is substantiated. The lag time to maximum correlation is about 3.5 hours and is indicative of the time it takes for the aquifer to respond to the river at well 6.

Figure 23 shows the correlation coefficients for water levels in well 4 and the Columbia River. The strength of this correlation is 0.94. Again, the statistical test substantiates this correlation as valid. The lag time for this maximum correlation is about 9 hours.

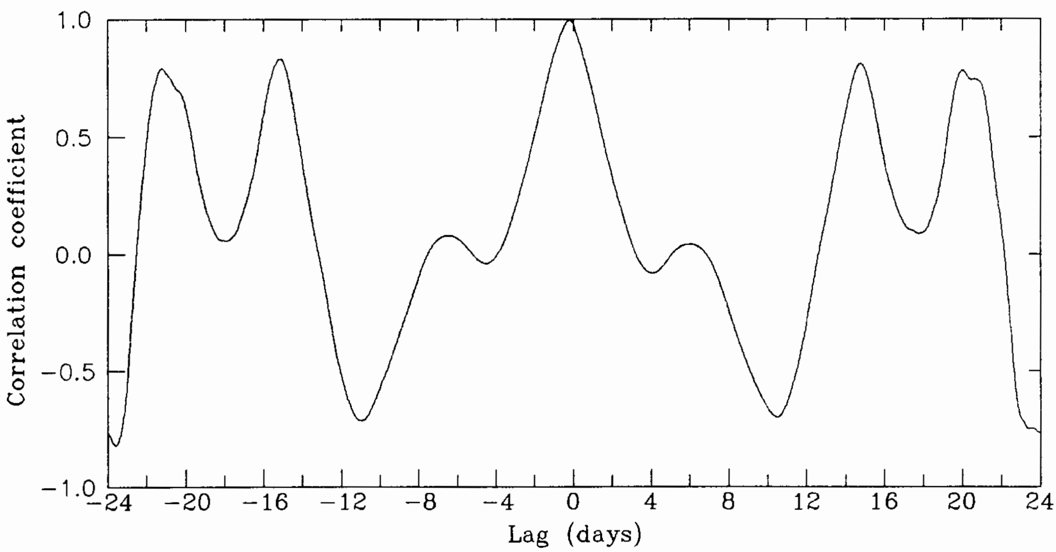
Figure 24 is a correlogram of water levels in wells 4 and 6. The correlation of these two data sets is 0.99. From the statistical test, there is no evidence to suggest independence of the data sets, substantiating the strong correlation. This strong correlation suggests that the variations in the two data sets are nearly identical except for the lag and magnitude. The lag between well 4 and 6 is about 3.5 hours.

Lag times calculated include a correction for the difference in location of the river stage recorder. A correction factor of 20 minutes (L. Hubbard, personal communication) per mile was used to correct time lag estimates.

A comparison of figures 17, 18 and 19 shows that the magnitude of the response of the aquifer to river stage decreases with distance. The small changes in river stage of less than 0.1 meters are not seen in the aquifer. Larger stage changes of 0.5 meters are translated to 0.13 meters in



<u>Figure 23.</u> Correlogram for water levels in well 4 and the Columbia River.



<u>Figure 24.</u> Correlogram for water levels in well 4 and 6.

well 6 and to 0.07 meters in well 4. Well 6 is about 150 meters from the Columbia River and well 4 is about 600 meters away. The magnitude of the response of the aquifer to the river is indeed inversely proportional to distance between them.

The relationship of water levels in Blue Lake and the aquifer has been shown when the level of the lake was lowered 3 meters in October, 1981 to alleviate a milfoil problem (Conley, 1981). The normal water level of Blue Lake is higher than in the aquifer and the subsequent lowering of the water level brought it down to an elevation equivalent to or lower than the water level in the aquifer. It was thought that the lake water level would recover naturally but this did not occur (W.D. McFarland, personal communication). The Troutdale sandstone on the south shore of the lake was assumed to be a source of recharge. If it is a source of recharge, it was insufficient to recover the water level in Blue Lake. In the October 1982 water was pumped into Blue Lake from well 12 and the Blue Lake water level was recovered. This event provides evidence that under static conditions, neither of the water sources has a significant effect on the other.

CHAPTER V

CONCLUSIONS

The question of whether a hydraulic connection exists between the Blue Lake gravel aquifer and the Columbia River has been evaluated. The northern extent of the aquifer was shown to be in contact with the river along the south shore of the river. It is suggested that a hydraulic conduit exists in this area. The correlation of water levels between the river and aquifer shows that there is a definite response of the aquifer to the changes in river stage. This correlation does not provide evidence for exchange and mixing of water between the two. The evaluation of stable isotopic compositions shows that under stressed conditions, water from the Columbia River enters the aquifer and penetrates at least as far as the pumping wells.

On the basis of these evidences, it is concluded that the Blue Lake gravel aquifer has a strong hydraulic connection with the Columbia River. Under stressed conditions the contribution of water from the river was estimated to be 72% and is significant. Under static conditions there is no evidence to suggest any significant mixing of waters. The hydraulic boundary between the river and the aquifer must be between the south shore of the Columbia River and the well closest to it (well 6). This delineates a zone about 122 meters wide within which the boundary exists.

The hydraulic relationship between the aquifer and Blue Lake was also evaluated. Mapping of the aquifer sediments showed no evidence to suggest a hydraulic connection. Furthermore, analysis of water levels under static conditions showed no influence. However, analysis of isotopic compositions under stressed conditions shows a small influence of Blue Lake water.

These evidences indicate that there is a weak hydraulic connection between the aquifer and Blue Lake, but only under stressed conditions. Under all other circumstances Blue Lake is considered to be isolated from the aquifer.

A need for further research in this area is indicated by the lack of information about the eastern and northern extent of the aquifer. Moreover, the hydraulic relationship of the aquifer to adjacent hydrogeologic units is not defined. Additionally but not lastly, the absence of Blue Lake and Columbia River waters in samples taken under static conditions indicates that other possible sources of recharge to the aquifer need to be explored.

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APPENDIX A

WELL IDENTIFICATION CROSS REFERENCE

WELL ID	WELL LOCATION NUMBER	U.S.G.S. ID	CITY OF PORTLAND ID
1	IN/3E-21acab2	6269	21ac(m1)
2	IN/3E-21acab3	6269	21ac(m1)
3	IN/3E-21accd2	6267	21ac(m2)
4	IN/3E-21accd3	6267	21ac(m2)
5	IN/3E-21accd4	6267	21ac(m2)
6	IN/3E-21bdba1	6271	13TW
7	IN/3E-21bcbc1	6272	19TW
8	IN/3E-21adbc1	6266	18TW
9	IN/3E-21dbbb3	6268	21db(m3)
10	IN/3E-21dbbb6	6268	21db(m3)
11	IN/3E-21cbcd1	6273	-
12	IN/3E-21acca2	6270	12PW
13	IN/3E-21bdba2	6264	13PW
14	IN/3E-20adbc2	6245	14PW
15	IN/3E-21bd1	-	21bd(p2)
16	IN/3E-21ac3	-	21ac(p5)
17	IN/3E-21acbb1	6265	17PW
18	IN/3E-21adbc2	6262	18PW
19	IN/3E-21bcbc2	6263	19PW
20	IN/3E-21adaa1	900260	21ad(p2)
21	IN/3E-ad1	-	21ad(p1)
22	IN/3E-ddc	6278	-
23	IN/3E-21ac1	-	21ac1
24	IN/3E-21acc	900192	21ac2
25	IN/3E-21addc1	900261	21ad(p3)
26	IN/3E-21dbbb2	900268	21db(p1)
27	IN/3E-21dbbc1	900269	21db(p2)
28	IN/3E-21dbcc2	6274	-
29	IN/3E-21dbcc1	900271	-
30	IN/3E-21cbcd2	900266	-
31	IN/3E-21dcab	6277	-
32	IN/3E-21dd	-	21dd

APPENDIX B

HYDROLOGIC AND METEOROLOGIC DATA

RIVER STAGE, WATER LEVELS, AND BAROMETRIC PRESSURE
FOR FEBRUARY, 1991

JULIAN DAY	TIME (MINUTES)	COLUMBIA RIVER STAGE (METERS)	WELL 6 WATER LEVEL (METERS)	WELL 9 WATER LEVEL (METERS)	BAROMETRIC PRESSURE (CENTIMETERS)
32	30	3.813	3.011	2.731	75.954
32	60	3.807	3.011	2.733	75.905
32	90	3.801	3.011	2.734	75.900
32	120	3.792	3.011	2.736	75.895
32	150	3.786	3.011	2.739	75.888
32	180	3.773	3.005	2.739	75.870
32	210	3.716	2.999	2.739	75.857
32	240	3.661	2.990	2.739	75.819
32	270	3.627	2.978	2.739	75.791
32	300	3.594	2.969	2.739	75.773
32	330	3.566	2.960	2.739	75.766
32	360	3.551	2.957	2.739	75.761
32	390	3.536	2.950	2.739	75.761
32	420	3.533	2.947	2.739	75.766
32	450	3.533	2.947	2.736	75.753
32	480	3.539	2.947	2.734	75.740
32	510	3.545	2.947	2.728	75.745
32	540	3.545	2.947	2.728	75.705
32	570	3.603	2.947	2.725	75.659
32	600	3.630	2.947	2.722	75.644
32	630	3.652	2.947	2.716	75.568
32	660	3.667	2.954	2.716	75.537
32	690	3.679	2.960	2.716	75.486
32	720	3.700	2.960	2.716	75.461
32	750	3.709	2.963	2.716	75.420
32	780	3.719	2.963	2.716	75.408
32	810	3.725	2.966	2.717	75.382
32	840	3.728	2.966	2.717	75.382
32	870	3.737	2.966	2.717	75.331
32	900	3.737	2.966	2.717	75.288
32	930	3.737	2.966	2.717	75.265
32	960	3.737	2.963	2.717	75.263
32	990	3.737	2.963	2.717	75.242
32	1020	3.740	2.963	2.717	75.222
32	1050	3.752	2.963	2.717	75.258
32	1080	3.770	2.978	2.717	75.268
32	1110	3.795	2.984	2.722	75.319
32	1140	3.816	2.990	2.722	75.301
32	1170	3.837	3.008	2.722	75.278
32	1200	3.862	3.014	2.722	75.230
32	1230	3.883	3.030	2.725	75.225
32	1260	3.904	3.042	2.733	75.199
32	1290	3.926	3.057	2.746	75.199
32	1320	3.938	3.066	2.752	75.220
32	1350	3.944	3.075	2.761	75.214
32	1380	3.956	3.075	2.761	75.194
32	1410	3.953	3.082	2.766	75.202
32	1440	3.950	3.082	2.774	75.181
33	30	3.944	3.088	2.783	75.181
33	60	3.935	3.088	2.783	75.187
33	90	3.901	3.088	2.783	75.225
33	120	3.874	3.088	2.786	75.255
33	150	3.856	3.085	2.789	75.278
33	180	3.840	3.066	2.789	75.298
33	210	3.822	3.060	2.789	75.306
33	240	3.798	3.048	2.789	75.314
33	270	3.755	3.039	2.789	75.321
33	300	3.722	3.027	2.783	75.324
33	330	3.697	3.024	2.783	75.334
33	360	3.679	3.018	2.777	75.367
33	390	3.670	3.011	2.774	75.397
33	420	3.664	3.008	2.768	75.451
33	450	3.664	3.008	2.768	75.486
33	480	3.673	3.008	2.757	75.522
33	510	3.679	3.008	2.755	75.565
33	540	3.685	3.011	2.754	75.606
33	570	3.697	3.011	2.754	75.654
33	600	3.709	3.011	2.751	75.662

