HYDROGEOLOGICAL ASSESSMENT OF THE POTENTIAL FOR FUTURE GROUND-WATER DEVELOPMENT IN GENESEE, IDAHO

A thesis

Presented in Partial Fulfillment of the Requirements for the

Degree of Master of Science

with a

Major in Hydrology

in the

College of Graduate Studies

University of Idaho

by

William R. Lawrence

April 1995

Major Professor: Dale R. Ralston, Ph.D.

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AUTHORIZATION TO SUBMIT

THESIS

This thesis of William R. Lawrence, submitted for the degree of Master of Science with a major in Hydrology and titled "Hydrogeological assessment of the potential for future ground-water development in Genesee, Idaho ", has been reviewed in final form and approved, as indicated by the signatures and dates given below. Permission is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

Water contamination in Genesee, Idaho, caused a short-term shut down of City Well #3. While Well #3 was off line, Well #5 supplied all of the city's water. The increased demand caused apparent water level decline in the upper (Wanapum) aquifer and prompted a search for an alternate source. After an unsuccessful attempt at drilling to find an adequate water source, this study was implemented to analyze the occurrence, quantity, and quality of ground water in the Genesee area with respect to long-term availability.

An investigation of the ground-water resources in the Genesee area included well location, water level measurements, collection of pumpage records, and the compilation of geological and hydrological data for Moscow, Pullman, Lewiston, and Clarkston. A hydrogeological conceptual model was created for Genesee from comparisons of this data. The model indicates that several locations are not recommended for further development of the Wanapum aquifer because of contamination, elevation, low yield, and well interference.

Based on the model, development of the upper aquifer may require the drilling of several test wells to obtain the desired yield. No conclusions can be made for the availability of water in the lower (Grande Ronde) aquifer. Careful collection of all geologic and hydrologic data is recommended during the construction of any new well. Water levels, water quality, and pumpage data should be collected on a regular basis.

ACKNOWLEDGEMENTS

I wish to express personal thanks to my major professor, Dr. Dale Ralston, for making this project a reality, for his guidance, insights, encouragement throughout my graduate studies, and countless hours dedicated to this project. I would also like to thank Dr. John Bush and Dr. John Hammel for their time, encouragement, and significant contributions to this project.

I am greatly appreciative of Bob Luedke and Mert Geltz for keeping me up to date on City affairs. I also thank the city of Genesee for providing the funding for this project, without which it would not have been possible. Many thanks are also given to all of the friendly members of the community that were helpful and supportive of this project.

Thanks are also extended to Ron Clarke, Jack Pierce, Andrew Provant, and Steve Gill for assisting in map compilation and for sacrificing their bodies to gather rock samples.

Finally, very special thanks go to my friends and family for their transportation, help, support, and encouragement. The completion of this project was made possible only through their constant prayers and our trust in God.

TABLE OF CONTENTS

	Page
ABSTRACT	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF FIGURES AND TABLES	vii
CHAPTER 1 INTRODUCTION	1
Statement of Problem	1
Purpose and Objectives	2
Method of Study	2
Review of Literature	2
Compilation of Geological Data	3
Well-numbering System	4
Field Inventory	4
Analyses of Data	6
Well Potential and Design	6
General Description of Genesee Area	7
CHAPTER 2 REGIONAL HYDROGEOLOGY	9
Introduction	9
General Geologic Setting	9
General Stratigraphy	11
General Structure	13
General Hydrogeology	14
Water-yielding Capacities	15
Local Aquifers	16
CHAPTER 3 STUDY AREA HYDROGEOLOGY	22
Introduction	22
Definition of Study Area	22
Study Area Geology and Stratigraphy	23
Basement Composition	23
Basalt Sequence and Vantage Formation	24
Sediments	28
Study Area Structure and Compositional Features	28
Study Area Aquifers	32

CHAPTER 4 ANALYSIS OF WELL DEVELOPMENT.................. 34

Introduction.. 34
Well Inventory.. 34
Municipal Wells....................................... 38
Domestic Wells.. 43
Analyses of Pumpage and Water Level Data............ 46
Ground-Water Pumpage.............................. 46
Well Depths and Ground-Water Levels............ 49
Water Level Decline............................... 53
Data Reliability.................................. 53
Water Quality... 56

CHAPTER 5 ANALYSIS OF THE GROUND-WATER-FLOW SYSTEM..... 62

Introduction.. 62
Flow Characteristics.................................. 62
Ground-Water Recharge................................. 63
Ground-Water Discharge................................ 66

CHAPTER 6 WELL DEVELOPMENT POTENTIAL................... 69

Introduction.. 69
Knowledge of Aquifers................................. 69
Alternative #1 -- Upper Aquifer....................... 70
Alternative #2 -- Lower Aquifer....................... 74
Development Options................................... 75

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS.............. 78

General Conclusions................................... 78
Specific Conclusions.................................. 78
Recommendations....................................... 79

REFERENCES CITED... 80

LIST OF ILLUSTRATIONS

		Page
Figure 1.	Well-numbering Systems of Washington and Idaho	5
Figure 2.	Location map and bedrock geology of the Genesee-Uniontown area	8
Figure 3.	Areal extent of the Columbia River Basalt Group and associated faults of the Clearwater embayment	10
Figure 4.	Generalized stratigraphic section for the Genesee-Uniontown area	12
Figure 5.	Geologic cross-section based on Washington State University (WSU) and Pullman wells	18
Figure 6.	Geologic cross-section from Pullman to Moscow	19
Figure 7.	Generalized representations of Pullman-Moscow and Clarkston-Lewiston wells	20
Figure 8.	Stratigraphy of the Columbia River Basalt Group of the eastern Columbia Plateau	25
Figure 9.	Generalized northwest-southeast geologic cross-section through the study area	30
Figure 10.	Generalized cross-section of wells drilled for the city of Genesee	31
Table 1.	Well data for the Genesee area	35-37
Figure 11.	Well locations and water level contours for ground-water flow in the study area	39
Figure 12.	Well locations, yields, depths, and elevations for city wells and test wells	40
Figure 13.	Frequency distribution of well bottom elevations in the Genesee area	44
Figure 14.	Frequency distribution of well depth elevations in the Genesee area	45

Figure 15. Total pumpage for Genesee municipal wells.... 47

Figure 16. Pumpage for Wells #1 and #2................. 48

Figure 17. Pumpage for Well #3......................... 50

Figure 18. Pumpage for Well #5......................... 51

Figure 19. Frequency distribution of water level elevations in Genesee area wells............. 52

Figure 20. Water levels during pumping and non-pumping for Well #5......................... 54

Figure 21. Water levels during pumping and non-pumping for Well #3......................... 55

Figure 22. Nitrate sampling summary ('78-'94)........... 57

Table 2. Nitrate sampling summary for Genesee......... 59

Table 3. PCE sampling summary for Genesee............. 60

Figure 23. PCE sampling summary ('89-'94)............... 61

Figure 24. Areal distribution of recharge for the Moscow-Pullman area......................... 65

Figure 25. Map showing areas for development of new upper aquifer wells..................... 73

Figure 26. Well construction designs for the city of Genesee......................... 77

CHAPTER 1

INTRODUCTION

Statement of Problem

Genesee, located in northern Idaho, depends solely on ground water for its municipal water supply. The water used by the city is currently pumped from two municipal wells. The aquifer that yields water to these wells is located within the Wanapum Formation of the Yakima Basalt Subgroup of the Columbia River Basalt Group (Swanson and others, 1979). Water samples taken from one of the city wells have consistently shown the presence of nitrates and tetrachloroethylene (PCE) with levels sometimes above the regulation limits set by the Idaho Division of Environmental Quality (DEQ). A second well has had an apparent decrease in yield since its construction in 1980. Together, these concerns have prompted Genesee to have the ground-water resources in the area evaluated. This thesis is an assessment of the potential for long-term ground-water use for the city of Genesee, Idaho.

Purpose and Objectives

The purpose of this study is to provide a report to serve as the basis for long-term water planning for the city of Genesee. The general objective is to analyze ground-water development potential in the Genesee area. Specific objectives include:

1) Assemble and review available literature.
2) Describe the regional hydrogeological setting.
3) Describe the study area hydrogeological setting.
4) Compile, present, and evaluate results from a well inventory and water level measurements.
5) Develop a hydrogeologic conceptual model.
6) Analyze the development potential.
7) Present conclusions, results, and recommendations.

Method of Study

Review of Literature

Ground water investigations in the Genesee area were conducted by Bond (1962), Ralston (1972), and Bond and Kauffman (1979). These reports discuss the availability of ground water in the vicinity of Genesee. A report by Walters and Glancy (1979) on the geology and ground-water occurrence in Whitman County, Washington, also provides information applicable to the study area.

Camp (1978), Hooper and Webster (1982), and Rember and Bennett (1979) provide surficial and geological maps of the area. The stratigraphy of the Columbia River Basalt Group is discussed by Swanson and others (1979), Reidel and others (1989), and Bush and Seward (1992). Anderson (1991) and Bush and Seward (1992) provide discussions on the geology of the area. Jones and Ross (1972), Eyck and Warnick (1984), Baines (1992), Kopp (1994), Cohen (1979), Luzier and Burt (1974), and Smoot (1987) provide discussions on the local hydrogeology.

A report by W.E. Thompson and Associates (1979) provides pumpage data for Genesee. Data for pumpage, water quality, and well construction, were obtained from the city of Genesee, Wyatt-Jaykim Engineers, and the Idaho DEQ.

Compilation of Geological Data

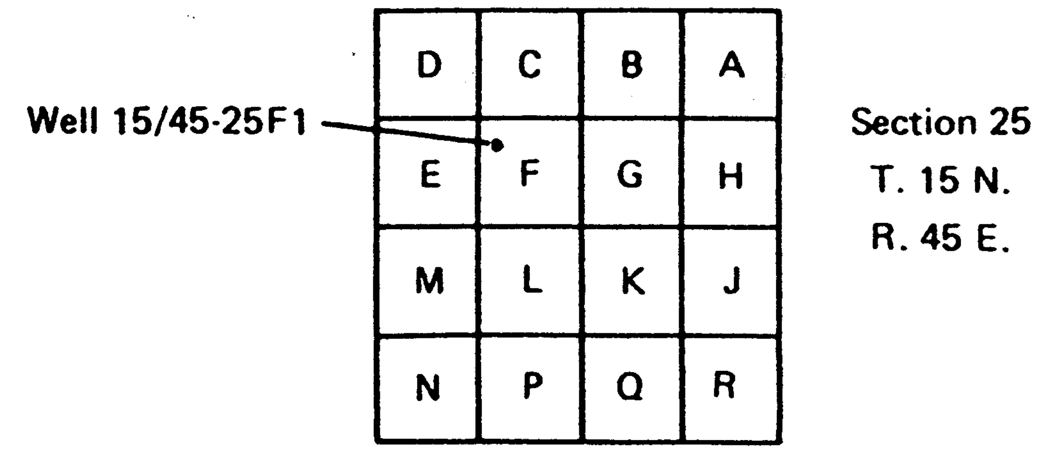
The collection of geologic data included the location and sampling of outcrops, a chemical analysis of the rock samples, the compilation of data from published geologic maps, and a comparison of well logs. Outcrops were sampled in several locations around Genesee and the elevation of each was documented. Representative samples were sent to the geoanalytical lab at Washington State University (WSU) for chemical analysis under the direction of Peter Hooper. The information obtained was used to compile 7½ minute geologic quadrangle maps for the study area. Information presented by John Bond in his analysis of the well logs and cuttings from Wells #6 and #7 were used in constructing cross-sections and in compiling geological information for the study area (Bond, 1994).

Well-numbering System

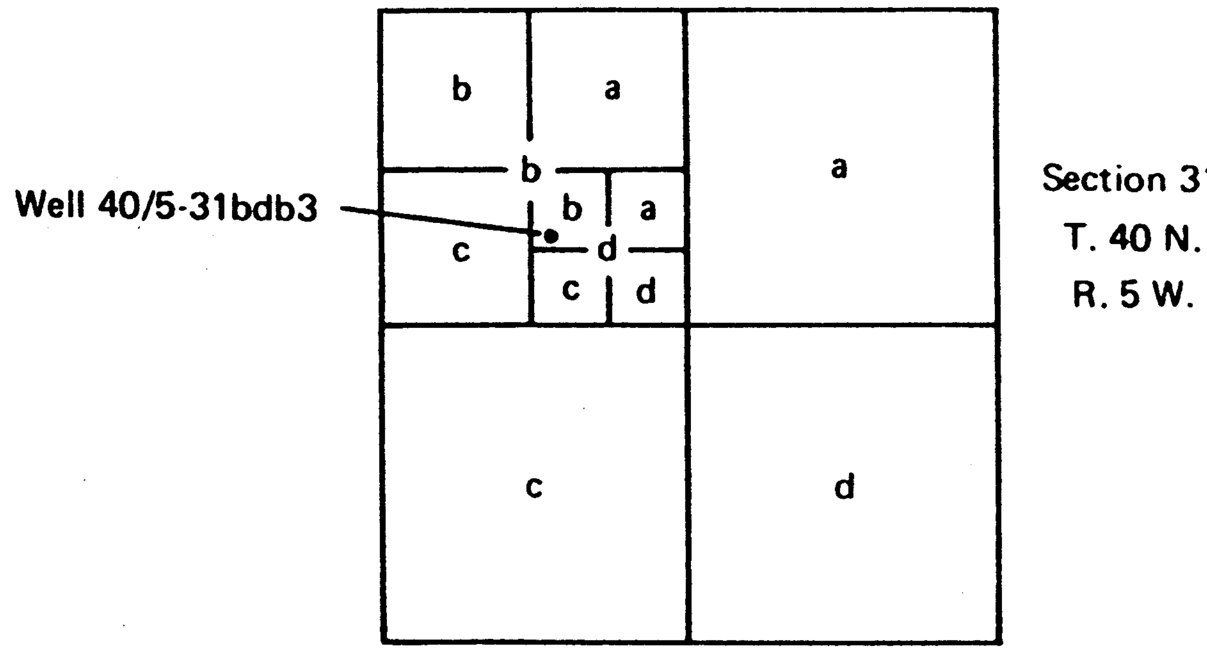
Idaho and Washington identify wells on the basis of the township and range system, but divide the sections differently. Idaho wells are referenced to the Boise baseline and meridian. Both States identify the township, range, and section of the well and use letter codes to divide the quarter-quarter sections. In Washington, quarter-quarter sections are divided by letters in a similar manner to which sections are numbered in a township. Letters begin in the northeast corner and wind around in alphabetical order. In Idaho, quarter-quarter sections are lettered counter-clockwise. The same method is used for quarter-quarter and quarter-quarter-quarter sections. This letter code is then added to the township-range-section number to provide a location for the well. If there is more than one well in the smallest subdivision, then these several wells are numbered usually in order of drilling. Examples of the well-numbering systems are shown in **figure 1**, for Washington well 15/45-25F1 and Idaho well 40/5-31bdb3 (Lum and others, 1990).