33	630	3.709	3.011	2.748	75.667
33	660	3.709	3.011	2.749	75.674
33	690	3.706	3.011	2.748	75.677
33	720	3.700	3.011	2.748	75.684
33	750	3.685	3.011	2.748	75.695
33	780	3.673	3.005	2.748	75.712
33	810	3.658	2.999	2.748	75.758
33	840	3.639	2.990	2.746	75.783
33	870	3.624	2.981	2.746	75.814
33	900	3.609	2.969	2.742	75.860
33	930	3.587	2.957	2.733	75.903
33	960	3.575	2.947	2.729	75.941
33	990	3.560	2.932	2.723	75.951
33	1020	3.548	2.923	2.701	75.971
33	1050	3.548	2.911	2.690	76.002
33	1080	3.548	2.908	2.687	76.025
33	1110	3.548	2.908	2.684	76.045
33	1140	3.557	2.908	2.679	76.083
33	1170	3.572	2.908	2.679	76.098
33	1200	3.587	2.908	2.676	76.116
33	1230	3.609	2.914	2.676	76.142
33	1260	3.627	2.923	2.676	76.162
33	1290	3.639	2.932	2.676	76.192
33	1320	3.648	2.935	2.676	76.210
33	1350	3.655	2.938	2.676	76.220
33	1380	3.655	2.938	2.676	76.248
33	1410	3.658	2.938	2.676	76.251
33	1440	3.658	2.938	2.676	76.248
34	30	3.658	2.938	2.676	76.251
34	60	3.658	2.938	2.676	76.258
34	90	3.652	2.938	2.676	76.261
34	120	3.645	2.938	2.676	76.276
34	150	3.636	2.935	2.676	76.294
34	180	3.624	2.929	2.676	76.271
34	210	3.615	2.926	2.676	76.266
34	240	3.603	2.917	2.676	76.263
34	270	3.587	2.911	2.676	76.256
34	300	3.581	2.908	2.676	76.251
34	330	3.572	2.905	2.676	76.256
34	360	3.566	2.905	2.676	76.246
34	390	3.563	2.902	2.676	76.238
34	420	3.557	2.899	2.676	76.233
34	450	3.545	2.899	2.676	76.220
34	480	3.542	2.899	2.676	76.203
34	510	3.542	2.905	2.676	76.208
34	540	3.557	2.917	2.676	76.218
34	570	3.566	2.926	2.676	76.236
34	600	3.569	2.929	2.676	76.241
34	630	3.578	2.932	2.676	76.243
34	660	3.581	2.932	2.676	76.241
34	690	3.581	2.932	2.676	76.241
34	720	3.581	2.932	2.676	76.261
34	750	3.569	2.935	2.676	76.297
34	780	3.560	2.935	2.676	76.314
34	810	3.545	2.932	2.676	76.332
34	840	3.530	2.923	2.676	76.345
34	870	3.511	2.914	2.676	76.363
34	900	3.496	2.905	2.676	76.383
34	930	3.481	2.899	2.676	76.391
34	960	3.459	2.886	2.667	76.406
34	990	3.459	2.880	2.661	76.424
34	1020	3.459	2.877	2.656	76.429
34	1050	3.463	2.862	2.650	76.472
34	1080	3.466	2.856	2.641	76.484
34	1110	3.472	2.853	2.641	76.482
34	1140	3.475	2.844	2.635	76.464
34	1170	3.478	2.844	2.629	76.449
34	1200	3.481	2.844	2.629	76.439
34	1230	3.484	2.844	2.629	76.431
34	1260	3.490	2.853	2.629	76.426
34	1290	3.493	2.856	2.629	76.426
34	1320	3.496	2.862	2.629	76.429
34	1350	3.499	2.868	2.629	76.418
34	1380	3.502	2.868	2.629	76.373
34	1410	3.508	2.874	2.629	76.335
34	1440	3.511	2.877	2.629	76.317
35	30	3.514	2.880	2.629	76.261

35	60	3.511	2.880	2.629	76.203
35	90	3.511	2.880	2.630	76.167
35	120	3.505	2.880	2.630	76.116
35	150	3.456	2.880	2.630	76.058
35	180	3.429	2.880	2.635	76.002
35	210	3.405	2.880	2.641	75.949
35	240	3.377	2.877	2.644	75.910
35	270	3.310	2.865	2.644	75.898
35	300	3.264	2.856	2.644	75.890
35	330	3.252	2.844	2.644	75.883
35	360	3.228	2.833	2.644	75.855
35	390	3.213	2.818	2.641	75.837
35	420	3.197	2.812	2.638	75.816
35	450	3.158	2.806	2.635	75.844
35	480	3.149	2.798	2.621	75.910
35	510	3.133	2.792	2.609	75.946
35	540	3.136	2.787	2.597	75.989
35	570	3.136	2.787	2.597	76.012
35	600	3.149	2.787	2.588	76.010
35	630	3.170	2.787	2.588	76.027
35	660	3.179	2.787	2.586	76.032
35	690	3.200	2.787	2.586	76.027
35	720	3.228	2.787	2.586	76.030
35	750	3.252	2.787	2.583	76.048
35	780	3.258	2.787	2.583	76.063
35	810	3.271	2.787	2.583	76.063
35	840	3.295	2.787	2.583	76.043
35	870	3.313	2.787	2.583	76.022
35	900	3.313	2.787	2.583	76.020
35	930	3.322	2.787	2.583	76.025
35	960	3.322	2.781	2.576	76.040
35	990	3.322	2.777	2.574	76.048
35	1020	3.322	2.774	2.574	76.048
35	1050	3.322	2.771	2.574	76.050
35	1080	3.322	2.766	2.568	76.050
35	1110	3.319	2.765	2.566	76.048
35	1140	3.319	2.761	2.566	76.045
35	1170	3.319	2.761	2.562	76.045
35	1200	3.319	2.760	2.559	76.050
35	1230	3.322	2.760	2.556	76.058
35	1260	3.335	2.760	2.556	76.096
35	1290	3.374	2.760	2.553	76.103
35	1320	3.399	2.760	2.553	76.109
35	1350	3.417	2.769	2.553	76.121
35	1380	3.438	2.775	2.553	76.149
35	1410	3.459	2.781	2.553	76.185
35	1440	3.472	2.789	2.553	76.225
36	30	3.459	2.789	2.553	76.271
36	60	3.444	2.789	2.553	76.330
36	90	3.420	2.789	2.553	76.378
36	120	3.408	2.789	2.553	76.441
36	150	3.392	2.786	2.553	76.515
36	180	3.374	2.781	2.537	76.586
36	210	3.356	2.774	2.530	76.637
36	240	3.341	2.765	2.530	76.680
36	270	3.328	2.758	2.524	76.741
36	300	3.313	2.754	2.518	76.782
36	330	3.301	2.746	2.515	76.825
36	360	3.289	2.737	2.515	76.901
36	390	3.274	2.733	2.505	76.947
36	420	3.267	2.729	2.504	76.975
36	450	3.264	2.728	2.504	76.990
36	480	3.264	2.728	2.504	77.018
36	510	3.271	2.728	2.504	77.033
36	540	3.286	2.728	2.504	77.089
36	570	3.310	2.734	2.504	77.102
36	600	3.325	2.746	2.504	77.132
36	630	3.386	2.758	2.504	77.147
36	660	3.426	2.763	2.504	77.175
36	690	3.469	2.778	2.504	77.201
36	720	3.502	2.793	2.502	77.201
36	750	3.527	2.810	2.507	77.170
36	780	3.551	2.816	2.515	77.147
36	810	3.566	2.830	2.525	77.122
36	840	3.581	2.838	2.537	77.099
36	870	3.591	2.841	2.545	77.081
36	900	3.597	2.847	2.551	77.081

36	930	3.600	2.850	2.554	77.086
36	960	3.606	2.853	2.563	77.084
36	990	3.609	2.859	2.569	77.074
36	1020	3.609	2.865	2.574	77.059
36	1050	3.609	2.865	2.580	77.031
36	1080	3.609	2.868	2.583	77.015
36	1110	3.606	2.871	2.588	76.972
36	1140	3.606	2.871	2.589	76.962
36	1170	3.606	2.871	2.592	76.959
36	1200	3.606	2.871	2.595	76.970
36	1230	3.606	2.871	2.595	76.980
36	1260	3.606	2.871	2.597	76.959
36	1290	3.609	2.880	2.600	76.934
36	1320	3.624	2.883	2.608	76.911
36	1350	3.642	2.896	2.611	76.898
36	1380	3.658	2.902	2.614	76.888
36	1410	3.667	2.908	2.618	76.896
36	1440	3.673	2.908	2.618	76.896
37	30	3.679	2.917	2.623	76.886
37	60	3.685	2.920	2.630	76.876
37	90	3.670	2.926	2.635	76.840
37	120	3.648	2.929	2.644	76.779
37	150	3.633	2.935	2.653	76.733
37	180	3.630	2.941	2.658	76.718
37	210	3.612	2.941	2.658	76.733
37	240	3.594	2.938	2.658	76.744
37	270	3.575	2.938	2.658	76.711
37	300	3.569	2.938	2.661	76.688
37	330	3.560	2.932	2.661	76.675
37	360	3.548	2.926	2.661	76.672
37	390	3.536	2.923	2.661	76.680
37	420	3.523	2.917	2.661	76.685
37	450	3.530	2.908	2.661	76.723
37	480	3.551	2.908	2.661	76.731
37	510	3.563	2.908	2.661	76.736
37	540	3.575	2.908	2.661	76.731
37	570	3.597	2.914	2.661	76.726
37	600	3.615	2.920	2.661	76.690
37	630	3.633	2.932	2.661	76.670
37	660	3.639	2.941	2.661	76.660
37	690	3.655	2.947	2.662	76.629
37	720	3.655	2.957	2.667	76.589
37	750	3.664	2.960	2.675	76.578
37	780	3.673	2.969	2.679	76.556
37	810	3.682	2.975	2.685	76.533
37	840	3.682	2.978	2.690	76.523
37	870	3.682	2.978	2.691	76.512
37	900	3.682	2.978	2.694	76.479
37	930	3.679	2.984	2.697	76.472
37	960	3.679	2.981	2.697	76.469
37	990	3.673	2.981	2.697	76.469
37	1020	3.658	2.981	2.697	76.477
37	1050	3.655	2.978	2.697	76.490
37	1080	3.648	2.972	2.697	76.500
37	1110	3.648	2.966	2.697	76.497
37	1140	3.648	2.966	2.697	76.492
37	1170	3.648	2.966	2.697	76.484
37	1200	3.645	2.963	2.697	76.482
37	1230	3.636	2.963	2.697	76.487
37	1260	3.624	2.957	2.697	76.487
37	1290	3.615	2.954	2.697	76.490
37	1320	3.606	2.947	2.697	76.502
37	1350	3.606	2.947	2.697	76.510
37	1380	3.600	2.944	2.694	76.517
37	1410	3.594	2.938	2.693	76.540
37	1440	3.581	2.938	2.691	76.553
38	30	3.575	2.938	2.690	76.558
38	60	3.575	2.935	2.690	76.561
38	90	3.575	2.935	2.685	76.578
38	120	3.575	2.929	2.682	76.591
38	150	3.575	2.929	2.679	76.594
38	180	3.575	2.926	2.679	76.578
38	210	3.575	2.926	2.679	76.578
38	240	3.575	2.923	2.679	76.584
38	270	3.536	2.920	2.676	76.584
38	300	3.499	2.917	2.676	76.566
38	330	3.499	2.908	2.676	76.561

38	360	3.499	2.899	2.676	76.566
38	390	3.499	2.893	2.667	76.561
38	420	3.499	2.883	2.661	76.558
38	450	3.499	2.877	2.658	76.571
38	480	3.499	2.871	2.653	76.576
38	510	3.499	2.865	2.649	76.586
38	540	3.499	2.859	2.644	76.622
38	570	3.499	2.859	2.640	76.639
38	600	3.499	2.859	2.638	76.647
38	630	3.499	2.859	2.635	76.657
38	660	3.499	2.859	2.630	76.665
38	690	3.499	2.862	2.630	76.660
38	720	3.499	2.871	2.630	76.624
38	750	3.499	2.883	2.630	76.589
38	780	3.499	2.890	2.630	76.576
38	810	3.499	2.896	2.630	76.561
38	840	3.499	2.896	2.629	76.540
38	870	3.499	2.902	2.630	76.538
38	900	3.499	2.902	2.630	76.535
38	930	3.499	2.902	2.630	76.535
38	960	3.502	2.902	2.630	76.530
38	990	3.502	2.902	2.632	76.525
38	1020	3.502	2.902	2.632	76.523
38	1050	3.502	2.902	2.632	76.523
38	1080	3.502	2.902	2.632	76.528
38	1110	3.502	2.902	2.632	76.538
38	1140	3.502	2.902	2.632	76.533
38	1170	3.502	2.899	2.633	76.535
38	1200	3.502	2.896	2.632	76.540
38	1230	3.502	2.890	2.632	76.545
38	1260	3.502	2.883	2.632	76.545
38	1290	3.502	2.880	2.632	76.551
38	1320	3.502	2.877	2.632	76.551
38	1350	3.502	2.871	2.632	76.553
38	1380	3.502	2.868	2.632	76.553
38	1410	3.502	2.862	2.633	76.548
38	1440	3.502	2.862	2.630	76.548
39	30	3.502	2.859	2.630	76.540
39	60	3.502	2.859	2.627	76.545
39	90	3.496	2.856	2.626	76.558
39	120	3.493	2.853	2.621	76.563
39	150	3.453	2.850	2.618	76.558
39	180	3.432	2.844	2.617	76.558
39	210	3.417	2.841	2.617	76.548
39	240	3.405	2.833	2.614	76.545
39	270	3.383	2.827	2.611	76.540
39	300	3.371	2.821	2.611	76.530
39	330	3.362	2.815	2.609	76.525
39	360	3.350	2.807	2.597	76.523
39	390	3.341	2.801	2.595	76.525
39	420	3.335	2.795	2.592	76.530
39	450	3.325	2.787	2.580	76.543
39	480	3.325	2.778	2.574	76.548
39	510	3.347	2.775	2.573	76.548
39	540	3.356	2.771	2.568	76.553
39	570	3.368	2.768	2.562	76.540
39	600	3.374	2.768	2.562	76.533
39	630	3.386	2.768	2.557	76.528
39	660	3.399	2.768	2.557	76.545
39	690	3.408	2.768	2.556	76.525
39	720	3.420	2.768	2.556	76.510
39	750	3.447	2.769	2.556	76.482
39	780	3.472	2.780	2.556	76.454
39	810	3.487	2.792	2.556	76.436
39	840	3.502	2.795	2.554	76.431
39	870	3.520	2.800	2.554	76.431
39	900	3.530	2.801	2.554	76.439
39	930	3.551	2.803	2.554	76.446
39	960	3.566	2.806	2.554	76.449
39	990	3.581	2.809	2.554	76.454
39	1020	3.591	2.812	2.554	76.459
39	1050	3.600	2.815	2.554	76.464
39	1080	3.609	2.815	2.554	76.467
39	1110	3.618	2.819	2.554	76.474
39	1140	3.630	2.819	2.554	76.477
39	1170	3.636	2.824	2.554	76.482
39	1200	3.642	2.824	2.554	76.490

39	1230	3.642	2.824	2.554	76.497
39	1260	3.636	2.824	2.554	76.545
39	1290	3.627	2.824	2.554	76.571
39	1320	3.615	2.824	2.554	76.586
39	1350	3.606	2.824	2.554	76.589
39	1380	3.600	2.821	2.556	76.589
39	1410	3.575	2.821	2.556	76.596
39	1440	3.560	2.818	2.556	76.609
40	30	3.542	2.812	2.556	76.604
40	60	3.527	2.809	2.556	76.584
40	90	3.514	2.809	2.556	76.568
40	120	3.508	2.809	2.556	76.556
40	150	3.505	2.809	2.556	76.556
40	180	3.496	2.809	2.556	76.540
40	210	3.484	2.809	2.556	76.525
40	240	3.466	2.806	2.556	76.530
40	270	3.417	2.801	2.556	76.553
40	300	3.380	2.793	2.556	76.573
40	330	3.353	2.783	2.556	76.599
40	360	3.331	2.771	2.551	76.614
40	390	3.307	2.761	2.544	76.617
40	420	3.289	2.755	2.542	76.606
40	450	3.280	2.749	2.542	76.558
40	480	3.274	2.746	2.542	76.553
40	510	3.258	2.740	2.542	76.553
40	540	3.252	2.729	2.528	76.553
40	570	3.240	2.720	2.524	76.551
40	600	3.225	2.710	2.519	76.545
40	630	3.222	2.704	2.513	76.543
40	660	3.222	2.697	2.509	76.543
40	690	3.228	2.696	2.505	76.505
40	720	3.240	2.696	2.504	76.472
40	750	3.249	2.696	2.505	76.449
40	780	3.261	2.696	2.505	76.424
40	810	3.258	2.684	2.493	76.406
40	840	3.246	2.685	2.493	76.391
40	870	3.228	2.685	2.492	76.385
40	900	3.222	2.684	2.492	76.378
40	930	3.203	2.685	2.487	76.378
40	960	3.188	2.684	2.487	76.370
40	990	3.179	2.684	2.483	76.360
40	1020	3.173	2.679	2.481	76.357
40	1050	3.155	2.673	2.473	76.355
40	1080	3.142	2.665	2.472	76.350
40	1110	3.158	2.658	2.463	76.350
40	1140	3.173	2.650	2.458	76.380
40	1170	3.179	2.643	2.451	76.396
40	1200	3.179	2.633	2.441	76.411
40	1230	3.179	2.629	2.434	76.411
40	1260	3.176	2.621	2.432	76.418
40	1290	3.167	2.612	2.426	76.421
40	1320	3.152	2.606	2.416	76.426
40	1350	3.136	2.597	2.412	76.434
40	1380	3.115	2.589	2.412	76.431
40	1410	3.100	2.582	2.402	76.418
40	1440	3.088	2.576	2.399	76.406
41	30	3.069	2.566	2.394	76.396
41	60	3.060	2.556	2.385	76.388
41	90	3.051	2.554	2.377	76.385
41	120	3.042	2.547	2.367	76.391
41	150	3.039	2.541	2.364	76.401
41	180	3.039	2.536	2.364	76.403
41	210	3.039	2.533	2.356	76.408
41	240	3.039	2.531	2.350	76.411
41	270	3.039	2.525	2.344	76.411
41	300	3.039	2.524	2.338	76.393
41	330	3.042	2.524	2.338	76.385
41	360	3.048	2.524	2.338	76.378
41	390	3.085	2.524	2.338	76.380
41	420	3.109	2.524	2.335	76.368
41	450	3.124	2.524	2.333	76.363
41	480	3.139	2.524	2.329	76.360
41	510	3.152	2.524	2.326	76.365
41	540	3.173	2.524	2.323	76.363
41	570	3.185	2.524	2.323	76.352
41	600	3.188	2.524	2.323	76.342
41	630	3.194	2.524	2.323	76.340