Field Inventory

A database of approximately 110 wells within the general Genesee area was established using well logs obtained from the



Well Numbering System of Washington



Well Numbering System of Idaho

Figure 1 Well-numbering Systems of Washington and Idaho.

Idaho Department of Water Resources (IDWR) in Coeur d' Alene, Idaho. Well information and locations were confirmed by visiting well sites in the Genesee area. Well drillers were contacted in order to locate well information unavailable to owners.

A field study was conducted to subsidize the database for wells not on file. An electrical-tape was used to determine the depth to water in accessible wells, and land surface elevations were determined by plotting the well locations on contour maps. Data for wells where well logs are not available were gathered from the owners. The field study included regular measurements of water levels in Wells #3, #5, and #6, in addition to the collection of city pumpage data.

Analyses of Data

Water level, pumpage, and water quality data were analyzed for the ground-water system in Genesee. Analysis was focused on determining the existence of long-term trends with respect to water levels, annual pumpage, and contaminant levels. To determine the availability of ground water in the area, recharge to and discharge from the aquifers underlying Genesee were investigated.

Well Potential and Design

All of the information gathered in the course of study was compiled and analyzed to evaluate potential drilling sites and designs for a new city well. Geological information was used to aid the process of well location. Hydrological information was coupled with the geology to suggest locations where a well has a good probability to produce large amounts of high quality water. Geology and hydrology were incorporated into the construction of well designs.

General Description of Genesee Area

The Genesee-Uniontown area is located in northern Idaho and southeastern Washington. The area includes parts of Latah and Nez Perce Counties in Idaho, and a portion of Whitman County in Washington. The area around Genesee that was studied in detail covers approximately 120 square miles and is outlined on (**figure 2**). The boundaries shown on the figure are general representations of geologic features except for the western boundary. The portion of the Genesee-Uniontown area beyond the western boundary was studied on a reconnaissance level only and is not included in the study area.

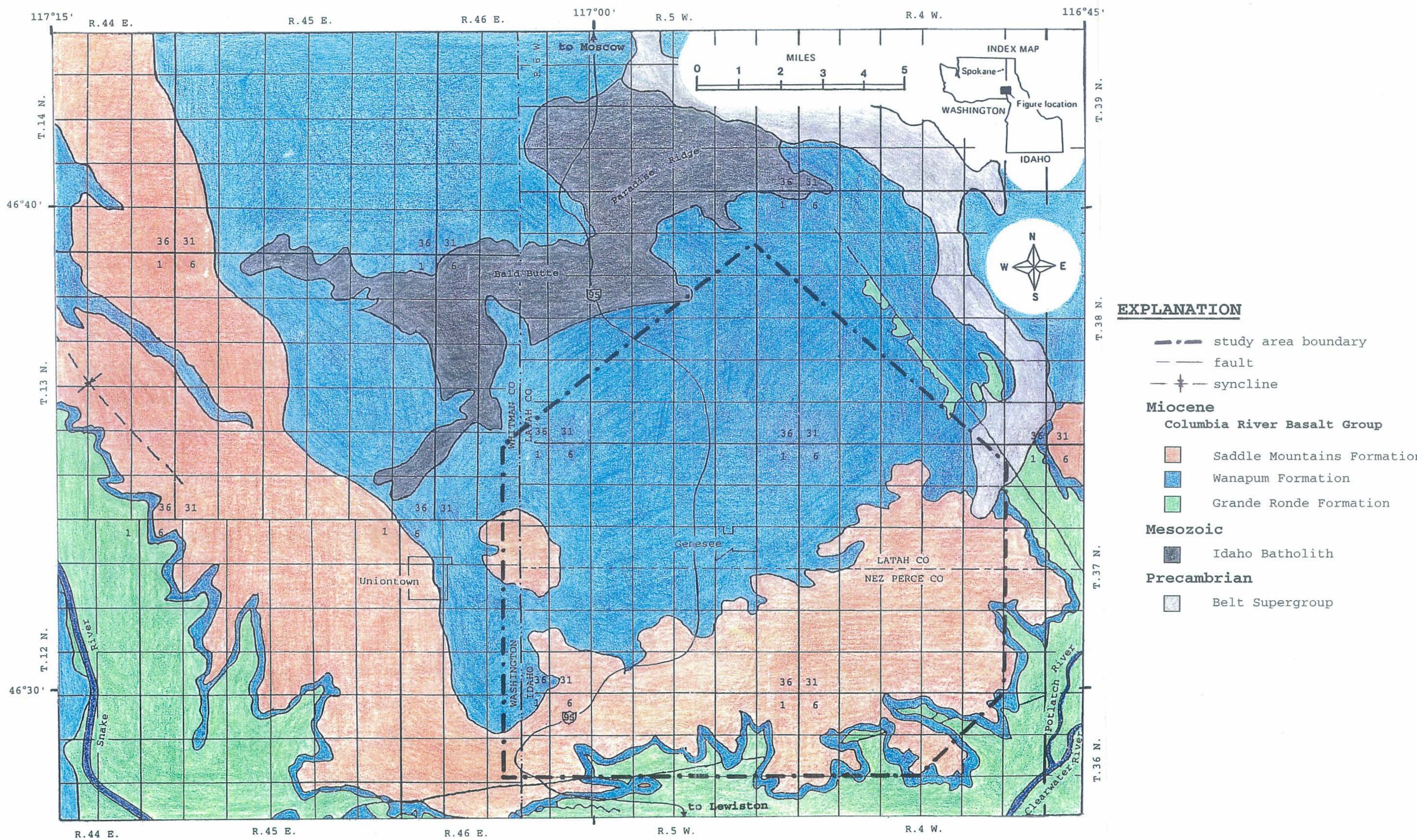


Figure 2 Location map and bedrock geology of the Genesee-Uniontown area (after Swanson and others, 1979).

CHAPTER 2

REGIONAL HYDROGEOLOGY

Introduction

The geological compositions, stratigraphic positions, structural orientations, and thicknesses of rock and sediment units control the rate and direction of ground-water flow. Presuming that hydrogeological characteristics can be applied from local areas where the stratigraphy is well defined to the study area, the geology, stratigraphy, and structure become important in the formulation of a hydrogeological conceptual model.

General Geologic Setting

The basins along the eastern margin of the Columbia River Basalts in northern Idaho and southeastern Washington have similar geological compositions. The basins are generally composed of a sequence of basalt flows lapping on older granitic and metamorphic rocks. The areal extent of this sequence of Columbia River Basalt flows can be seen in **figure 3**.

The Columbia River Basalts commonly have interbedded sediments and are overlain by sediments at their margins.

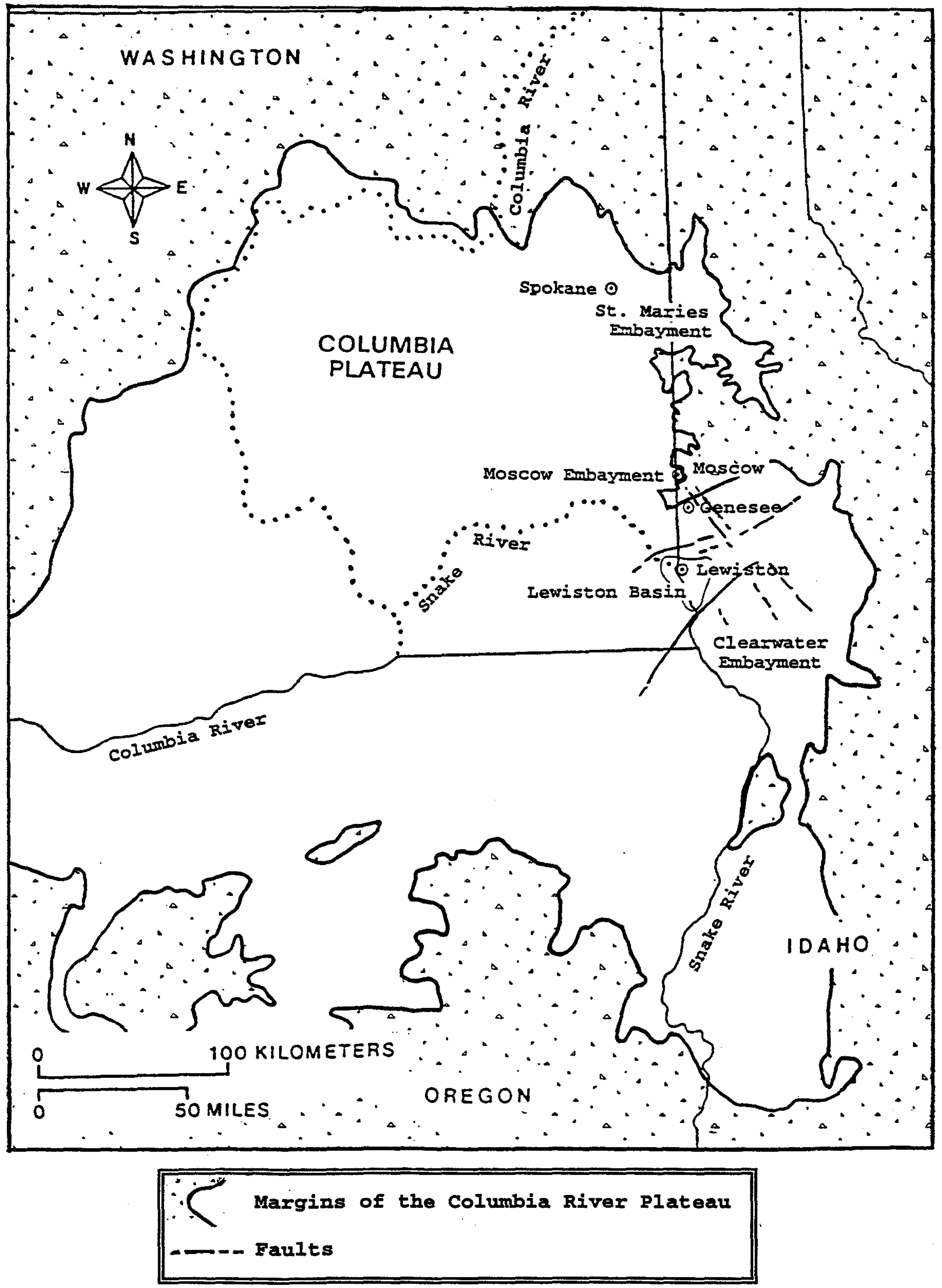


Figure 3 **Areal extent of the Columbia River Basalt Group and associated faults of the Clearwater embayment** (after Rember and Bennett, 1979, Fecht and others, 1987, and Hooper and Swanson, 1987).

Sediment interbeds form as lava flows dam streams, resulting in lake deposition (Camp and others, 1982), or form as weathering processes change the physical characteristics of the basalt before it is covered. In the general area that includes Genesee, Moscow, Pullman, and Colfax, overlying sediments and erosional features dominate the topography; hills are formed by loess (Lum and others, 1990) and deep canyons are eroded in the basalt.

General Stratigraphy

The stratigraphy of the northern Idaho and southeastern Washington region is typically explained in terms of three units; basement rock, basalt, and overlying sediment. Underlying the region is basement material composed of intrusive and meta-sedimentary rocks. Covering the basement rocks are numerous basalt flows that comprise the Columbia River Basalt Group (CRBG). The thickness of the basalt sequence varies depending on the specific location, but total thicknesses average 1,300 to 3000 feet (Walters and Glancy, 1969). Individual flows that comprise the basalt sequence range from tens to hundreds of feet thick (Lum and others, 1990). The loess dunes that form the uppermost geologic unit have a typical range in thicknesses from 0 to 300 feet (Lum and others, 1990). A generalized stratigraphic section for the Genesee-Uniontown area is provided in **figure 4**.

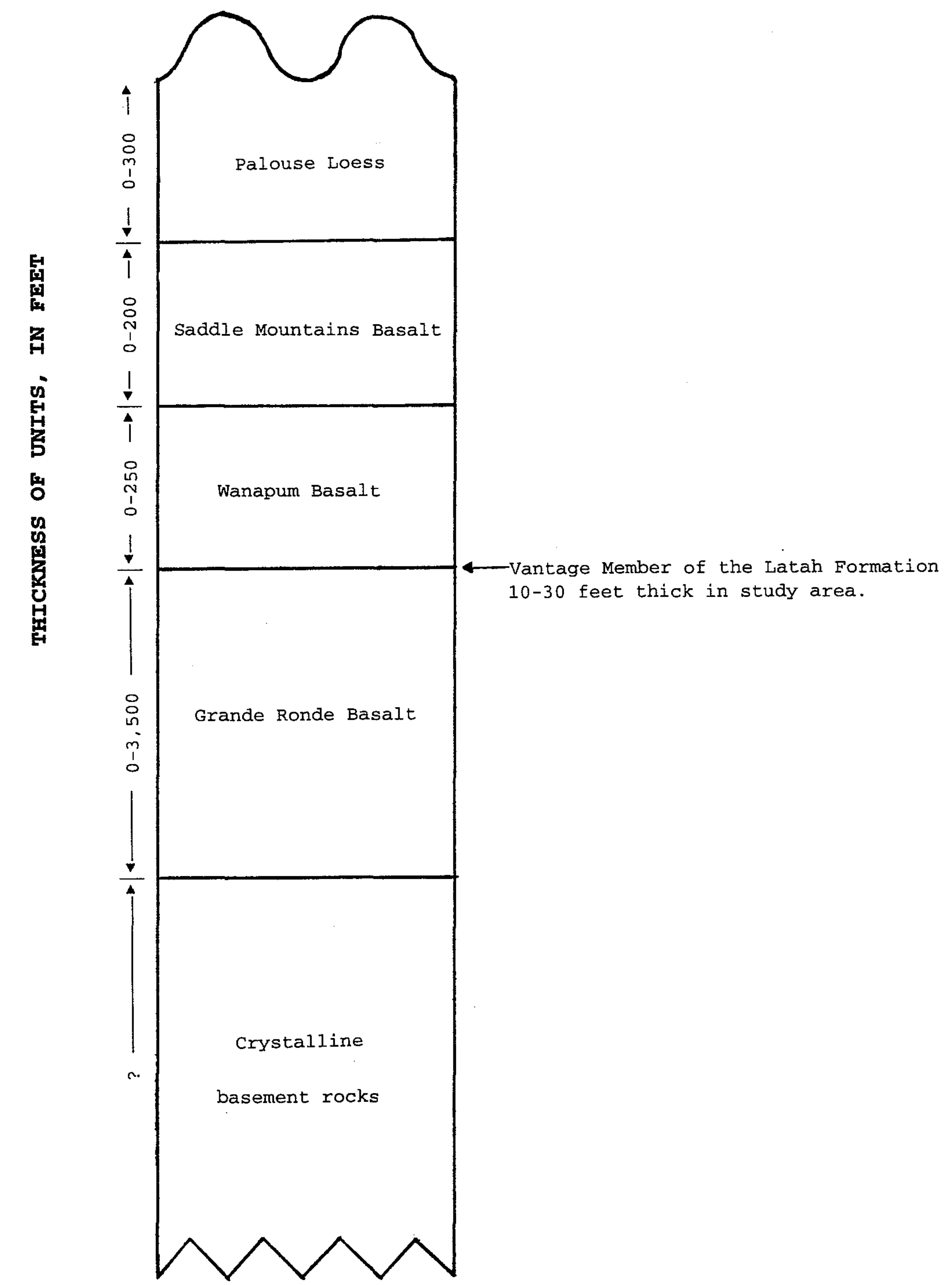


Figure 4 **Generalized stratigraphic section for the Genesee-Uniontown area** (after Kopp, 1994).

General Structure

The general structure within the northern Idaho and eastern Washington region is determined by the external and internal physical characteristics of the CRBG and its associated structural disconformities. External characteristics determine large scale features such as the lateral extent of a flow or its regional dip. Internal characteristics are based on the cooling history of an individual flow and determine its appearance in cross-section. Structural disconformities caused by faulting or folding also play a very important role in the regional structural setting.

The extent to which a basalt flow spreads is an external characteristic that varies from one basalt flow to the next. Variation is largely dependent upon the volume and viscosity of the material that is extruded. Flows that have great volumes and that spread over large areas are laterally extensive. Flows with small volumes will tend to fill channels, valleys, or depressions as they extrude from feeder dikes. Small volume viscous flows are usually channel-filling flows while large volume viscous flows are locally extensive and have great thicknesses.

Regional dip is common in places where the basalt flows are laterally extensive and lap onto basement rock, thin as they spread, or are deformed by faulting or folding. In the areas near Genesee that are covered by the CRBG, the upper surface of the basalt flows commonly show deviation from horizontal in response to one or more of these processes.

Most basalt flows exhibit similar internal physical characteristics. Vesicular or scoraceous zones are formed at the top and bottom of the flows. In the center portion of the flows, where slow cooling occurred, vertical hexagonal columns form. This portion of a flow is called the colonnade. Above the colonnade and extending to the vesicular top of the flow, is the entablature. The entablature is characterized by much smaller columns in the form of fans having no particular orientation.

Faults in the Clearwater embayment of northern Idaho and those associated with the Lewiston Basin are shown in **figure 3**. The major trend appears to have a northwest-southeast orientation. A second trend has a general northeast-southwest orientation (Rember and Bennett, 1979). The northwest-southeast trend is represented south of Genesee by an east-west trending fault series associated with the Lewiston Structure.

General Hydrogeology

The general hydrogeology of the Palouse region in northern Idaho and eastern Washington is understood relative to the water-yielding capacities of the stratigraphic units and the characteristics of the local aquifers. A discussion of the well yields and water level declines of the local aquifers helps in the construction of a hydrogeological conceptual model that is applicable throughout the region.

Water-yielding Capacities

The four units discussed with respect to their water-yielding capacities are the crystalline basement rocks, the basalts, the sediment interbeds, and the loess soil. The water-yielding capacity of the crystalline basement rocks are limited because the hydraulic conductivity related to fracturing and weathering is small. In general, wells completed in this unit can only be pumped at rates up to 5 gallons per minute (gpm) (Kopp, 1994) and are mostly used for watering stock or for single household use only (Lum and others, 1990).

The basalt flows form a layered aquifer system that can yield significant quantities of water to wells. The basalt flow centers, including the colonnade and entablature, generally have low vertical and horizontal hydraulic conductivity and yield small amounts of water. The flow tops and bottoms have a complex set of fractures and vesicular zones. Large quantities of water can be obtained from these zones. The yield of a well increases as more of these flow contacts are penetrated (Lum and others, 1990).

Sediment interbeds produce significant quantities of water in specific areas of the region where the material is coarse grained. Wells that pump from these interbeds can have yields as high as several hundred gallons per minute (Moscow City Well #3).

The loess soil that covers the area has a high storage capacity and provides a low yield source of water for domestic and farm wells. Yields vary from 0 to 30 gpm (Baines, 1992).

Local Aquifers

Municipal water supplies for the Palouse region are generally obtained from two aquifers; an upper aquifer associated with the Wanapum Basalt, and a lower aquifer occurring in the Grande Ronde Basalt. These aquifers have been developed extensively in the Moscow-Pullman and Lewiston-Clarkston areas and have experienced water level declines in Moscow and Pullman.

The first municipal wells drilled in Moscow and Pullman were completed in the Wanapum Formation in the early 1890's. Well depths are in the 150 to 350 foot range and, where water-bearing sediment interbeds are present, yields are on the order of several hundred gallons per minute. These coarse grained sediments occur primarily in the Moscow area (Smoot, 1987).

The extensive development of the Wanapum Aquifer in the Moscow-Pullman area changed the balance of the local ground-water system. Even though changes in recharge and natural discharge were probably not observed, discharge in the form of pumpage was significantly increased. The increased pumpage caused water levels in the Moscow Basin to drop from near land surface at about 1890 to almost 120 feet below land surface by the 1960's (Jones and Ross, 1972).

Changes in recharge and natural discharge were probably not observed because increased pumpage would have little effect on recharge rates and amounts and would only reduce the natural discharge slightly. Recharge to the Wanapum Aquifer comes from precipitation which infiltrates through the overlying Palouse Formation (Kopp, 1994). Natural discharge occurs to seeps where the basalt is truncated (Cohen, 1979), to streams where they have cut down into the aquifer, as downward ground-water movement through fractures and discontinuities to the Grande Ronde Basalts, and as lateral flow. Natural discharge probably decreased, but quantitative measurements were not attainable.

The Grande Ronde Aquifer was developed in the 1950's and 1960's as the main aquifer which serves the communities of Moscow, Pullman, Lewiston, and Clarkston. Water is produced dominantly from the flow contacts between the Grande Ronde flows. **Figures 5 and 6** show well data for the Pullman-Moscow area and several producing zones common to many of the municipal wells. **Figure 7** shows a comparison of Moscow, Pullman, Lewiston, and Clarkston wells. Shown are the depths, yields, producing zones, and interpreted relative position of the

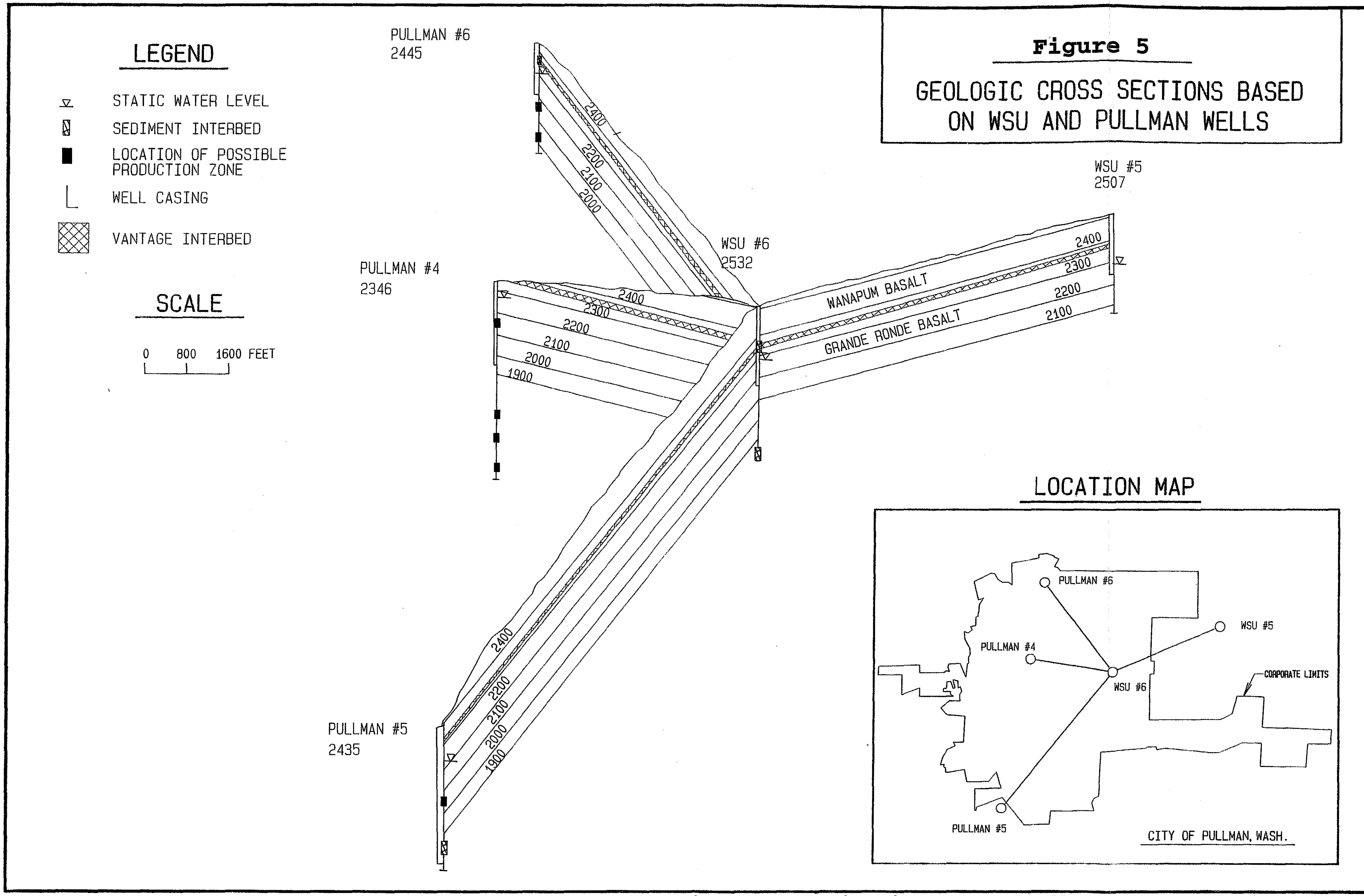


Figure 5 **Geologic cross-section based on Washington State University (WSU) and Pullman wells**
(from Wyatt-Jaykim Engineers and Ralston, 1986).