41	660	3.194	2.524	2.318	76.312
41	690	3.197	2.524	2.318	76.286
41	720	3.197	2.524	2.316	76.256
41	750	3.194	2.528	2.316	76.241
41	780	3.194	2.536	2.316	76.213
41	810	3.203	2.541	2.316	76.175
41	840	3.210	2.547	2.316	76.164
41	870	3.228	2.559	2.316	76.162
41	900	3.237	2.562	2.316	76.142
41	930	3.243	2.569	2.316	76.134
41	960	3.252	2.576	2.316	76.144
41	990	3.264	2.580	2.321	76.147
41	1020	3.274	2.585	2.321	76.144
41	1050	3.271	2.585	2.321	76.144
41	1080	3.200	2.585	2.321	76.144
41	1110	3.222	2.585	2.321	76.144
41	1140	3.228	2.585	2.321	76.149
41	1170	3.231	2.585	2.321	76.152
41	1200	3.231	2.585	2.321	76.154
41	1230	3.231	2.580	2.321	76.159
41	1260	3.228	2.576	2.321	76.159
41	1290	3.228	2.573	2.321	76.144
41	1320	3.225	2.569	2.321	76.134
41	1350	3.216	2.566	2.321	76.131
41	1380	3.213	2.559	2.321	76.134
41	1410	3.206	2.554	2.321	76.131
41	1440	3.200	2.550	2.323	76.124
42	30	3.191	2.547	2.321	76.111
42	60	3.188	2.542	2.321	76.076
42	90	3.182	2.539	2.323	76.043
42	120	3.182	2.531	2.323	76.045
42	150	3.200	2.531	2.323	76.040
42	180	3.213	2.530	2.323	76.010
42	210	3.228	2.531	2.323	75.992
42	240	3.246	2.534	2.323	76.010
42	270	3.267	2.539	2.318	76.012
42	300	3.280	2.544	2.318	75.999
42	330	3.301	2.557	2.318	75.969
42	360	3.325	2.560	2.318	76.002
42	390	3.350	2.560	2.318	76.027
42	420	3.359	2.565	2.318	76.065
42	450	3.365	2.565	2.315	76.111
42	480	3.368	2.574	2.315	76.106
42	510	3.377	2.579	2.315	76.109
42	540	3.395	2.579	2.315	76.091
42	570	3.399	2.583	2.315	76.093
42	600	3.405	2.586	2.323	76.096
42	630	3.411	2.586	2.323	76.103
42	660	3.414	2.588	2.323	76.098
42	690	3.417	2.588	2.323	76.093
42	720	3.414	2.594	2.326	76.083
42	750	3.408	2.594	2.329	76.073
42	780	3.414	2.594	2.330	76.043
42	810	3.420	2.603	2.335	76.022
42	840	3.426	2.614	2.339	76.007
42	870	3.441	2.621	2.344	75.997
42	900	3.456	2.637	2.348	75.997
42	930	3.478	2.649	2.353	75.994
42	960	3.502	2.665	2.362	76.002
42	990	3.514	2.675	2.365	76.012
42	1020	3.539	2.682	2.371	76.022
42	1050	3.557	2.688	2.374	76.048
42	1080	3.563	2.696	2.380	76.060
42	1110	3.575	2.701	2.384	76.088
42	1140	3.581	2.707	2.387	76.114
42	1170	3.609	2.711	2.391	76.142
42	1200	3.630	2.716	2.393	76.167
42	1230	3.648	2.720	2.400	76.190
42	1260	3.664	2.725	2.403	76.203
42	1290	3.676	2.725	2.408	76.233
42	1320	3.676	2.733	2.411	76.253
42	1350	3.667	2.733	2.414	76.266
42	1380	3.655	2.733	2.419	76.297
42	1410	3.645	2.733	2.420	76.312
42	1440	3.636	2.733	2.423	76.317
43	30	3.597	2.733	2.426	76.317
43	60	3.578	2.733	2.432	76.317

43	90	3.563	2.733	2.434	76.337
43	120	3.545	2.733	2.434	76.350
43	150	3.505	2.733	2.434	76.368
43	180	3.481	2.733	2.434	76.383
43	210	3.444	2.733	2.434	76.416
43	240	3.426	2.733	2.434	76.434
43	270	3.383	2.733	2.434	76.439
43	300	3.359	2.733	2.434	76.434
43	330	3.338	2.733	2.434	76.429
43	360	3.319	2.728	2.434	76.439
43	390	3.301	2.723	2.434	76.454
43	420	3.286	2.714	2.434	76.477
43	450	3.267	2.711	2.434	76.490
43	480	3.252	2.702	2.434	76.505
43	510	3.234	2.690	2.434	76.515
43	540	3.213	2.681	2.434	76.523
43	570	3.216	2.672	2.431	76.525
43	600	3.219	2.667	2.431	76.523
43	630	3.249	2.661	2.426	76.515
43	660	3.264	2.656	2.425	76.507
43	690	3.277	2.653	2.420	76.479
43	720	3.286	2.653	2.420	76.446
43	750	3.292	2.652	2.420	76.426
43	780	3.301	2.650	2.420	76.406
43	810	3.301	2.650	2.420	76.388
43	840	3.307	2.650	2.420	76.375
43	870	3.335	2.650	2.420	76.363
43	900	3.368	2.650	2.420	76.352
43	930	3.399	2.661	2.420	76.335
43	960	3.429	2.675	2.420	76.324
43	990	3.487	2.690	2.420	76.319
43	1020	3.533	2.707	2.420	76.314
43	1050	3.566	2.720	2.420	76.314
43	1080	3.600	2.733	2.425	76.319
43	1110	3.624	2.745	2.432	76.319
43	1140	3.652	2.755	2.437	76.322
43	1170	3.670	2.761	2.443	76.330
43	1200	3.682	2.772	2.451	76.335
43	1230	3.697	2.783	2.455	76.340
43	1260	3.703	2.783	2.460	76.345
43	1290	3.709	2.789	2.467	76.355
43	1320	3.719	2.793	2.472	76.355
43	1350	3.725	2.798	2.478	76.357
43	1380	3.728	2.806	2.481	76.365
43	1410	3.731	2.806	2.489	76.373
43	1440	3.734	2.810	2.493	76.380
44	30	3.737	2.813	2.501	76.378
44	60	3.737	2.819	2.504	76.391
44	90	3.737	2.821	2.509	76.398
44	120	3.737	2.821	2.512	76.411
44	150	3.737	2.821	2.513	76.413
44	180	3.737	2.829	2.521	76.416
44	210	3.719	2.835	2.524	76.426
44	240	3.703	2.835	2.525	76.444
44	270	3.661	2.844	2.531	76.459
44	300	3.633	2.847	2.537	76.474
44	330	3.615	2.850	2.542	76.490
44	360	3.606	2.850	2.548	76.502
44	390	3.630	2.856	2.551	76.528
44	420	3.642	2.865	2.554	76.548
44	450	3.648	2.871	2.557	76.573
44	480	3.658	2.871	2.563	76.609
44	510	3.679	2.880	2.563	76.629
44	540	3.694	2.883	2.568	76.660
44	570	3.709	2.890	2.571	76.670
44	600	3.722	2.890	2.577	76.685
44	630	3.722	2.896	2.583	76.703
44	660	3.725	2.899	2.585	76.711
44	690	3.740	2.902	2.592	76.713
44	720	3.746	2.908	2.600	76.708
44	750	3.731	2.914	2.608	76.708
44	780	3.716	2.917	2.614	76.711
44	810	3.706	2.917	2.620	76.708
44	840	3.703	2.926	2.621	76.703
44	870	3.697	2.926	2.627	76.708
44	900	3.697	2.932	2.630	76.728
44	930	3.700	2.941	2.632	76.744

44	960	3.712	2.950	2.638	76.756
44	990	3.728	2.969	2.644	76.761
44	1020	3.746	2.981	2.653	76.766
44	1050	3.764	2.996	2.662	76.777
44	1080	3.786	3.008	2.672	76.805
44	1110	3.828	3.024	2.678	76.807
44	1140	3.862	3.033	2.690	76.802
44	1170	3.883	3.051	2.704	76.799
44	1200	3.895	3.066	2.717	76.805
44	1230	3.904	3.078	2.726	76.810
44	1260	3.911	3.085	2.737	76.807
44	1290	3.911	3.091	2.748	76.799
44	1320	3.895	3.097	2.755	76.787
44	1350	3.883	3.097	2.765	76.777
44	1380	3.874	3.103	2.774	76.789
44	1410	3.868	3.103	2.780	76.802
44	1440	3.862	3.103	2.780	76.787
45	30	3.859	3.103	2.789	76.761
45	60	3.847	3.103	2.801	76.741
45	90	3.844	3.103	2.804	76.726
45	120	3.844	3.109	2.807	76.718
45	150	3.844	3.106	2.807	76.703
45	180	3.844	3.106	2.813	76.657
45	210	3.847	3.106	2.816	76.632
45	240	3.859	3.115	2.822	76.624
45	270	3.868	3.121	2.829	76.591
45	300	3.883	3.130	2.835	76.558
45	330	3.904	3.139	2.847	76.510
45	360	3.929	3.155	2.853	76.477
45	390	3.953	3.167	2.862	76.457
45	420	3.978	3.179	2.874	76.449
45	450	3.987	3.188	2.880	76.441
45	480	4.002	3.197	2.883	76.441
45	510	4.002	3.203	2.886	76.436
45	540	4.005	3.210	2.893	76.434
45	570	4.026	3.213	2.899	76.441
45	600	4.042	3.219	2.902	76.454
45	630	4.048	3.219	2.905	76.454
45	660	4.051	3.225	2.905	76.429
45	690	4.054	3.231	2.917	76.383
45	720	4.057	3.240	2.923	76.375
45	750	4.057	3.246	2.935	76.363
45	780	4.060	3.249	2.938	76.324
45	810	4.060	3.252	2.941	76.309
45	840	4.057	3.258	2.947	76.309
45	870	4.036	3.258	2.950	76.299
45	900	4.020	3.258	2.950	76.294
45	930	4.011	3.258	2.954	76.289
45	960	4.005	3.258	2.960	76.302
45	990	4.005	3.261	2.960	76.289
45	1020	4.005	3.264	2.960	76.274
45	1050	4.005	3.274	2.963	76.294
45	1080	4.008	3.283	2.969	76.312
45	1110	4.029	3.286	2.969	76.314
45	1140	4.042	3.292	2.972	76.312
45	1170	4.048	3.301	2.978	76.319
45	1200	4.048	3.301	2.984	76.312
45	1230	4.048	3.307	2.984	76.299
45	1260	4.048	3.313	2.993	76.291
45	1290	4.048	3.313	2.996	76.289
45	1320	4.042	3.313	2.999	76.281
45	1350	4.033	3.313	2.999	76.269
45	1380	4.026	3.313	3.005	76.266
45	1410	4.020	3.313	3.008	76.261
45	1440	4.011	3.313	3.008	76.253
46	30	3.996	3.313	3.008	76.248
46	60	3.984	3.313	3.008	76.246
46	90	3.965	3.313	3.008	76.236
46	120	3.947	3.304	3.008	76.220
46	150	3.935	3.301	3.008	76.210
46	180	3.920	3.295	3.008	76.208
46	210	3.911	3.289	3.008	76.203
46	240	3.901	3.280	3.008	76.200
46	270	3.892	3.277	3.008	76.200
46	300	3.889	3.271	3.008	76.197
46	330	3.889	3.271	3.008	76.203
46	360	3.889	3.271	3.008	76.205