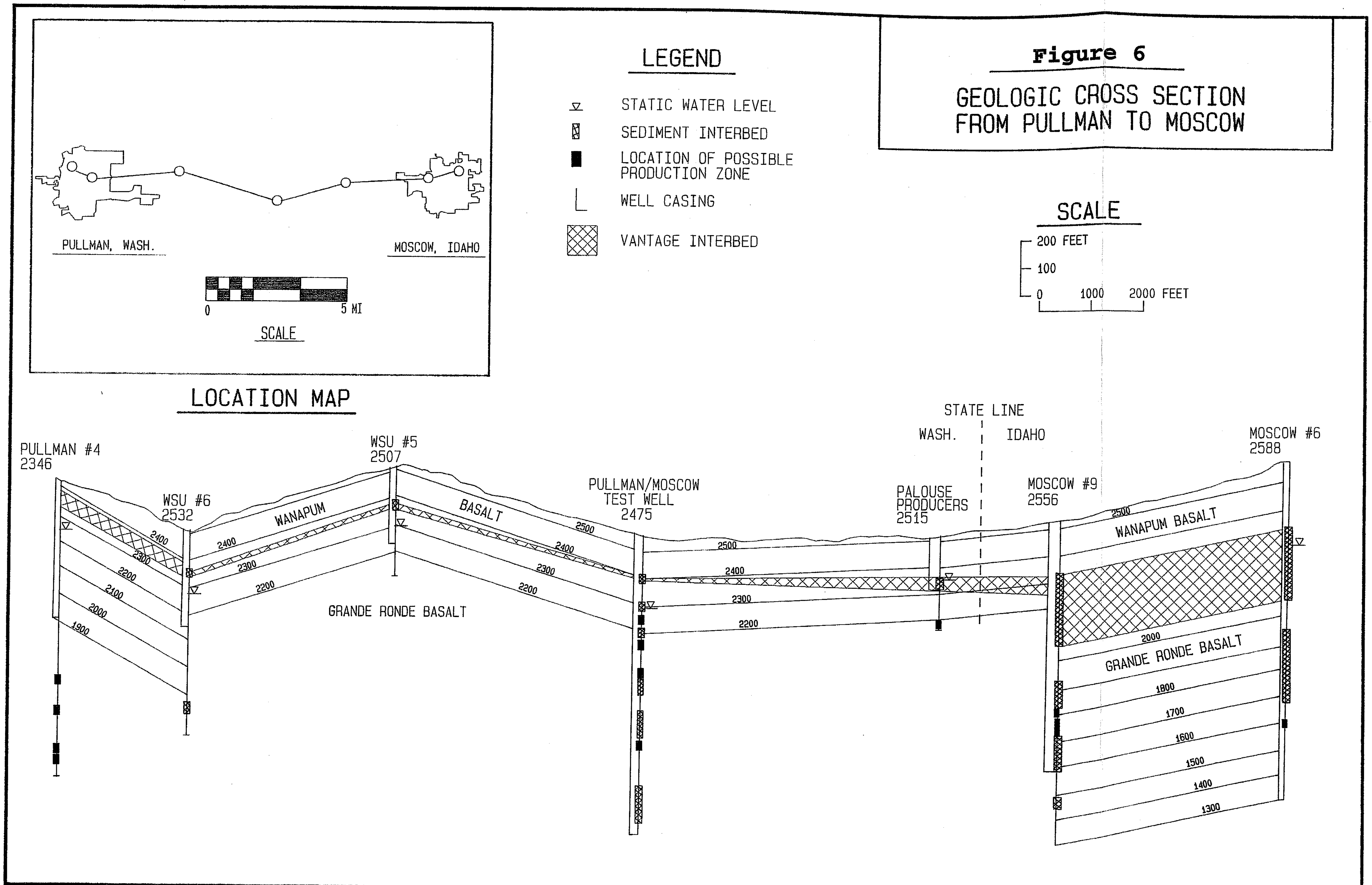


Figure 6 **Geologic cross-section from Pullman to Moscow** (from Wyatt-Jaykim Engineers and Ralston, 1986).

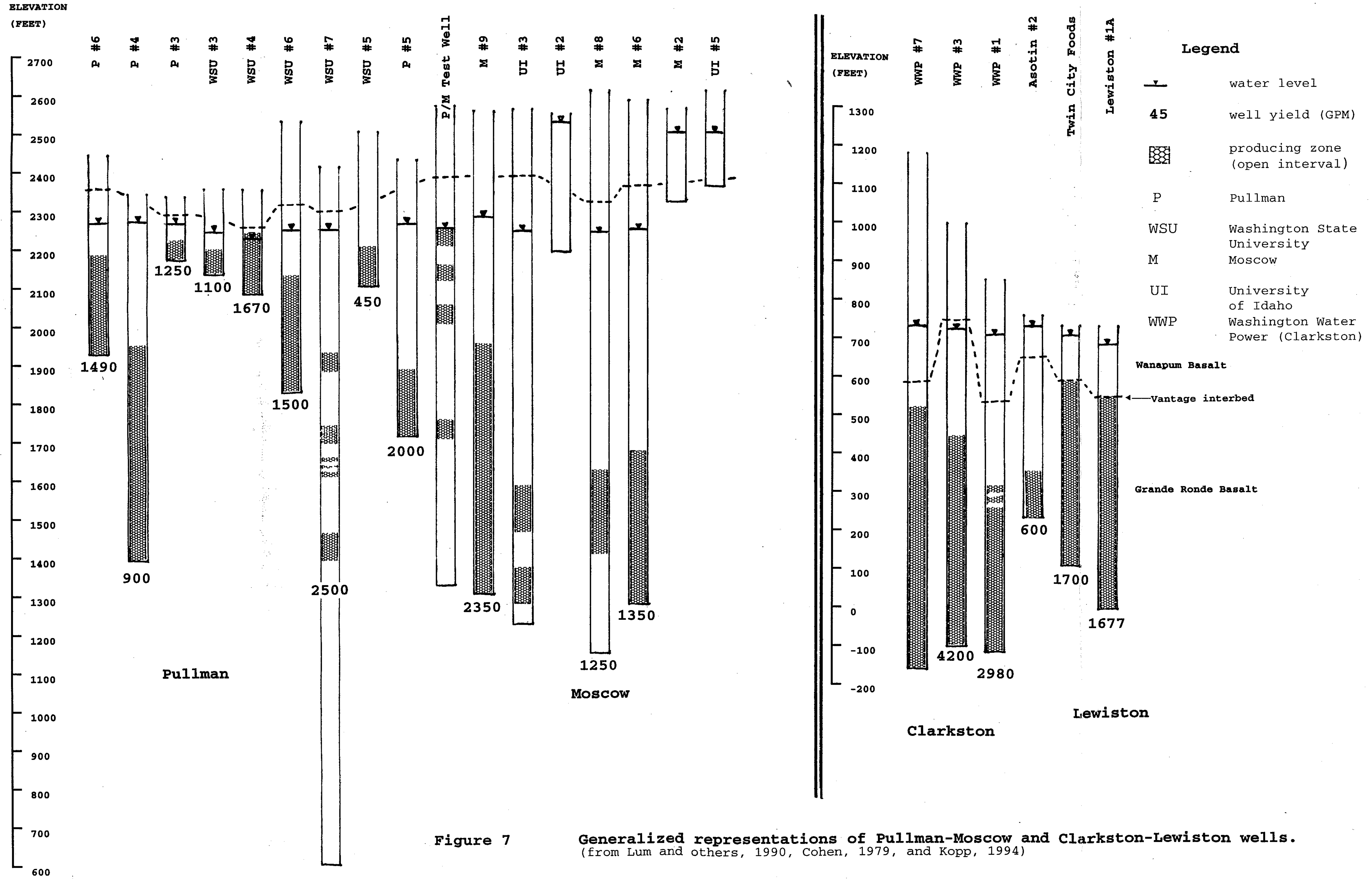


Figure 7 **Generalized representations of Pullman-Moscow and Clarkston-Lewiston wells.**
(from Lum and others, 1990, Cohen, 1979, and Kopp, 1994)

Vantage Interbed. Deep wells in Pullman penetrate the Grande Ronde Formation 500 to 1000 feet below the Vantage Interbed and are pumped at rates from 900 to 2500 gpm. In Moscow, Lewiston, and Clarkston, penetration depths are similar, but yields range from 400 to 4000 gpm. Data from all of these wells indicate that high producing zones within the upper 1000 feet of the Grande Ronde occur throughout the region.

Water levels in the Grande Ronde Formation in the Moscow-Pullman Basin have declined at a rate of 1 to 2 feet per year in response to pumping since the 1960's on the order of 7 million gallons per day (Lum and others, 1990). Water levels in the Lewiston-Clarkston area have not declined because of a hydraulic connection of the aquifer with the Snake and Clearwater Rivers.

CHAPTER 3

STUDY AREA HYDROGEOLOGY

Introduction

A hydrogeological conceptual model is formulated in order to develop a long-term plan for ground-water use in the Genesee area. The model is based on correlations with the Moscow-Pullman and Lewiston-Clarkston areas, where the geology and stratigraphy, structure and composition of the rock units, and aquifer characteristics are similar to those of the Genesee area.

Definition of Study Area

The Genesee-Uniontown area is located on the northern edge of the Clearwater embayment near the margin of the Columbia River Basalt Group (CRBG). The study area boundaries are generally defined by the location of the basement ridges to the north and the canyons in the south and east. The western boundary is not hydrogeologically defined and represents the limits of the well inventory investigation.

Study Area Geology and Stratigraphy

The geologic setting in Genesee is representative of the general geologic setting in the areas near the Clearwater embayment. In these areas there are four major stratigraphic units; crystalline basement rocks, Grande Ronde, Wanapum, and Saddle Mountains Basalts. In addition to these units are interbedded and surficial sediments not shown in **figure 2**. Based on well logs, maps, outcrop locations, and rock samples, all of these stratigraphic units are present in the Genesee area.

Basement Composition

The two types of basement rock that form the mountain ridges north of the study area are the Belt Supergroup and Idaho Batholith rocks. The Belt Supergroup rocks include quartzites and garnet-biotite gneisses. These rocks are approximately 230 to 500 million years (m.y.) old and were formed in the Precambrian Era (Anderson, 1991). They are located northeast of the study area where they form Tomer Butte and its southeast extension.

The Idaho Batholith rocks are meta-sedimentary and intrusive rocks classified as quartz diorites and syenites (Anderson, 1991). This group of Cretaceous granitic rocks has an approximate age of 70 to 150 m.y. and marks the northwest boundary of the study area near the base of Paradise Ridge.

Basalt Sequence and Vantage Formation

In Latah County the CRBG is divided from base upward into the Imnaha, Grande Ronde, Wanapum, and Saddle Mountains Basalts. The Grande Ronde Formation, Vantage Member of the Latah Formation, and Wanapum Formation occur as continuous layers over the study area. Each of the CRBG formations is made up of a number of flows that are differentiated by their relative age, chemical composition, and physical appearance. The Vantage Member of the Latah Formation is a layer that separates the Grande Ronde and Wanapum Formations. Weathered zones or sediment layers of this type often result from long quiescent periods between basalt flows. A detailed stratigraphic section of the Columbia River Basalt Group is presented in **figure 8**.

The Imnaha Basalts are interpreted by Hooper and Swanson (1987) to be approximately 17.5 million years (m.y.) old. This group of flows is laterally extensive and was extruded from feeder dikes south and west of the study area (Swanson and others, 1979). Near the study area these basalts are only seen in the deepest canyon cuts of the Clearwater River. There is no evidence suggesting that the Imnaha Formation underlies Grande Ronde Basalt in the Genesee area.

The Grande Ronde Formation overlies the Imnaha Formation and is composed of aphyric and fine grained basalts that have been age dated between 15.6 and 17.0 m.y. (Reidel and others, 1989). The Grande Ronde Formation is divided into four units

Epoch	Group	Formation*	Age (m. y.)	Member**	Flows	Magnetic Polarity***	Some Approximate Correlations
Early to Late Miocene	Columbia River Basalt Group	Saddle Mountains Basalt (<1%)	6	Lower Monumental		N	
					Tammany Creek		
				Ice Harbor	Goose Island	N	
			8.5		Martindale	R	
					Basin City	N	
				Buford		R	
			10.5	Elephant Mountain		N-T	
				Swamp Creek			Craigmont, Grangeville, Windy Ridge
			12	Pomona		R	Icicle Flat Member
				Esquatzel		N	
				Weissenfels Ridge	Slippery Cr.	N	Eden flow
					Tenmile Cr.	N	
					Lewiston Orchards	N	
					Cloverland	N	
				Asotin		N	
				Wilbur Creek	Lapwai	N	
				Umatilla	Sillusi	N	
					Umatilla	N	
		Wanapum Basalt (5-10%)		Priest Rapids	Lolo	R	Cricket Flat
					Rosalia	R	Powatka
				Roza		T	
				Frenchman Springs		N	Shumaker Cr.
				Eckler Mountain	Lookingglass	N	
					Dodge	N	
					Robinette Mountain	N	
			14.5				← Vantage interbed
		Grande Ronde Basalt (>85%)				N_2	Picture Gorge
						R_2	
						N_1	
						R_1	
			16.5				
		Imnaha Basalt (5-10%)		Rock Creek and American Bar types interleaved			
			17				

*Showing approximate volume as percent of Columbia River Basalt Group.
**Informal magnetopolarity units in Grande Ronde Basalt.
***Magnetic Polarity (N = normal; R = reversed; T = transitional).

Figure 8 **Stratigraphy of the Columbia River Basalt Group of the eastern Columbia Plateau.** (after Hooper and Swanson, 1987).

based on changes in magnetic polarity. From oldest to youngest, the flows of the Grande Ronde are designated R1, N1, R2, and N2. The R1 and R2 series of flows were extruded at a time when the earth's magnetic poles were reversed from normal. The N1 and N2 basalts were extruded during times of normal polarity. The N2 series is not present in the study area due to its limited lateral extensiveness. The R2 flows are thus the uppermost series of Grande Ronde Basalts found in the study area.

The total thickness of the Grande Ronde Basalts in the Genesee area is unknown because no well has been drilled in the immediate area that fully penetrates this formation. The base of this unit was found to be at a depth of about 1,300 feet in Moscow and about 2,300 feet in Pullman.

The Vantage Member of the Latah Formation is approximately 15.4 m.y. old. This interbed is a sedimentary zone of irregular and varying thicknesses that was formed as a result of weathering and associated sediment deposition between the Grande Ronde Formation and the overlying Wanapum Formation. The Vantage Member typically consists of siltstone, claystone, or tuffaceous rock (Swanson and others, 1979) and is approximately 20 feet thick throughout the study area.

The Wanapum Basalts overlie the Vantage Formation and are approximately 14.0 m.y. old (Hooper and Swanson, 1987). From oldest to youngest, the four members present in eastern Washington are the Eckler, Frenchman Springs, Roza, and Priest Rapids Members. Only the Priest Rapids Member is present in the Genesee area. This member consists of at least two reversed magnetic flows having a total thickness of approximately 140 feet (Swanson and others, 1979). These basalts filled stream channels and other weathering features in the surface of the Vantage Formation. This resulted in an irregular bottom flow surface. The flow top is relatively uniform due to the large thicknesses of the Priest Rapids flows.

The Wanapum Basalts are physically and geochemically different from Grande Ronde Basalts. They are typically coarse grained, having abundant plagioclase and olivine phenocrysts, and generally have higher titanium concentrations and lower magnesium concentrations (Camp and others, 1982).

The Saddle Mountains Formation is the youngest unit of the CRBG and was extruded over a period from approximately 14.0 to 6.0 m.y. ago (Swanson and others, 1979). This formation is composed of ten members, but only three members are believed to be present in the study area. The identified members, from oldest to youngest, are the Wilbur Creek, Asotin, and Weissenfels Ridge Members. These basalts originated from sources in the upper North Fork of the Clearwater River and are interpreted by Camp and others (1982) to have flowed westward, filling ancestral drainages of the Clearwater and Snake Rivers. The thickest parts of these flows appear to coincide with an ancestral Clearwater River channel located north of the present-day river channel. The extent of these flows is truncated by the canyons south of Genesee.

The individual flows of the Saddle Mountains Basalts range from 0 to 140 feet thick. These basalts are mostly aphyric and appear similar to the Grande Ronde Basalts in field specimens, but are geochemically distinct from both the Grande Ronde and Wanapum Basalts.

Sediments

During the Pleistocene Era a fertile layer of loess, known as the Palouse Formation, was deposited over the area by prevailing winds. The fine grained sediment originated from soils in the Pasco basin approximately 95 miles to the west.

Other sediments present in the study area are alluvium deposited by streams. These sediments are located on the flood plains of Cow Creek and its tributaries.

Study Area Structure and Compositional Features

From well logs and information gleaned from field studies, several deformational structures are observed in the Genesee area, including regional dip and faults. In addition to the deformational structures present in the study area, compositional features described as pillow-palagonite structures also exist.

Hooper and Swanson (1987) state that isostatic adjustment and the subsequent rise of the Idaho Batholith and related plutonic bodies caused regional dip in northern Idaho. The directions of the dip, away from the ridges of basement rock, are consistent with observations in the study area.

A cross-section created through Genesee from well logs and geological maps, shows a regional dip toward the south. (**figure 9**) In this cross-section, the Vantage Interbed is used as a geologic marker because it separates the Grande Ronde Basalts from the Wanapum Basalts. In the well logs, a variation can be observed in the elevation of this unit as you move from south to north. Two miles south of Genesee the Vantage elevation is approximately 2520 feet (AMSL). In Genesee this contact is about 2560 feet (AMSL). Approximately two miles north of town the contact is about 2610 feet (AMSL).

There are insufficient data to show an eastward or westward component to the regional dip. From the large scale trends in the Clearwater embayment, however, a slight westward component is suggested (Bush, 1994).

The presence of faults in the study area is difficult to determine because of the small number of outcrops. A fault is speculated in the vicinity of Cow Creek, north of Genesee, similar to the one bordering the northeast portion of the study area (Bush, 1994). It is uncertain if the faults mapped north of the Lewiston Basin have any significance to the Genesee study area.

In Genesee there is lateral variation in the composition of the Priest Rapids flow. This variation in composition is shown by the comparison of well logs and yields for the city wells; (**figure 10**) large changes in well productivity occur on the

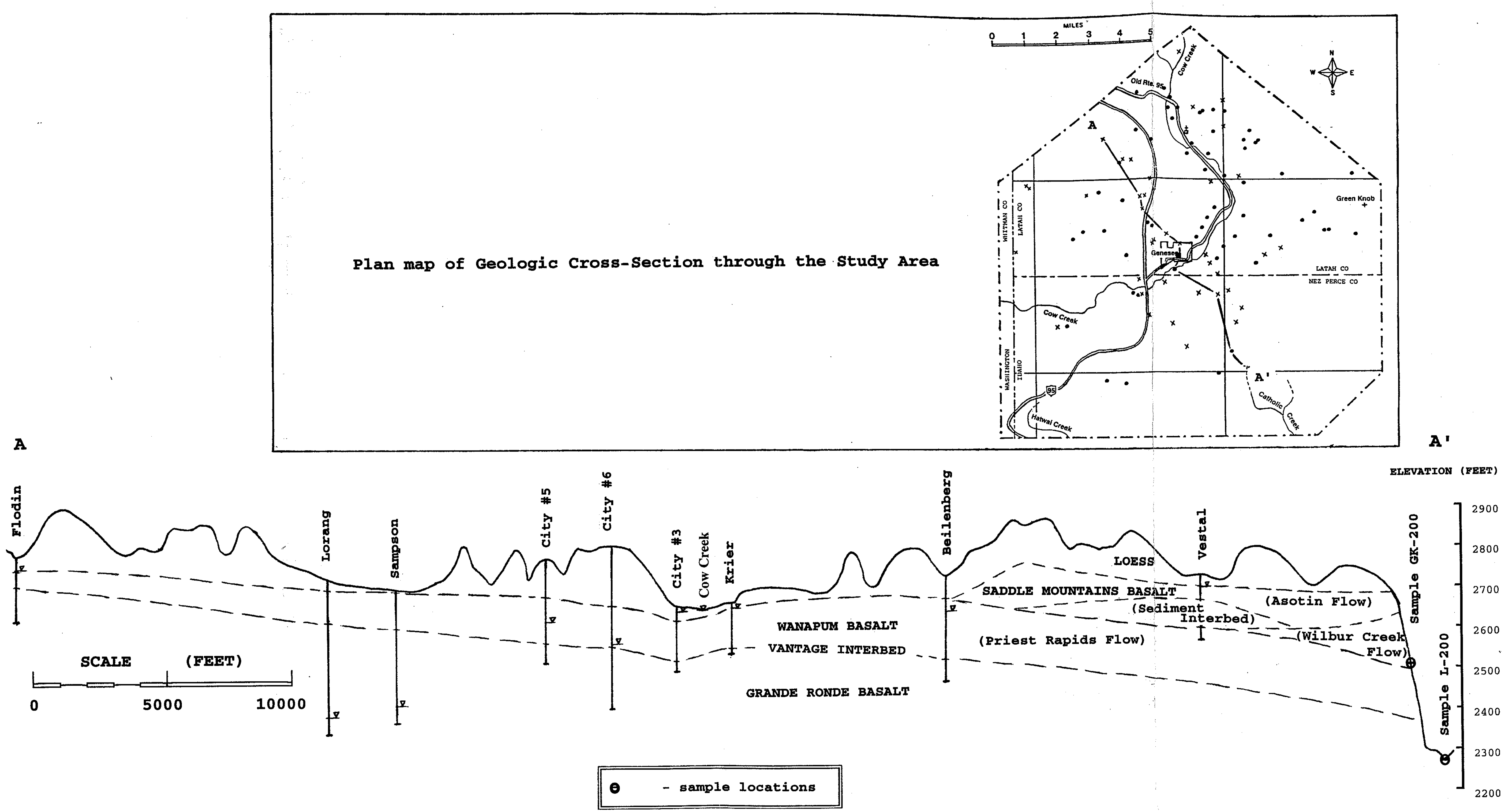


Figure 9 Generalized northwest-southeast geologic cross-section through the study area.

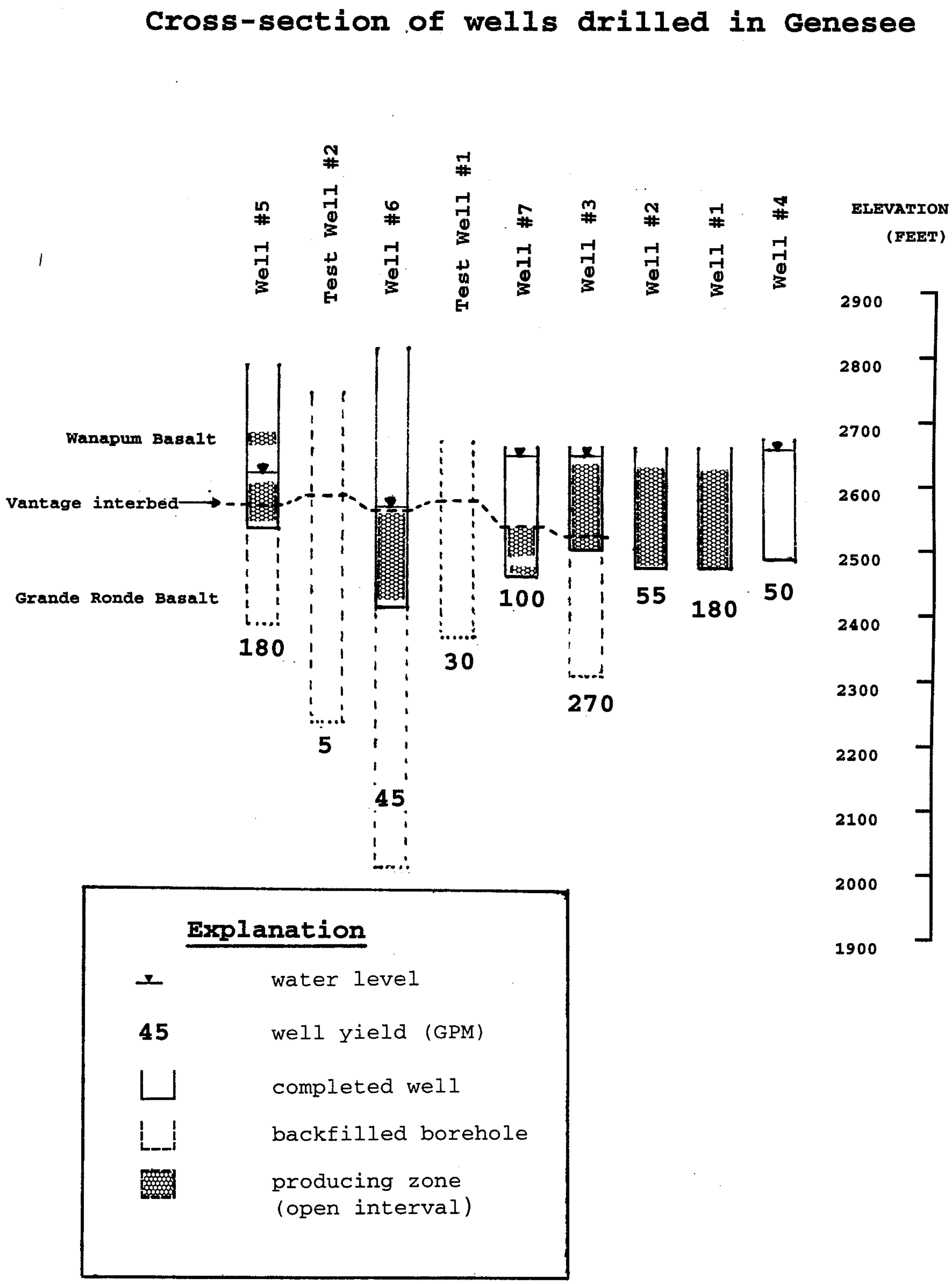


Figure 10 **Generalized cross-section of wells drilled for the city of Genesee.** (see Fig. 12 for locations)

scale of a few city blocks. These changes in yield seem to correlate strongly with changes in geology and the presence of pillow-palagonite structures (Bond, 1994). These structures are formed at the advancing edge of a basalt flow as the fluid lava comes in contact with water or wet, unconsolidated sediments (Camp and others, 1982); the basalt chills rapidly to form a fractured, porous rock. Lateral variability in rock composition is caused by the distribution of small streams or ponded water as the basalt flow invades an area.

Evidence of the lateral compositional variation and the site specific presence or absence of the pillow lavas is seen in comparisons of Well #3 to Test Well #1 and of Well #5 to Well #6. Although the rock units in the well logs are common to both sets of wells, the compositions vary enough in a few hundred feet to cause well yields to differ significantly. The compositional variation is observed in Wells #3 and #5 where the basalt is highly fracture, but is not observed in Test Well #1 or in Well #6 where the basalt is dense.