46	390	3.892	3.271	3.008	76.208
46	420	3.901	3.271	3.008	76.213
46	450	3.908	3.271	3.002	76.220
46	480	3.917	3.271	2.999	76.225
46	510	3.920	3.271	2.999	76.228
46	540	3.926	3.271	2.999	76.225
46	570	3.929	3.271	2.999	76.223
46	600	3.929	3.271	2.999	76.223
46	630	3.929	3.271	2.999	76.230
46	660	3.926	3.271	2.999	76.223
46	690	3.941	3.271	2.999	76.208
46	720	3.950	3.271	2.999	76.192
46	750	3.953	3.271	2.999	76.175
46	780	3.962	3.271	2.999	76.157
46	810	3.962	3.271	2.999	76.144
46	840	3.962	3.271	2.999	76.131
46	870	3.962	3.271	2.999	76.129
46	900	3.965	3.271	2.999	76.126
46	930	3.968	3.271	2.999	76.121
46	960	3.975	3.271	2.999	76.114
46	990	3.987	3.271	2.999	76.111
46	1020	3.996	3.271	2.999	76.114
46	1050	4.011	3.271	2.999	76.116
46	1080	4.033	3.277	2.999	76.119
46	1110	4.057	3.289	2.999	76.119
46	1140	4.081	3.304	2.999	76.124
46	1170	4.100	3.313	2.999	76.119
46	1200	4.118	3.319	3.005	76.124
46	1230	4.130	3.328	3.008	76.121
46	1260	4.145	3.331	3.008	76.144
46	1290	4.148	3.335	3.014	76.149
46	1320	4.157	3.335	3.018	76.147
46	1350	4.161	3.344	3.021	76.157
46	1380	4.161	3.344	3.027	76.164
46	1410	4.161	3.347	3.027	76.175
46	1440	4.161	3.347	3.030	76.175
47	30	4.124	3.347	3.033	76.175
47	60	4.100	3.347	3.036	76.187
47	90	4.072	3.347	3.036	76.195
47	120	4.051	3.347	3.036	76.200
47	150	4.029	3.347	3.036	76.203
47	180	4.014	3.338	3.036	76.203
47	210	3.990	3.335	3.036	76.205
47	240	3.975	3.325	3.036	76.215
47	270	3.962	3.319	3.036	76.225
47	300	3.950	3.316	3.036	76.241
47	330	3.938	3.307	3.036	76.238
47	360	3.938	3.307	3.033	76.243
47	390	3.938	3.307	3.033	76.266
47	420	3.938	3.307	3.030	76.284
47	450	3.938	3.307	3.030	76.291
47	480	3.938	3.307	3.027	76.302
47	510	3.941	3.307	3.027	76.309
47	540	3.947	3.307	3.027	76.319
47	570	3.953	3.307	3.027	76.330
47	600	3.953	3.307	3.027	76.330
47	630	3.950	3.307	3.027	76.332
47	660	3.947	3.304	3.027	76.309
47	690	3.944	3.301	3.024	76.297
47	720	3.950	3.295	3.027	76.286
47	750	3.962	3.295	3.027	76.276
47	780	3.968	3.295	3.027	76.251
47	810	3.968	3.295	3.027	76.228
47	840	3.972	3.295	3.027	76.225
47	870	3.975	3.295	3.027	76.220
47	900	3.975	3.289	3.027	76.223
47	930	3.972	3.283	3.027	76.223
47	960	3.968	3.283	3.021	76.225
47	990	3.959	3.277	3.018	76.230
47	1020	3.959	3.274	3.014	76.233
47	1050	3.956	3.274	3.014	76.233
47	1080	3.950	3.274	3.014	76.238
47	1110	3.950	3.274	3.011	76.241
47	1140	3.953	3.274	3.011	76.243
47	1170	3.962	3.274	3.011	76.253
47	1200	3.968	3.274	3.011	76.269
47	1230	3.975	3.274	3.011	76.269

47	1260	3.984	3.274	3.011	76.269
47	1290	3.984	3.274	3.011	76.263
47	1320	3.984	3.274	3.011	76.266
47	1350	3.984	3.274	3.011	76.271
47	1380	3.981	3.274	3.011	76.291
47	1410	3.978	3.274	3.011	76.324
47	1440	3.968	3.274	3.011	76.340
48	30	3.947	3.274	3.011	76.342
48	60	3.929	3.274	3.005	76.363
48	90	3.911	3.264	3.002	76.375
48	120	3.895	3.252	2.996	76.385
48	150	3.880	3.249	2.990	76.401
48	180	3.862	3.237	2.990	76.441
48	210	3.844	3.228	2.984	76.497
48	240	3.828	3.219	2.975	76.517
48	270	3.819	3.206	2.957	76.538
48	300	3.804	3.200	2.947	76.563
48	330	3.795	3.188	2.941	76.586
48	360	3.789	3.185	2.938	76.606
48	390	3.789	3.185	2.932	76.632
48	420	3.789	3.185	2.929	76.660
48	450	3.792	3.185	2.926	76.678
48	480	3.801	3.185	2.923	76.690
48	510	3.810	3.185	2.923	76.711
48	540	3.819	3.185	2.923	76.728
48	570	3.822	3.185	2.920	76.744
48	600	3.825	3.185	2.920	76.764
48	630	3.856	3.185	2.917	76.777
48	660	3.874	3.185	2.917	76.784
48	690	3.889	3.185	2.917	76.774
48	720	3.901	3.185	2.917	76.779
48	750	3.908	3.185	2.917	76.782
48	780	3.914	3.185	2.917	76.777
48	810	3.917	3.185	2.917	76.777
48	840	3.917	3.185	2.917	76.779
48	870	3.917	3.179	2.911	76.787
48	900	3.904	3.176	2.911	76.789
48	930	3.895	3.176	2.911	76.794
48	960	3.892	3.176	2.911	76.797
48	990	3.880	3.170	2.911	76.810
48	1020	3.871	3.170	2.911	76.820
48	1050	3.865	3.164	2.911	76.843
48	1080	3.862	3.164	2.905	76.860
48	1110	3.862	3.164	2.905	76.868
48	1140	3.862	3.164	2.902	76.881
48	1170	3.880	3.164	2.902	76.898
48	1200	3.892	3.164	2.899	76.909
48	1230	3.904	3.164	2.899	76.911
48	1260	3.917	3.170	2.899	76.919
48	1290	3.917	3.173	2.899	76.916
48	1320	3.917	3.173	2.899	76.914
48	1350	3.914	3.179	2.899	76.914
48	1380	3.908	3.179	2.899	76.921
48	1410	3.901	3.179	2.899	76.924
48	1440	3.895	3.179	2.899	76.934
49	30	3.886	3.179	2.899	76.934
49	60	3.877	3.176	2.899	76.942
49	90	3.856	3.170	2.899	76.947
49	120	3.837	3.167	2.899	76.944
49	150	3.819	3.164	2.899	76.919
49	180	3.801	3.158	2.899	76.919
49	210	3.786	3.152	2.899	76.919
49	240	3.770	3.139	2.899	76.919
49	270	3.752	3.136	2.896	76.914
49	300	3.740	3.127	2.896	76.906
49	330	3.728	3.121	2.890	76.896
49	360	3.722	3.118	2.890	76.886
49	390	3.719	3.115	2.883	76.876
49	420	3.719	3.115	2.883	76.868
49	450	3.719	3.115	2.880	76.863
49	480	3.728	3.115	2.880	76.863
49	510	3.740	3.115	2.874	76.865
49	540	3.752	3.115	2.874	76.863
49	570	3.761	3.115	2.874	76.863
49	600	3.770	3.118	2.874	76.865
49	630	3.773	3.118	2.874	76.873
49	660	3.776	3.118	2.874	76.883