Study Area Aquifers

Three aquifers have currently been identified for the Genesee area. The uppermost aquifer is composed of loess and alluvium and is a shallow, unconfined system above the basalt. The springs and hand dug wells present in the study area derive their water from this aquifer. The second aquifer is present in the Wanapum Formation and has well depths that range from 25 to 175 feet depending on the local thickness of sediments. Most wells, including Genesee's municipal wells, derive water from this aquifer. The third aquifer identified in the Genesee area is generally present at depths greater than 150 feet. This aquifer consists of the top portions of the Grand Ronde Formation, but yields water to few wells throughout the study area. Wells drilled into the top of the Grande Ronde Formation derive large quantities of water from the overlying Wanapum Aquifer as it cascades down unsealed boreholes.

CHAPTER 4

ANALYSIS OF WELL DEVELOPMENT

Introduction

The investigation of the wells in the Genesee area provides the basis for interpretation of the local geology and in the determination of ground-water availability. The physical characteristics of municipal and domestic wells were studied and analyzed in addition to municipal pumpage, local water levels, and the quality of the city's water supply.

Well Inventory

A well inventory was conducted in order to gain knowledge of ground-water development in the Genesee area. **Table 1** provides a summary of the information gained. The investigation was conducted by visiting each well and determining the elevations of the well cap and static depth to water. Ground level elevations were approximated by locating the wells on a 1 : 24,000 scale topographic map. Water level elevations were measured with an electric tape capable of measuring water levels to the nearest 0.01 feet. Water level data were taken from drillers logs for wells where access was denied, where well caps

Genesee Township	Range	n/a = data not available Section	Owner	Drilled Depth (ft)	Depth to water (ft)	Elevation to well cap (ft. AMSL)	Year Drilled	Water Level Elevation	Well Driller	Well log avail	Comments
36N	5W	4bd	Blume, Kurt	n/a	n/a	2755	n/a	n/a	n/a	n/a	no info
36N	5W	4add	Evans, Jim	58	50	2650	`59	2600	n/a	n	n/a
36N	5W	5cad	Holben, Barry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
36N	5W	1aaa	Olsen, Dick	179	35	2620	`83	2585	Witt	y	n/a
36N	5W	3bbd	Stout, Martin	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
36N	5W	13bdb	Weber, Bartle	780	705	2160	`74	1455	n/a	y	n/a
37N	4W	30abb	Borgen, Kim	300	106.5	2864	`12	2757	n/a	n	n/a
37N	4W	7aba	Davis, Lee	133	100	2710	`53	2610	n/a	y	high calcium, pump at 110'
37N	4W	19bcc	Dwyer, Mike	533	233.6	2740	`72	2506	Uhlenkott	y	Casc. 2590,pump 504'
37N	4W	17bda	Hampton, Spencer	135	9.8	2778	n/a	2768	Detray	y	clay
37N	4W	17aac	Hampton, Wade	127	40.98	2830	n/a	2789	n/a	n	n/a
37N	4W	6aab	Johnson, Norm	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	4W	17cbb	Kraut, Elmor	100	50	2770	n/a	2720	n/a	n	n/a
37N	4W	7cd	Knoke	60	10	2710	`76	2700	Detray	n/a	n/a
37N	4W	18bbb	Nelson, Jay	110	35	2736	`49	2701	Spray	n	sealed well cap
37N	4W	30caa	Odberg, Jim Jr.	90	23.08	2784	`24	2761	n/a	n	n/a
37N	4W	31bdd	Vestal, Larry	161	20	2720	`82	2700	Witt	y	not accessible
37N	4W	10caa2	Wahl, Dave	225	112	2820	`75	2708	Adcock	y	n/a
37N	4W	10caa1	Wahl, Dave	80	n/a	2820	n/a	n/a	n/a	n/a	80 feet to granite
37N	4W	8dcb	Zenner, Al	n/a	n/a	2900	n/a	n/a	n/a	n/a	no info
37N	4W	11cbd	Zenner, Andy	210	n/a	2855	n/a	n/a	n/a	n	n/a
37N	5W	24aaa	Baumgartner, Bob	174	92.00	2679	`76	2605	Detray	y	n/a
37N	5W	4bcc	Baumgartner, Larry D.	317	87	2770	`79	2683	Witt	y	n/a
37N	5W	22cba	Baumgartner, Ralph	90	20	2662	`26	2642	n/a	n	turbine pump
37N	5W	24cab	Becker, Dale	190	106.3	2765	`54	2659	n/a	n	n/a
37N	5W	35aad	Becker, Don	325	238.9	2755	`74	2516	Uhlenkott	n	Casc. 2616 15 gpm
37N	5W	23bca	Becker, Steve	145	37.93	2690	`93	2652	Clearwater	y	n/a
37N	5W	24daa	Beilenberg, Bob	260	97	2735	`77	2638	Detray	y	Casc. 2689
37N	5W	9ca	Bond, Rod	421	393	2770	`70	2377	Burns&Witt	y	n/a
37N	5W	15ba	Broemeling, Kent	n/a	n/a	n/a	n/a	n/a	n/a	n	spring fed
37N	5W	5dba	Burt, Dave	160	9	2755	`87	2746	Detray	y	n/a
37N	5W	15aab1	Callahan, Marlyn	125	66.18	2737	`82	2671	Uhlenkott	n	n/a
37N	5W	15aab2	Callahan, Marlyn	n/a	55.53	2725	n/a	2669	n/a	n	abandoned
37N	5W	22cab	CCC Camp	300	50	2645	`32	2595	n/a	n	sealed, pump at 100', 5 gpm
37N	5W	14acd1	City (#1)	190	n/a	2661	`10	n/a	n/a	n	sealed,55 gpm
37N	5W	14acd2	City (#2)	190	n/a	2661	`10	n/a	n/a	n	sealed,180 gpm
37N	5W	14acd3	City (#3)	160	20	2661	`64	2646	Detray/Adcock	y	270 gpm
37N	5W	13dbc	City (#4) Luedke	190	18.3	2673	`10	2655	n/a	n	50 gpm
37N	5W	11cdb	City (#5) Neyens	255	165	2786	`80	2621	Uhlenkott	y	180 gpm

Table 1 Well data for the Genesee area

Genesee		n/a = data not available		Drilled	Depth	Elevation		Water		Well	
				Depth	to water	to well cap	Year	Level		log	
Township	Range	Section	Owner	(ft)	(ft)	(ft. AMSL)	Drilled	Elevation	Well Driller	avail	Comments
37N	5W	14aba	City (#6)	392	241	2810	`93	2569	Uhlenkott	y	40 gpm
37N	5W	14acd4	City (#7)	205	20	2661	`94	2641	Burns&Witt	n	100 gpm
37N	5W	25ac	Gilje, Thor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
37N	5W	10cd	Grieser, Andy	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
37N	5W	10acd	Hasfurther, Ed	97	4	2722	`73	2718	Burns&Witt	y	sealed
37N	5W	10da	Hasfurther, Lawrence	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	8db	Herman, Bob	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	5ad	Herman, Ron	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
37N	5W	13bdd	Janni, Frank	74	11.28	2670	`67	2659	Adcock	y	n/a
37N	5W	1aba	Jenkins, Kenny	345	231.6	2730	`83	2498	Dewitt	y	Casc. 166', 5 gpm, aban.
37N	5W	4bb	Johann, John	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
37N	5W	12ccc	Johnson, Charolette	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	3aba	Johnson, Mark	n/a	9.43	2740	`76	2731	n/a	n/a	n/a
37N	5W	8cc	Kambitsch, Del	n/a	n/a	2725	`24	n/a	n/a	n/a	no info
37N	5W	22baa	Kinzer, Tom	80	28.03	2656	`32	2628	n/a	n	n/a
37N	5W	3adc	Klemm, Lloyd	210	30.76	2732	`92	2701	Uhlenkott	y	n/a
37N	5W	27acb	Konen, Leonard	280	68.22	2730	`75	2662	Burns&Witt	y	n/a
37N	5W	30dba	Krick, Paul	128	13	2670	`77	2651	Detray	y	n/a
37N	5W	14dc	Krier, Elmer	127	30	2670	`69	n/a	Burns&Witt	y	n/a
37N	5W	3dba	Lorang, Dan	100	12.42	2728	`92	2716	Uhlenkott	y	40 gpm
37N	5W	3caa	Lorang, Dan #2	403	361	2750	`84	2389	Uhlenkott	y	Casc, aban.trickle 120'
37N	5W	22dbb	Mervyn, Bill	64	16.54	2650	`90	2633	Witt	y	n/a
37N	5W	13adc	Meyer, John	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	11bd	Meyer, Roy	n/a	n/a	n/a	n/a	n/a	n/a	n	spring fed
37N	5W	26caa	Morscheck, Fred	275	218.2	2780	`73	2562	Adcock	y	Casc. 2647 8 gpm
37N	5W	1ddc	Myers, M.G.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	4dac	Ringe, Rudy	200	n/a	2810	`33	n/a	n/a	n/a	jet pump
37N	5W	10abb	Sampson, Don	334	289.9	2710	`73	2420	Adcock	y	casc.2620
37N	5W	34abd	Shelton, Jory	n/a	n/a	n/a	n/a	n/a	n/a	n/a	spring fed
37N	5W	12bdd	Sobczyk, Stan	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	12abd	Stout, John	52	23	2690	`72	2667	Adcock	y	n/a
37N	5W	16add	Tyler, Darrell	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
37N	5W	15caa	Weber, Ed	n/a	n/a	n/a	n/a	n/a	n/a	n	spring fed
37N	6W	1aad	Anderson, Bill #1	130	9.47	2680	n/a	2671	Witt	n/a	n/a
37N	6W	1ada	Anderson, Bill #2	249	152.4	2725	n/a	2573	Witt	n/a	10' to rock
37N	6W	13bda	Esser, Don	285	166.1	2650	`87	2484	Detray	y	n/a
37N	6W	29cbc	Kinzer, Art	318	218	2680	`94	n/a	Uhlenkott	n	n/a
38N	4W	30add	Anderson, Jay	n/a	n/a	2800	n/a	n/a	n/a	n/a	no info
38N	4W	31aab	Boyd, Tom	119	27	2750	`70	2723	Burns&Witt	n	Buried well cap

Table 1 Well data for the Genesee area (continued)

Genesee		n/a = data not available		Drilled	Depth	Elevation		Water		Well	
				Depth	to water	to well cap	Year	Level		log	
Township	Range	Section	Owner	(ft)	(ft)	(ft. AMSL)	Drilled	Elevation	Well Driller	avail	Comments
38N	4W	30bbb	Cyr, Curtis	n/a	n/a	2770	n/a	n/a	n/a	n/a	no info
38N	4W	19ccb	Diehl, Les	86	17.2	2789	n/a	2772	n/a	n	n/a
38N	4W	29aa	Hansen, Ole	170	140	n/a	`73	n/a	Olsen	y	n/a
38N	4W	32dd	Haxton, B.	100	39	n/a	`72	n/a	Adcock	y	n/a
38N	4W	30bcd	Linehan, Greg #1	300	90.75	2785	`23	2694	n/a	n	n/a
38N	4W	9abc	Morken, Ed	200	n/a	n/a	n/a	n/a	n/a	n/a	no info
38N	4W	9aaa	Morken, Ed Jr.	175	n/a	n/a	n/a	n/a	n/a	n/a	no info
38N	4W	29cc	Moser, Doug	128	40	2760	`73	2720	Burns&Witt	y	n/a
38N	4W	29cc	Moser, Doug	68	0.3	2760	`73	2763	Burns&Witt	y	flowing
38N	4W	31dcc	Peterson, Vernon	90	71.88	2770	`54	2698	Spray	n	n/a
38N	4W	31ccc	Poe, D.L.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	no info
38N	4W	30dca	Roy, Steve	n/a	n/a	2790	n/a	n/a	n/a	n/a	no info
38N	4W	35abb	Scharnhorst, Bruce	204	81	2420	`85	2339	Burns	y	n/a
38N	4W	35ca	Zenner, Russell	195	43	n/a	`77	n/a	Detray	y	n/a
38N	5W	35ada	Anderson, Andy	78	n/a	2720	n/a	n/a	Detray	n/a	n/a
38N	5W	33dab	Baumgartner, Lucy	n/a	n/a	2790	old	n/a	n/a	n/a	no info
38N	5W	23ac	Blasey, Dennis	129	n/a	2780	`92	n/a	Witt	y	n/a
38N	5W	33add	Broemeling, Marie	150	33.45	2779	`55	2746	n/a	n	n/a
38N	5W	27dac	Cvancara, Joe	100	5	n/a	n/a	n/a	n/a	n	no info
38N	5W	28cbd	Flodin, Art	160	69.57	2820	`84	2750	Detray	y	n/a
38N	5W	29adc	Helbling, Mrs.Jim Sr.	shallow	12.2	2730	`65	2718	Griesser	n	spring fed
38N	5W	14aba	Iverson, Gordon	70	44.39	n/a	old	n/a	n/a	n	n/a
38N	5W	3abb	Iverson, Ken	300	n/a	2850	`74	n/a	Witt	n	Clay, sealed
38N	5W	3abb	Iverson, Ken	80	33.95	2870	`84	2836	Witt	n	Granite Gravel
38N	5W	23dcc	Kanikkeberg, Jordan	120	110	2755	n/a	2645	n/a	n	sealed
38N	5W	34bcc	Kluss, Harold	185	41.5	2790	`74	2748	Detray	n	n/a
38N	5W	24ccb	Linehan, Greg #2	n/a	28.08	2802	n/a	2773	n/a	n	n/a
38N	5W	36cad	Morscheck, Ray	n/a	n/a	n/a	n/a	n/a	n/a	n	not accessible, no info
38N	5W	24cdc	Perkins, R & J	300	n/a	2820	n/a	n/a	Adcock	n	2 wells>300' , very low gpm
38N	5W	24ddc	Pitts, Marvin	n/a	n/a	2770	n/a	n/a	n/a	n	Buried well cap
38N	5W	26bad	Rivers & Palmer	n/a	n/a	n/a	n/a	n/a	n/a	n	n/a
38N	5W	23cdc	Roberts, Kim	49	14	2740	`80	2726	Hickam	y	n/a
38N	5W	27bdd	Rossebo, David	n/a	n/a	2780	n/a	n/a	n/a	n/a	no info
38N	5W	23bca	Smith, Howard	64	n/a	n/a	`46	n/a	Spray	n/a	sealed
38N	5W	36abc	Stout , Tim	n/a	n/a	2720	`20	n/a	n/a	n/a	no info
38N	5W	25cc	Wedin, Charles	n/a	n/a	2715	n/a	n/a	n/a	n/a	no info
38N	5W	25adc	Wedin, John	90	n/a	2760	n/a	n/a	n/a	n/a	no info
38N	5W	22bca	Weis, Alan	200	68	2840	`72	2772	Adcock	y	n/a