49	690	3.776	3.118	2.874	76.881
49	720	3.776	3.118	2.871	76.876
49	750	3.776	3.118	2.871	76.865
49	780	3.776	3.118	2.871	76.855
49	810	3.770	3.118	2.871	76.848
49	840	3.761	3.115	2.871	76.850
49	870	3.752	3.109	2.868	76.845
49	900	3.740	3.106	2.862	76.848
49	930	3.728	3.097	2.859	76.848
49	960	3.719	3.091	2.856	76.850
49	990	3.709	3.085	2.853	76.855
49	1020	3.697	3.072	2.847	76.863
49	1050	3.685	3.063	2.844	76.878
49	1080	3.676	3.054	2.832	76.881
49	1110	3.670	3.051	2.825	76.886
49	1140	3.667	3.045	2.822	76.909
49	1170	3.667	3.045	2.819	76.921
49	1200	3.667	3.045	2.819	76.926
49	1230	3.670	3.045	2.813	76.929
49	1260	3.679	3.045	2.813	76.929
49	1290	3.682	3.045	2.813	76.934
49	1320	3.685	3.045	2.813	76.937
49	1350	3.691	3.045	2.813	76.959
49	1380	3.691	3.045	2.807	76.957
49	1410	3.691	3.045	2.807	76.937
49	1440	3.691	3.045	2.807	76.863
50	30	3.691	3.045	2.807	76.835
50	60	3.679	3.036	2.807	76.886
50	90	3.673	3.033	2.807	76.904
50	120	3.661	3.030	2.807	76.914
50	150	3.652	3.024	2.801	76.896
50	180	3.642	3.021	2.801	76.876
50	210	3.633	3.014	2.801	76.838
50	240	3.627	3.005	2.792	76.820
50	270	3.615	2.999	2.792	76.797
50	300	3.609	2.993	2.786	76.792
50	330	3.603	2.984	2.777	76.792
50	360	3.594	2.981	2.774	76.799
50	390	3.594	2.981	2.761	76.807
50	420	3.594	2.978	2.761	76.812
50	450	3.606	2.978	2.757	76.832
50	480	3.621	2.978	2.754	76.840
50	510	3.639	2.981	2.754	76.853
50	540	3.667	2.993	2.754	76.871
50	570	3.679	3.002	2.754	76.888
50	600	3.697	3.008	2.754	76.916
50	630	3.700	3.014	2.754	76.924
50	660	3.706	3.018	2.754	76.934
50	690	3.712	3.021	2.754	76.934
50	720	3.719	3.021	2.754	76.934
50	750	3.722	3.021	2.754	76.924
50	780	3.722	3.027	2.754	76.916
50	810	3.722	3.027	2.754	76.909
50	840	3.722	3.027	2.754	76.893
50	870	3.722	3.027	2.754	76.878
50	900	3.728	3.027	2.754	76.868
50	930	3.728	3.027	2.754	76.865
50	960	3.728	3.027	2.754	76.876
50	990	3.725	3.024	2.754	76.873
50	1020	3.712	3.021	2.754	76.865
50	1050	3.706	3.014	2.754	76.865
50	1080	3.706	3.011	2.754	76.863
50	1110	3.706	3.008	2.754	76.855
50	1140	3.709	3.008	2.754	76.853
50	1170	3.709	3.005	2.754	76.825
50	1200	3.716	3.005	2.754	76.807
50	1230	3.725	3.005	2.754	76.802
50	1260	3.737	3.011	2.754	76.799
50	1290	3.749	3.014	2.754	76.789
50	1320	3.761	3.021	2.754	76.784
50	1350	3.773	3.021	2.754	76.784
50	1380	3.786	3.027	2.754	76.761
50	1410	3.795	3.033	2.754	76.749
50	1440	3.804	3.033	2.754	76.746
51	30	3.807	3.039	2.754	76.746
51	60	3.807	3.039	2.754	76.741
51	90	3.804	3.039	2.754	76.754

51	120	3.798	3.039	2.754	76.774
51	150	3.792	3.039	2.754	76.802
51	180	3.786	3.039	2.754	76.845
51	210	3.783	3.039	2.754	76.853
51	240	3.783	3.039	2.754	76.863
51	270	3.783	3.039	2.754	76.873
51	300	3.783	3.039	2.754	76.891
51	330	3.783	3.039	2.754	76.914
51	360	3.783	3.039	2.754	76.926
51	390	3.783	3.045	2.754	76.934
51	420	3.783	3.057	2.758	76.980
51	450	3.795	3.066	2.761	76.998
51	480	3.810	3.088	2.766	77.005
51	510	3.825	3.106	2.780	77.010
51	540	3.847	3.127	2.795	77.020
51	570	3.874	3.146	2.804	77.031
51	600	3.895	3.167	2.813	77.028
51	630	3.917	3.185	2.829	77.031
51	660	3.926	3.200	2.847	77.028
51	690	3.947	3.219	2.862	77.015
51	720	3.959	3.228	2.877	77.008
51	750	3.972	3.243	2.893	77.003
51	780	3.978	3.255	2.908	77.000
51	810	3.981	3.264	2.917	76.990
51	840	3.990	3.271	2.926	76.975
51	870	3.993	3.274	2.938	76.972
51	900	3.993	3.283	2.944	76.972
51	930	3.993	3.289	2.957	76.975
51	960	3.993	3.289	2.963	76.970
51	990	3.993	3.298	2.972	76.970
51	1020	3.993	3.298	2.981	76.975
51	1050	3.993	3.298	2.984	76.985
51	1080	3.993	3.301	2.987	77.003
51	1110	3.987	3.301	2.990	77.005
51	1140	3.984	3.301	2.993	77.005
51	1170	3.981	3.301	2.999	77.003
51	1200	3.981	3.307	3.005	76.995
51	1230	3.990	3.307	3.011	77.005
51	1260	3.999	3.310	3.011	77.003
51	1290	4.029	3.319	3.021	77.000
51	1320	4.048	3.325	3.024	77.000
51	1350	4.063	3.335	3.030	76.995
51	1380	4.087	3.341	3.030	76.990
51	1410	4.100	3.350	3.039	76.985
51	1440	4.112	3.356	3.042	76.982
52	30	4.124	3.368	3.051	76.977
52	60	4.133	3.374	3.057	76.980
52	90	4.142	3.380	3.063	76.970
52	120	4.145	3.389	3.066	76.962
52	150	4.106	3.395	3.072	76.942
52	180	4.081	3.395	3.078	76.914
52	210	4.066	3.395	3.085	76.901
52	240	4.045	3.395	3.088	76.876
52	270	4.029	3.395	3.091	76.868
52	300	4.011	3.395	3.094	76.850
52	330	3.996	3.395	3.094	76.840
52	360	3.978	3.395	3.094	76.820
52	390	3.962	3.395	3.094	76.805
52	420	3.953	3.395	3.094	76.805
52	450	3.947	3.392	3.094	76.802
52	480	3.941	3.386	3.094	76.799
52	510	3.938	3.386	3.094	76.794
52	540	3.938	3.386	3.094	76.736
52	570	3.941	3.386	3.094	76.708
52	600	3.953	3.386	3.094	76.695
52	630	3.965	3.386	3.100	76.667
52	660	3.975	3.392	3.103	76.650
52	690	3.984	3.395	3.109	76.601
52	720	3.990	3.399	3.112	76.563
52	750	4.005	3.402	3.121	76.538
52	780	4.020	3.408	3.127	76.487
52	810	4.039	3.408	3.127	76.446
52	840	4.051	3.408	3.133	76.444
52	870	4.054	3.414	3.139	76.441
52	900	4.063	3.414	3.139	76.403
52	930	4.072	3.414	3.139	76.375
52	960	4.075	3.414	3.139	76.363

52	990	4.081	3.414	3.142	76.340
52	1020	4.081	3.414	3.142	76.319
52	1050	4.081	3.414	3.142	76.327
52	1080	4.081	3.414	3.142	76.337
52	1110	4.081	3.417	3.142	76.342
52	1140	4.078	3.414	3.142	76.370
52	1170	4.078	3.417	3.142	76.380
52	1200	4.075	3.414	3.142	76.393
52	1230	4.069	3.414	3.142	76.464
52	1260	4.066	3.405	3.139	76.477
52	1290	4.063	3.402	3.136	76.487
52	1320	4.063	3.402	3.136	76.490
52	1350	4.042	3.402	3.136	76.487
52	1380	4.036	3.402	3.136	76.492
52	1410	4.029	3.402	3.130	76.500
52	1440	4.020	3.395	3.127	76.525
53	30	4.020	3.395	3.127	76.535
53	60	4.020	3.392	3.121	76.533
53	90	4.039	3.392	3.121	76.548
53	120	4.054	3.392	3.121	76.566
53	150	4.057	3.392	3.118	76.568
53	180	4.063	3.392	3.118	76.566
53	210	4.069	3.392	3.118	76.571
53	240	4.075	3.392	3.115	76.586
53	270	4.075	3.392	3.115	76.632
53	300	4.075	3.389	3.115	76.637
53	330	4.042	3.389	3.115	76.650
53	360	4.017	3.383	3.115	76.672
53	390	3.947	3.371	3.115	76.726
53	420	3.911	3.359	3.100	76.759
53	450	3.831	3.344	3.091	76.779
53	480	3.786	3.328	3.078	76.794
53	510	3.746	3.313	3.075	76.815
53	540	3.709	3.301	3.069	76.835
53	570	3.679	3.289	3.063	76.848
53	600	3.648	3.277	3.060	76.855
53	630	3.630	3.267	3.054	76.860
53	660	3.612	3.258	3.042	76.868
53	690	3.600	3.249	3.039	76.863
53	720	3.584	3.240	3.033	76.848
53	750	3.572	3.237	3.027	76.848
53	780	3.557	3.228	3.027	76.830
53	810	3.539	3.222	3.021	76.827
53	840	3.523	3.210	3.018	76.822
53	870	3.511	3.197	3.002	76.825
53	900	3.496	3.185	2.999	76.825
53	930	3.478	3.173	2.984	76.830
53	960	3.466	3.158	2.978	76.838
53	990	3.484	3.146	2.966	76.845
53	1020	3.484	3.136	2.954	76.858
53	1050	3.484	3.121	2.938	76.878
53	1080	3.472	3.109	2.932	76.886
53	1110	3.466	3.100	2.917	76.898
53	1140	3.450	3.085	2.911	76.906
53	1170	3.487	3.069	2.902	76.914
53	1200	3.517	3.063	2.890	76.934
53	1230	3.551	3.057	2.880	76.944
53	1260	3.581	3.054	2.874	76.952
53	1290	3.609	3.054	2.868	76.954
53	1320	3.636	3.051	2.859	76.952
53	1350	3.670	3.051	2.859	76.944
53	1380	3.700	3.051	2.853	76.939
53	1410	3.728	3.051	2.853	76.942
53	1440	3.755	3.051	2.853	76.962
54	30	3.776	3.051	2.847	76.957
54	60	3.801	3.057	2.847	76.954
54	90	3.828	3.066	2.847	76.954
54	120	3.853	3.082	2.847	76.952
54	150	3.880	3.088	2.847	76.947
54	180	3.901	3.097	2.847	76.957
54	210	3.923	3.103	2.847	76.970
54	240	3.941	3.109	2.847	76.980
54	270	3.965	3.115	2.847	76.990
54	300	3.978	3.121	2.847	76.998
54	330	3.996	3.130	2.847	77.000
54	360	4.011	3.142	2.847	77.005
54	390	4.023	3.149	2.850	77.015

54	420	4.042	3.155	2.853	77.023
54	450	4.039	3.161	2.859	77.036
54	480	4.029	3.167	2.862	77.048
54	510	3.978	3.170	2.865	77.051
54	540	3.926	3.170	2.868	77.051
54	570	3.850	3.170	2.871	77.048
54	600	3.819	3.170	2.874	77.046
54	630	3.813	3.170	2.874	77.038
54	660	3.816	3.170	2.874	77.036
54	690	3.819	3.170	2.874	77.010
54	720	3.819	3.170	2.880	76.985
54	750	3.819	3.170	2.883	76.962
54	780	3.810	3.170	2.890	76.934
54	810	3.776	3.170	2.890	76.919
54	840	3.706	3.170	2.893	76.904
54	870	3.670	3.170	2.893	76.883
54	900	3.630	3.164	2.893	76.865
54	930	3.594	3.152	2.893	76.850
54	960	3.557	3.139	2.893	76.832
54	990	3.523	3.127	2.893	76.822
54	1020	3.487	3.115	2.893	76.815
54	1050	3.453	3.097	2.890	76.822
54	1080	3.417	3.078	2.883	76.838
54	1110	3.377	3.057	2.871	76.845
54	1140	3.350	3.042	2.859	76.855
54	1170	3.417	3.027	2.847	76.863
54	1200	3.429	3.014	2.838	76.865
54	1230	3.466	3.002	2.829	76.876
54	1260	3.496	2.996	2.819	76.883
54	1290	3.533	2.990	2.816	76.886
54	1320	3.566	2.990	2.807	76.883
54	1350	3.591	2.984	2.801	76.886
54	1380	3.612	2.984	2.792	76.883
54	1410	3.639	2.984	2.789	76.898
54	1440	3.664	2.984	2.786	76.906
55	30	3.682	2.984	2.777	76.909
55	60	3.700	2.984	2.777	76.916
55	90	3.700	2.984	2.771	76.919
55	120	3.697	2.984	2.771	76.921
55	150	3.697	2.984	2.771	76.924
55	180	3.697	2.984	2.771	76.919
55	210	3.734	2.984	2.771	76.924
55	240	3.755	2.987	2.771	76.926
55	270	3.776	2.996	2.771	76.929
55	300	3.795	3.002	2.771	76.924
55	330	3.813	3.011	2.771	76.921
55	360	3.825	3.011	2.768	76.926
55	390	3.789	3.021	2.768	76.944
55	420	3.761	3.021	2.768	76.965
55	450	3.682	3.021	2.768	76.975
55	480	3.606	3.021	2.768	76.980
55	510	3.554	3.011	2.768	76.982
55	540	3.514	2.999	2.768	76.982
55	570	3.472	2.990	2.760	76.977
55	600	3.429	2.978	2.757	76.965
55	630	3.386	2.966	2.757	76.952
55	660	3.362	2.954	2.749	76.924
55	690	3.338	2.944	2.746	76.909
55	720	3.313	2.938	2.743	76.888
55	750	3.301	2.929	2.742	76.865
55	780	3.283	2.929	2.737	76.835
55	810	3.274	2.920	2.737	76.810
55	840	3.258	2.920	2.734	76.782
55	870	3.243	2.908	2.725	76.769
55	900	3.231	2.902	2.720	76.764
55	930	3.216	2.893	2.714	76.746
55	960	3.194	2.886	2.707	76.726
55	990	3.179	2.880	2.699	76.723
55	1020	3.164	2.862	2.684	76.726
55	1050	3.133	2.847	2.675	76.728
55	1080	3.109	2.838	2.661	76.736
55	1110	3.088	2.816	2.653	76.741
55	1140	3.066	2.806	2.643	76.749
55	1170	3.042	2.792	2.632	76.751
55	1200	3.018	2.774	2.620	76.756
55	1230	3.002	2.755	2.609	76.756
55	1260	3.014	2.743	2.600	76.766

55	1290	3.042	2.726	2.589	76.764
55	1320	3.051	2.716	2.577	76.766
55	1350	3.057	2.704	2.568	76.766
55	1380	3.063	2.697	2.557	76.764
55	1410	3.063	2.688	2.551	76.766
55	1440	3.066	2.676	2.542	76.772
56	30	3.066	2.665	2.531	76.777
56	60	3.066	2.659	2.524	76.777
56	90	3.066	2.653	2.518	76.774
56	120	3.066	2.647	2.509	76.764
56	150	3.072	2.647	2.504	76.754
56	180	3.085	2.647	2.502	76.749
56	210	3.130	2.647	2.493	76.746
56	240	3.161	2.647	2.492	76.746
56	270	3.188	2.647	2.481	76.749
56	300	3.219	2.647	2.480	76.754
56	330	3.237	2.647	2.473	76.754
56	360	3.258	2.647	2.469	76.756
56	390	3.274	2.647	2.469	76.756
56	420	3.298	2.647	2.469	76.756
56	450	3.344	2.650	2.469	76.764
56	480	3.389	2.656	2.461	76.794
56	510	3.429	2.656	2.461	76.799
56	540	3.478	2.669	2.461	76.799
56	570	3.517	2.675	2.461	76.797
56	600	3.527	2.691	2.461	76.784
56	630	3.530	2.697	2.461	76.779
56	660	3.536	2.704	2.461	76.766
56	690	3.539	2.713	2.461	76.761
56	720	3.542	2.719	2.461	76.749
56	750	3.539	2.728	2.464	76.733
56	780	3.548	2.739	2.469	76.695
56	810	3.554	2.746	2.473	76.665
56	840	3.560	2.761	2.483	76.639
56	870	3.560	2.780	2.495	76.624
56	900	3.554	2.789	2.501	76.609
56	930	3.554	2.795	2.507	76.591
56	960	3.554	2.801	2.513	76.571
56	990	3.548	2.809	2.518	76.561
56	1020	3.545	2.816	2.525	76.538
56	1050	3.542	2.816	2.528	76.530
56	1080	3.527	2.816	2.531	76.520
56	1110	3.527	2.816	2.534	76.517
56	1140	3.527	2.816	2.536	76.520
56	1170	3.548	2.816	2.536	76.520
56	1200	3.569	2.816	2.539	76.515
56	1230	3.591	2.816	2.542	76.505
56	1260	3.606	2.816	2.545	76.500
56	1290	3.615	2.816	2.545	76.500
56	1320	3.627	2.816	2.547	76.505
56	1350	3.606	2.825	2.548	76.497
56	1380	3.581	2.825	2.551	76.492
56	1410	3.566	2.825	2.551	76.487
56	1440	3.548	2.825	2.551	76.479
57	30	3.536	2.825	2.551	76.479
57	60	3.517	2.825	2.551	76.479
57	90	3.487	2.825	2.551	76.459
57	120	3.469	2.819	2.551	76.439
57	150	3.447	2.809	2.551	76.429
57	180	3.429	2.809	2.551	76.408
57	210	3.423	2.809	2.551	76.401
57	240	3.417	2.809	2.551	76.393
57	270	3.414	2.809	2.551	76.383
57	300	3.414	2.809	2.551	76.368
57	330	3.411	2.809	2.551	76.352
57	360	3.411	2.809	2.551	76.350
57	390	3.411	2.809	2.551	76.350
57	420	3.414	2.809	2.551	76.355
57	450	3.432	2.803	2.551	76.355
57	480	3.444	2.803	2.551	76.355
57	510	3.484	2.803	2.551	76.347
57	540	3.508	2.803	2.551	76.327
57	570	3.548	2.803	2.551	76.319
57	600	3.575	2.803	2.551	76.307
57	630	3.606	2.803	2.551	76.297
57	660	3.627	2.804	2.551	76.266
57	690	3.648	2.804	2.551	76.230

57	720	3.661	2.810	2.551	76.205
57	750	3.645	2.822	2.551	76.167
57	780	3.636	2.822	2.557	76.131
57	810	3.633	2.827	2.560	76.111
57	840	3.636	2.833	2.565	76.088
57	870	3.645	2.841	2.566	76.068
57	900	3.652	2.850	2.573	76.040
57	930	3.676	2.862	2.579	76.015
57	960	3.691	2.874	2.583	75.997
57	990	3.706	2.886	2.591	75.982
57	1020	3.728	2.899	2.597	75.954
57	1050	3.746	2.911	2.605	75.933
57	1080	3.758	2.920	2.612	75.916
57	1110	3.770	2.929	2.620	75.898
57	1140	3.780	2.929	2.627	75.880
57	1170	3.789	2.941	2.632	75.865
57	1200	3.795	2.944	2.638	75.847
57	1230	3.801	2.944	2.644	75.832
57	1260	3.801	2.950	2.649	75.824
57	1290	3.801	2.950	2.652	75.819
57	1320	3.801	2.950	2.655	75.804
57	1350	3.801	2.950	2.659	75.794
57	1380	3.801	2.960	2.661	75.789
57	1410	3.798	2.960	2.664	75.786
57	1440	3.798	2.960	2.665	75.783
58	30	3.764	2.960	2.667	75.783
58	60	3.746	2.960	2.670	75.773
58	90	3.719	2.960	2.670	75.740
58	120	3.694	2.960	2.672	75.715
58	150	3.682	2.960	2.672	75.695
58	180	3.676	2.960	2.672	75.672
58	210	3.673	2.960	2.672	75.662
58	240	3.676	2.960	2.672	75.649
58	270	3.688	2.960	2.672	75.644
58	300	3.703	2.960	2.672	75.618
58	330	3.719	2.960	2.673	75.603
58	360	3.734	2.960	2.676	75.603
58	390	3.755	2.963	2.679	75.590
58	420	3.789	2.972	2.685	75.580
58	450	3.828	2.975	2.684	75.575
58	480	3.868	2.981	2.690	75.562
58	510	3.898	2.993	2.693	75.555
58	540	3.935	3.002	2.699	75.512
58	570	3.947	3.008	2.710	75.466
58	600	3.953	3.021	2.716	75.446
58	630	3.938	3.030	2.722	75.438
58	660	3.935	3.030	2.733	75.420
58	690	3.929	3.030	2.736	75.410
58	720	3.920	3.030	2.740	75.382
58	750	3.901	3.036	2.745	75.331
58	780	3.886	3.036	2.749	75.275
58	810	3.853	3.036	2.754	75.232
58	840	3.822	3.036	2.760	75.184
58	870	3.792	3.036	2.768	75.176
58	900	3.770	3.036	2.768	75.138
58	930	3.740	3.036	2.768	75.098
58	960	3.725	3.036	2.771	75.057
58	990	3.712	3.045	2.774	75.021
58	1020	3.706	3.045	2.780	74.981
58	1050	3.700	3.060	2.783	74.960
58	1080	3.697	3.060	2.786	74.948
58	1110	3.688	3.060	2.786	74.938
58	1140	3.685	3.060	2.786	74.905
58	1170	3.682	3.060	2.789	74.882
58	1200	3.673	3.060	2.789	74.869
58	1230	3.661	3.060	2.789	74.859
58	1260	3.648	3.060	2.789	74.833
58	1290	3.645	3.054	2.789	74.813
58	1320	3.636	3.048	2.789	74.808
58	1350	3.615	3.039	2.789	74.788
58	1380	3.600	3.033	2.786	74.752
58	1410	3.578	3.024	2.786	74.699
58	1440	3.554	3.021	2.786	74.676
59	30	3.539	3.005	2.786	74.651
59	60	3.517	2.993	2.783	74.633
59	90	3.505	2.987	2.780	74.592
59	120	3.490	2.978	2.774	74.544