Table 1 Well data for the Genesee area (continued)

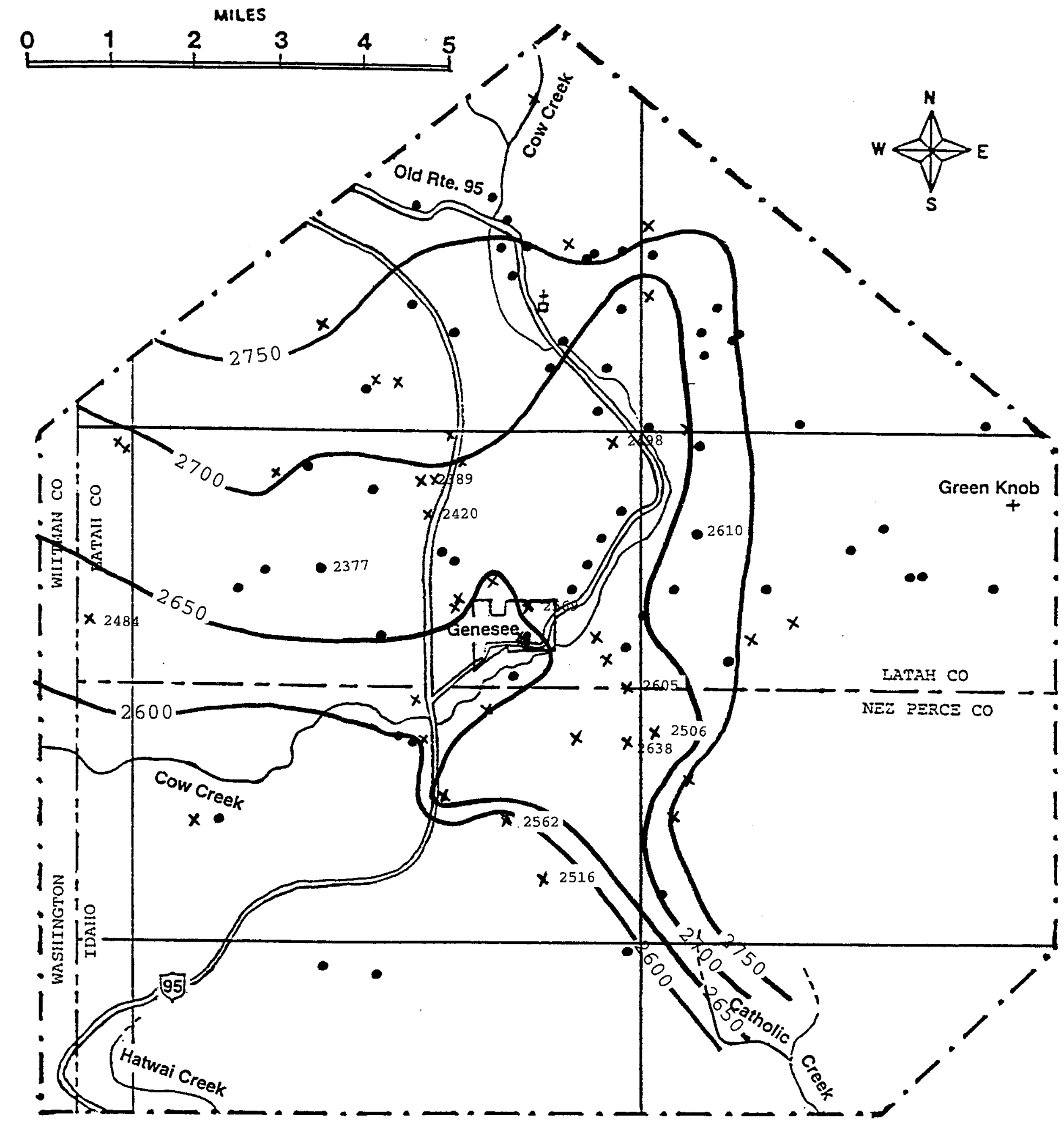
were sealed, or that have depths to water greater than the 300 foot length of the electrical tape. Well locations in the study area are shown in **figure 11**.

The accuracy of measured water level elevations should be within 10 feet of the true elevation. This error band is based on accuracy of the map on which well locations were plotted, precision of well location, and accuracy of the water level measurements. Water level elevations in wells that were not visited or where water levels were estimated may represent true water level elevations to within 20 feet.

Municipal Wells

Genesee's municipal wells derive nearly all of their water from the Wanapum Aquifer. The spatial variation of water-yielding characteristics are shown as locations, completed depths, elevations, and yields for the city wells and city test wells (**figure 12**).

City Wells #1 and #2 were drilled in the late 1890's and are located at the corner of Laurel and Chestnut Streets. They were the only municipal wells in Genesee until 1963. These wells are approximately 190 feet deep and have well casings that extend from the base of the pump house sump, 13 feet below ground level, to approximately 40 feet below ground level. Ground level elevation is approximately 2661 feet (AMSL).



(line symbol)	- water level elevation contours
50 FEET	- contour interval
x	- wells located and water levels measured
•	- wells located and water levels estimated
2420	- water level elevations in deep wells

Figure 11 Well locations and water level contours for ground-water flow in the study area.

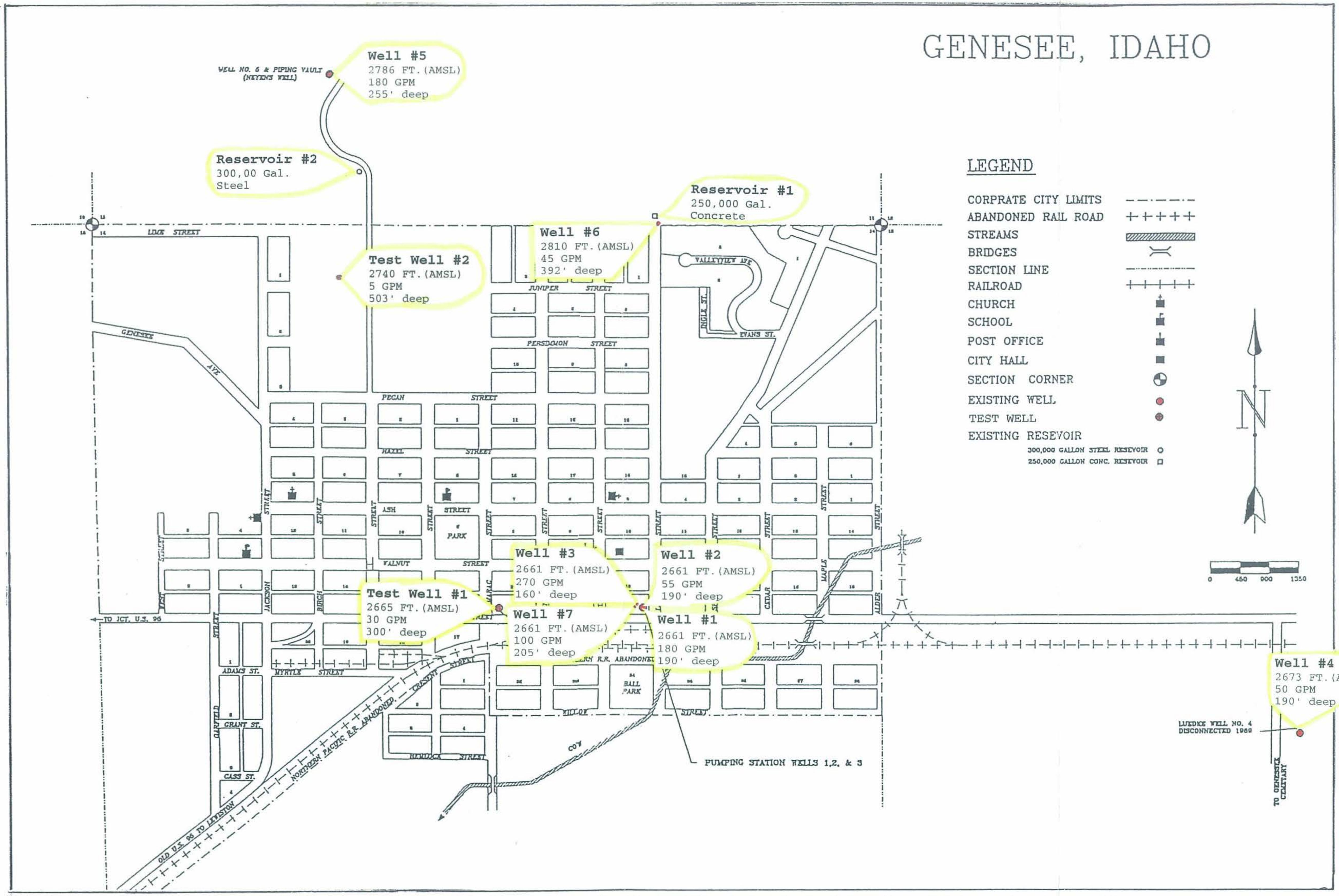


Figure 12 **Well locations, yields, depths, and elevations for city wells and test wells** (modified from Wyatt-Jaykim Engineers and Ralston, 1986).

Well #1 is equipped with a 15 horse power (h.p.) motor that runs a turbine pump capable of yielding 180 gallons per minute (gpm). This well served Genesee until October 1993 and is currently used only to irrigate the ball park south of Well #1 (**figure 12**).

Well #2 is equipped with a 7½ h.p. motor that runs a turbine pump capable of yielding 55 gpm. This well has not been run since 1993 and prior to 1993 was used only as a backup for Well #1.

Well #3 was drilled in 1963 and is located approximately 20 feet northwest of Wells #1 and #2 at the same ground level elevation. Completed depth is 160 feet with casing and a surface seal extending to about 46 feet below ground level. This well is equipped with a 20 h.p. motor mounted on a turbine pump that yielded 270 gpm as of November, 1994. Until 1980, this well was used in conjunction with Well #1 to provide all of the water used by Genesee residents.

Well #4, referred to as the Luedke well, was drilled to a depth of approximately 190 feet and was connected to the city water supply in the mid-1940's to boost pressure to the city cemetery. This well was owned by John Luedke and is located on property that belonged to him, approximately ½ mile east and ⅛ mile south of Genesee where the ground level is approximately 2673 feet (AMSL). Because of a 50 gpm yield and the low pressures generated by the pump in this well, it was ineffective in boosting water pressure. For this reason, Well #4 was disconnected in May of 1987.

Well #5 is located on Beech Street, approximately ¼ mile north of the Genesee city limits, at an elevation of about 2786 feet (AMSL). It was drilled in 1980 in conjunction with the construction of Reservoir #2. The total drill depth of Well #5 is 407 feet at which point circulation of the drilling fluids was lost. The 407 foot pilot hole was backfilled to 255 feet below ground level, reamed to an 8 inch diameter, cased to 255 feet, and grouted from ground surface to 120 feet. Upon completion, this well was test pumped at 450 gpm; but, reported yields of the 25 h.p. submersible pump have decreased from 330 gpm in 1980 to 150 gpm in 1995.

In 1980 Test Well #1 was drilled next to the City Shop where the elevation is about 2665 feet (AMSL). This well was estimated to yield 30 gpm at a depth of 303 feet. Because of the small yield this well was backfilled.

Test Well #2, also drilled in 1980, was located about 150 feet west of Beech Street between the city limits and Well #5, at an elevation of 2740 feet (AMSL). This well was backfilled after estimated yields at a depth of 503 feet averaged 5 gpm.

Well #6 was drilled in the fall of 1993 and is located approximately 70 feet south of Reservoir #1 at the north end of Laurel Street. This well was drilled 806 feet below the ground level elevation of about 2810 feet (AMSL). At this depth the yield of a 40 h.p. test pump were estimated to be in the 75 to 100 gpm range. Well #6 was then backfilled and sealed at a depth of 393 feet in order to utilize the water encountered at the 245 to 375 foot interval. Yields are now estimated to be about 45 gpm.