59	150	3.478	2.963	2.771	74.508
59	180	3.466	2.954	2.763	74.475
59	210	3.450	2.950	2.754	74.460
59	240	3.447	2.944	2.748	74.435
59	270	3.447	2.944	2.745	74.414
59	300	3.447	2.935	2.745	74.384
59	330	3.456	2.935	2.743	74.351
59	360	3.469	2.935	2.742	74.331
59	390	3.484	2.935	2.740	74.308
59	420	3.499	2.938	2.740	74.290
59	450	3.563	2.938	2.740	74.285
59	480	3.603	2.938	2.736	74.272
59	510	3.667	2.938	2.736	74.270
59	540	3.706	2.941	2.723	74.259
59	570	3.734	2.950	2.723	74.265
59	600	3.761	2.950	2.723	74.270
59	630	3.783	2.957	2.722	74.275
59	660	3.798	2.957	2.722	74.272
59	690	3.825	2.966	2.722	74.257
59	720	3.850	2.972	2.723	74.206
59	750	3.831	2.972	2.723	74.163
59	780	3.816	2.981	2.723	74.140
59	810	3.807	2.981	2.723	74.099
59	840	3.798	2.981	2.725	74.082
59	870	3.792	2.981	2.728	74.074
59	900	3.789	2.981	2.728	74.064
59	930	3.786	2.981	2.729	74.059
59	960	3.786	2.993	2.729	74.044
59	990	3.764	2.999	2.733	74.036
59	1020	3.758	3.011	2.736	74.044
59	1050	3.764	3.014	2.737	74.059
59	1080	3.780	3.036	2.740	74.054
59	1110	3.825	3.045	2.745	74.054
59	1140	3.862	3.060	2.749	74.041
59	1170	3.868	3.066	2.755	74.033
59	1200	3.868	3.078	2.761	74.031
59	1230	3.871	3.078	2.768	74.028
59	1260	3.874	3.088	2.774	74.023
59	1290	3.892	3.088	2.780	74.016
59	1320	3.892	3.088	2.783	74.011
59	1350	3.880	3.088	2.786	74.003
59	1380	3.877	3.088	2.786	73.990
59	1410	3.856	3.088	2.789	73.980
59	1440	3.831	3.088	2.792	73.975

PRECIPITATION FOR FEBRUARY 1991
(RECORDED AT PORTLAND INTERNATIONAL AIRPORT)

JULIAN DAY	PRECIPITATION (CENTIMETERS)
32	0.56
33	0.84
34	0.66
35	0.81
36	0.81
37	0.00
38	0.00
39	0.00
40	0.00
41	0.00
42	0.00
43	0.89
44	0.94
45	0.61
46	0.00
47	0.36
48	0.00
49	0.00
50	0.23
51	1.63
52	1.50
53	0.00
54	0.00
55	0.00
56	0.00
57	0.00
58	0.00
59	0.00

APPENDIX C

COMPUTER PROGRAMS

```
C     PROGRAM 5.9 DAVIS PG 249 BY AG JOHNSON  1/28/86
VERSION 1.1
C                                       ADDED PRINT OPTIONS
3/20/86
C     MODIFIED 7/12/91 BY JM WILKINSON
C          PRINT OPTION REMOVED
C          ADDED ABS() TO SQRT FUNCTIONS
C          INCREASED FILE SIZES
C          OUTPUT TO DISK FILES
C
C     ROUTINE CROSCR
C
C     PROGRAM TO PERFORM CROSSCORRELATION BETWEEN TWO
SEQUENCES OF DATA
C
C     XIN1 CONTAINS THE FIRST DATA SEQUENCE OF NIN1 ELEMENTS

C     XIN2 IS THE SECOND DATA SEQUENCE OF LENGTH NIN2

C     THE CORRELATION COEFFICIENTS CALCULATED AT EACH MATCH
POSITION ARE
C
C     STORED IN ARRAY XOUT.  THE NUMBER OF CORRELATION
COEFFICIENTS IN
C     XOUT IS NOT = NIN1 + NIN2 - 5.
C
C     IB1 = FIRST TERM OF XIN1 IN THE OVERLAPPED SEGMENT

C     IE1 = LAST TERM OF XIN1 IN THE OVERLAPPED SEGMENT

C     IB2 = FIRST TERM OF XIN2 IN THE OVERLAPPED SEGMENT

C     IE2 = LAST TERM OF XIN2 IN THE OVERLAPPED SEGMENT

C     LEN1 = NUMBER OF TERMS OF XIN1 IN THE OVERLAPPED
SEGMENT
C     LEN2 = NUMBER OF TERMS OF XIN2 IN THE OVERLAPPED
SEGMENT
C
C     THE SUBROUTINES REQUIRED ARE READM
C     THE MAXIMUM LENGTH OF EACH INPUT DATA SEQUENCE IS 2000
ELEMENTS.
C
      DIMENSION XIN1(2000),XIN2(2000),XOUT(4000)

      CHARACTER*1 RESPONS
      CHARACTER*14 FILENAME,TIM,DAT,DATOUT,MATOUT

      IMX=2000
C
C     READ IN THE TWO DATA SEQUENCES TO BE CROSSCORRELATED
      WRITE (*,*) ' INPUT THE DATE eg 10/5/90 '
```

```
      READ (*,910) DAT
      WRITE (*,*) ' INPUT THE TIME  eg 10:21 PST '

      READ (*,910) TIM
  206 WRITE (*,900)
  900 FORMAT (' INPUT DATA FILE NAME - eg A:CROSCR.DAT ')

      READ (*,910) FILENAME
      WRITE (*,903)
  903 FORMAT (' INPUT NAME OF OUTPUT FILE eg. A:DAT.OUT')

      READ (*,910) DATOUT
      WRITE (*,906)
  906 FORMAT (' INPUT NAME OF MATCH OUTPUT FILE eg.
A:MATCH.MAT')
      READ (*,910) MATOUT
  910 FORMAT (A)
      OPEN (5,FILE=FILENAME)
      OPEN (7,FILE=DATOUT,STATUS='NEW')
      OPEN (8,FILE=MATOUT,STATUS='NEW')
      WRITE (8,920) FILENAME,DAT,TIM
  920 FORMAT (1H0,' PROGRAM  CROSCR  DAVIS PG 249  VERSION
1.1 3/20/86',

     1/,'  DATA FILE = ',A14,' DATE ',A14,' TIME ',A14,/)

      CALL READM(XIN1,NIN1,MN,IMX,1)
  200 FORMAT (A1)
  201 CALL READM(XIN2,NIN2,MN,IMX,1)
  202 WRITE (8,2000)
      NOT=NIN1+NIN2-5
      IB1=1
      IE1=3
      IB2=NIN2-2
      IE2=NIN2
      LEN1=3
      DO 100 I=1,NOT
      SX=0.0
      SY=0.0
      SXY=0.0
      SXX=0.0
      SYY=0.0
      DO 101 J=1,LEN1
      J1=IB1+J-1
      J2=IB2+J-1
      X1=XIN1(J1)
      X2=XIN2(J2)
      SX=SX+X1
      SY=SY+X2
      SXY=SXY+X1*X2
      SXX=SXX+X1*X1
      SYY=SYY+X2*X2
```

```
  101 CONTINUE
      AN=LEN1
R=(AN*SXY-SX*SY)/SQRT(ABS((AN*SXX-SX*SX)*(AN*SYY-SY*SY)))
      T=R*SQRT(ABS((AN-2.0)/(1.0-R*R)))
      XOUT(I)=R
      WRITE (8,2001) I,IB1,IE1,IB2,IE2,LEN1,R,T
      IE1=IE1+1
      IF (IE1-NIN1) 2,2,1
    1 IB1=IB1+1
      IE1=NIN1
    2 IB2=IB2-1
      IF (IB2) 3,3,4
    3 IB2=1
      IE2=IE2-1
    4 LEN1=IE1-IB1+1
      LEN2=IE2-IB2+1
      IF (LEN1-LEN2) 5,100,6
    5 IB1=1
      IE2=IE2-1
      GO TO 4
    6 IB1=IB1+1
      IE2=NIN2
      GO TO 4
  100 CONTINUE
      DO 199 I=1,NOT
      WRITE (7,198) I,XOUT(I)
  199 CONTINUE
  198 FORMAT (1X,I4,',',F10.4)
  205 WRITE (*,*) ' DO YOU WANT TO DO ANOTHER DATA SET? '
      WRITE (*,*) ' IF YES, TYPE  Y , IF NOT RETURN '
      READ (*,200) RESPONS
      IF (RESPONS .EQ. 'Y') THEN
            CLOSE (5,STATUS='KEEP')
            CLOSE (7,STATUS='KEEP')
            CLOSE (8,STATUS='KEEP')
            GO TO 206
      ENDIF
      STOP
 2000 FORMAT (1H1,14X,'TERMS WHICH ARE MATCHED',7X,'NUMBER'/
     14X,'MATCH',8X,'FIRST',9X,'SECOND',6X,'OF TERMS',
     23X,'CORRELATION',7X,'T'/3X,'POSITION',4X,'DATA
SET',6X,
     32X,'DATA
SET',6X,'MATCHED',2X,'COEFFICIENT',5X,'VALUE'/)
```

```
 2001 FORMAT(1X,6I8,2F14.6)
      END
C     PROGRAM 4-1
C
C     SUBROUTINE TO READ A MATRIX
C     HAVING N ROWS AND M COLUMNS
C
      SUBROUTINE READM(A,N,M,N1,M1)
      DIMENSION A(N1,M1)
C     READ SIZE OF MATRIX
      READ(5,1000) N,M
C     READ MATRIX
      DO 100 I=1,N
      READ (5,1001) (A(I,J),J=1,M)
  100 CONTINUE
      RETURN
 1000 FORMAT(2I4)
 1001 FORMAT(10F8.0)
      END
```