Well #7 is located 15 feet southwest of Well #3 and is approximately 205 feet deep. This well is cased to 155 feet and had reported yields in excess of 300 gpm before the upper water bearing unit was sealed off (Luedke, 1994). Well #7 is grouted from ground level to 55 feet below land surface and yields approximately 100 gpm.

Domestic Wells

Most drilled domestic wells in the Genesee area have yields from 3 to 45 gpm and derive water from the Wanapum Aquifer. The wells completed in the Wanapum Aquifer that have bottom hole elevations from 2426 to 2575 feet (AMSL) are represented in **figure 13**. These wells have water level elevations whose approximate range is 2625 to 2725 feet (AMSL). **Figure 14** shows the frequency of wells drilled at specific depths below land surface. The large number of wells completed in the Wanapum Aquifer are represented by wells with depths from 50 to 200 feet.

Several domestic wells in the Genesee area partially

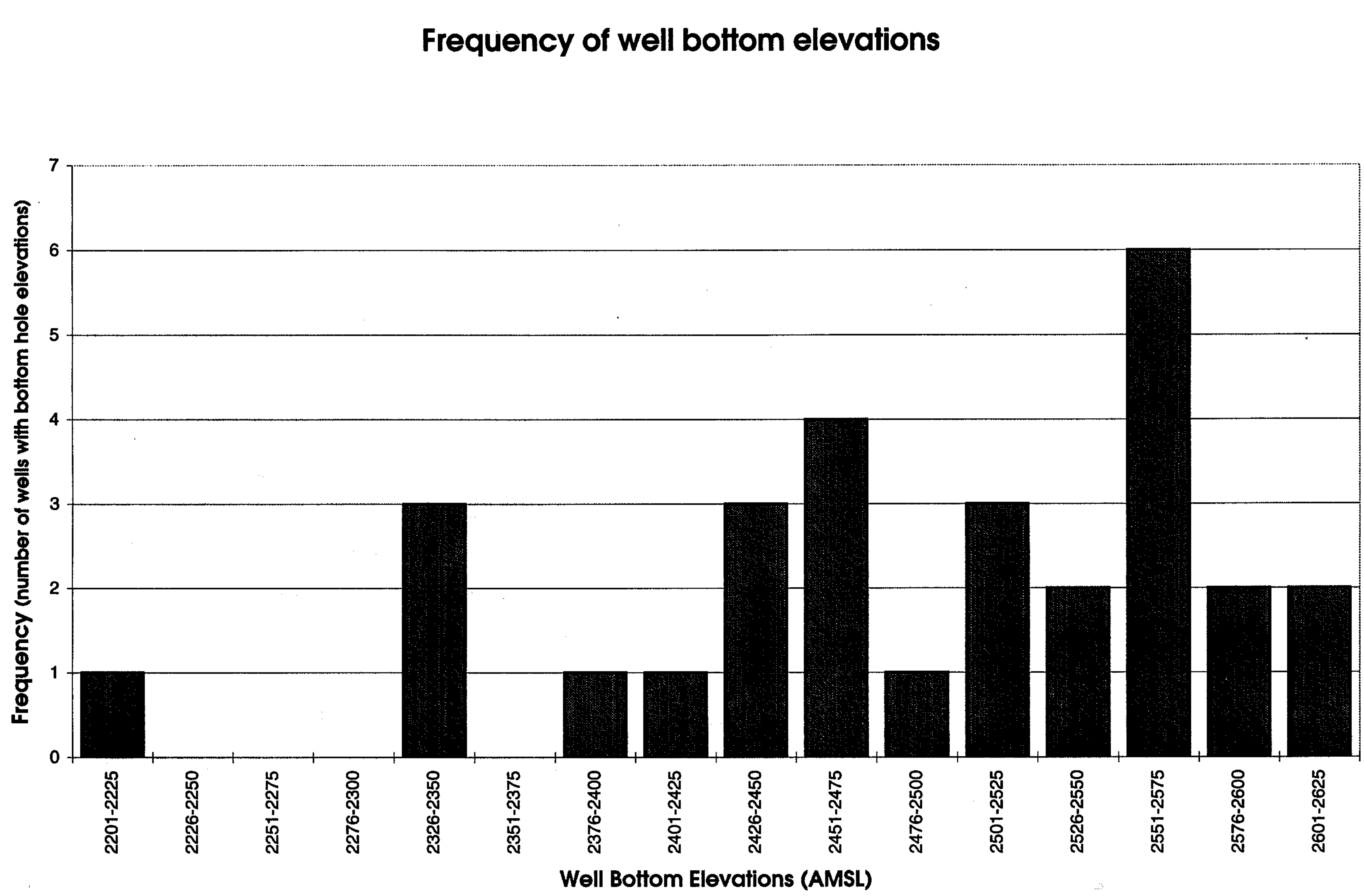


Figure 13 Frequency distribution of well bottom elevations in the Genesee area

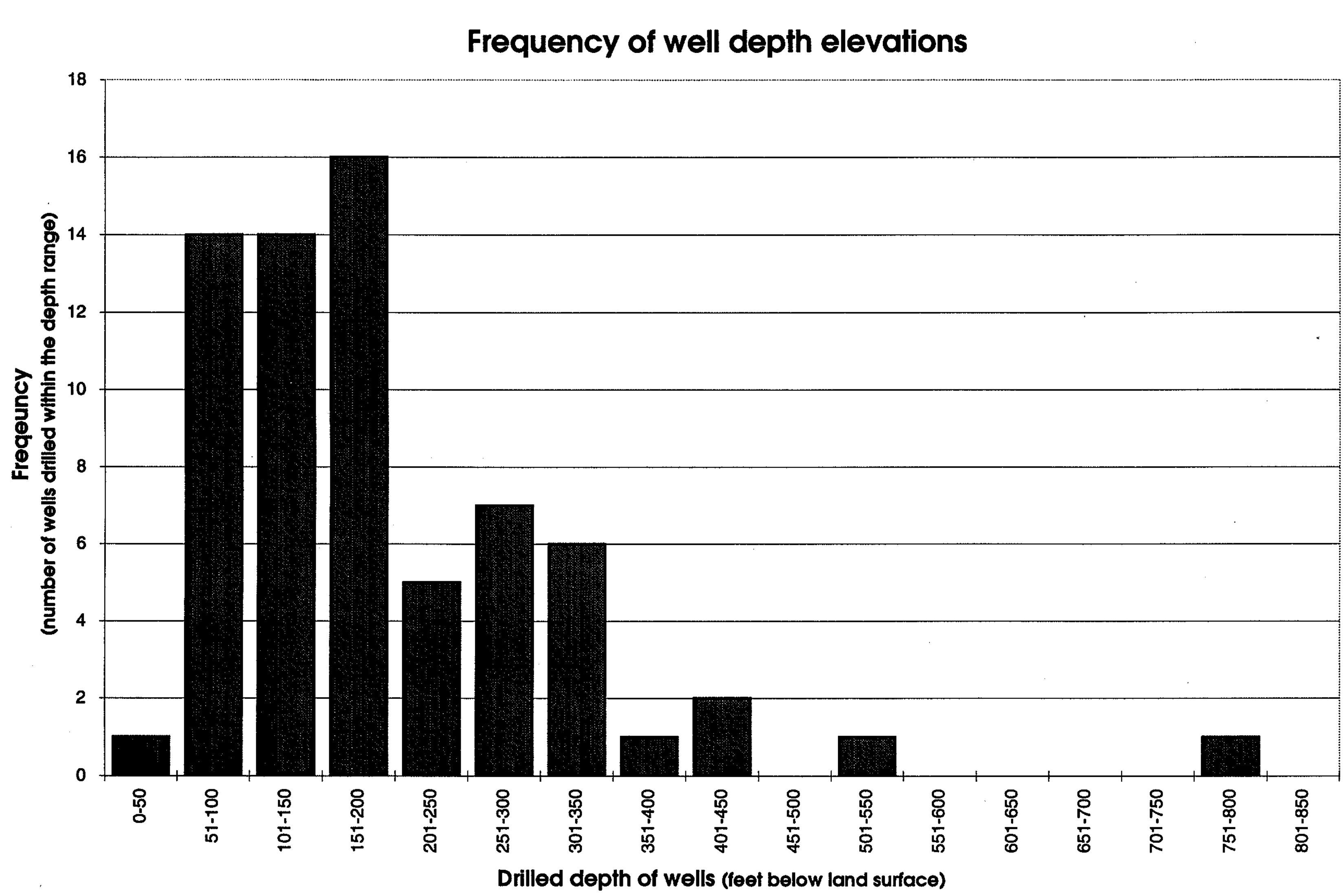


Figure 14 Frequency distribution of well depth elevations in the Genesee area

penetrate the Grande Ronde Formation. These wells have bottom hole elevations below 2426 feet (AMSL) and have water level elevations that range from 2400 feet to about 2600 feet (AMSL). None of the wells that produce ground water from the Grande Ronde Basalts intercept large producing zones in the uppermost Grande Ronde flows.

Analyses of Pumpage and Water Level Data

Pumpage and water level data are analyzed to determine ground-water availability with applications for long-term use. Quantity of pumpage, water levels, and their interrelationship in the study area are discussed below.

Ground-Water Pumpage

City pumpage data are available for the period of 1972 to 1994. A large portion of the data from 1974 to 1987 are incomplete; this adds difficulty to interpreting changes in pumpage over time. The periods of complete data, represented in **figure 15**, show no significant changes in water demand with time. Water use in the city has remained approximately constant at about 200 thousand gallons per day (gal/d).

Deviations from the normal annual pumpage for each municipal well in Genesee can be attributed to specific events. **Figure 16** depicts a fairly consistent yearly cycle of pumpage

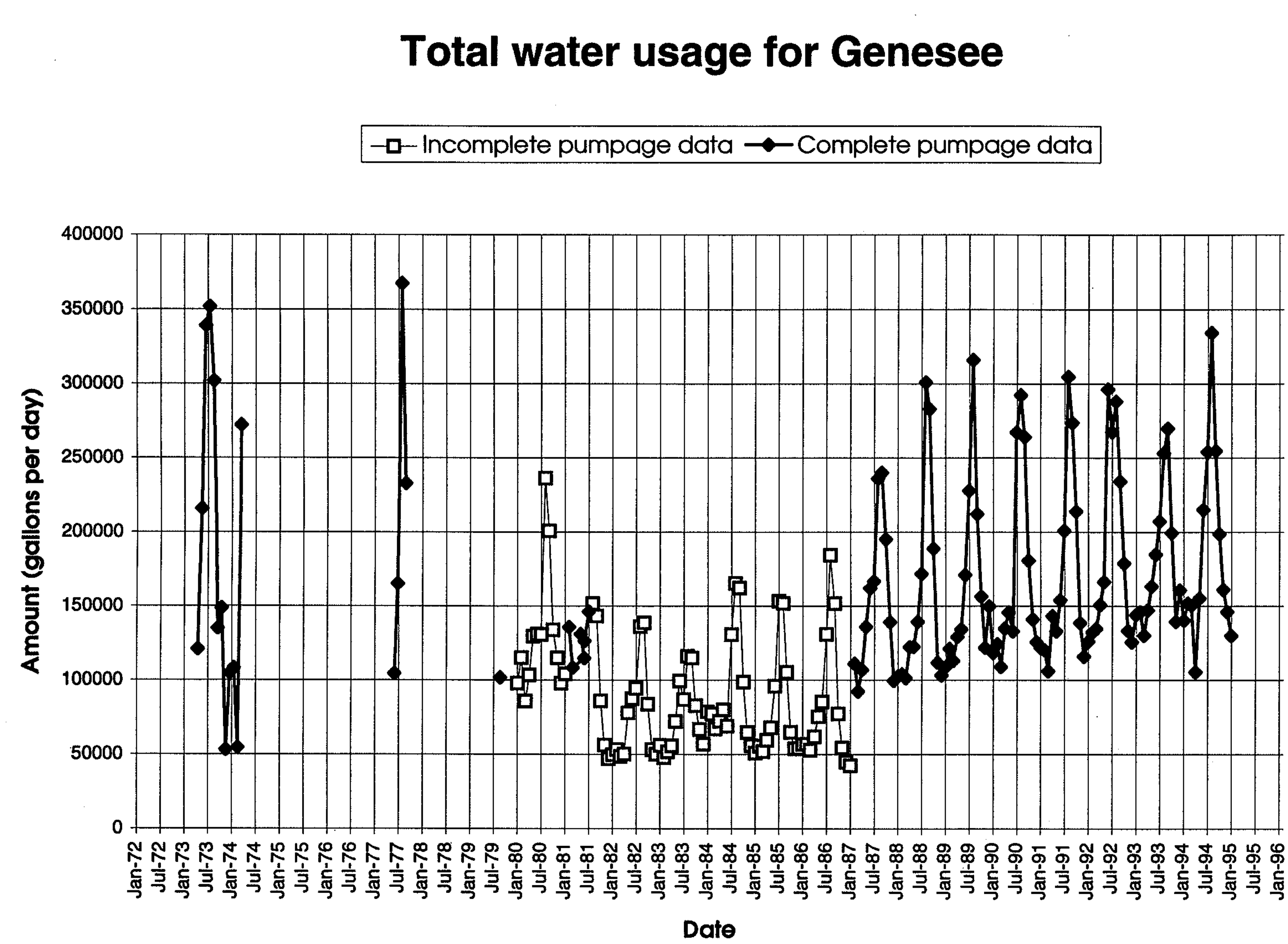


Figure 15 Total pumpage for Genesee municipal wells

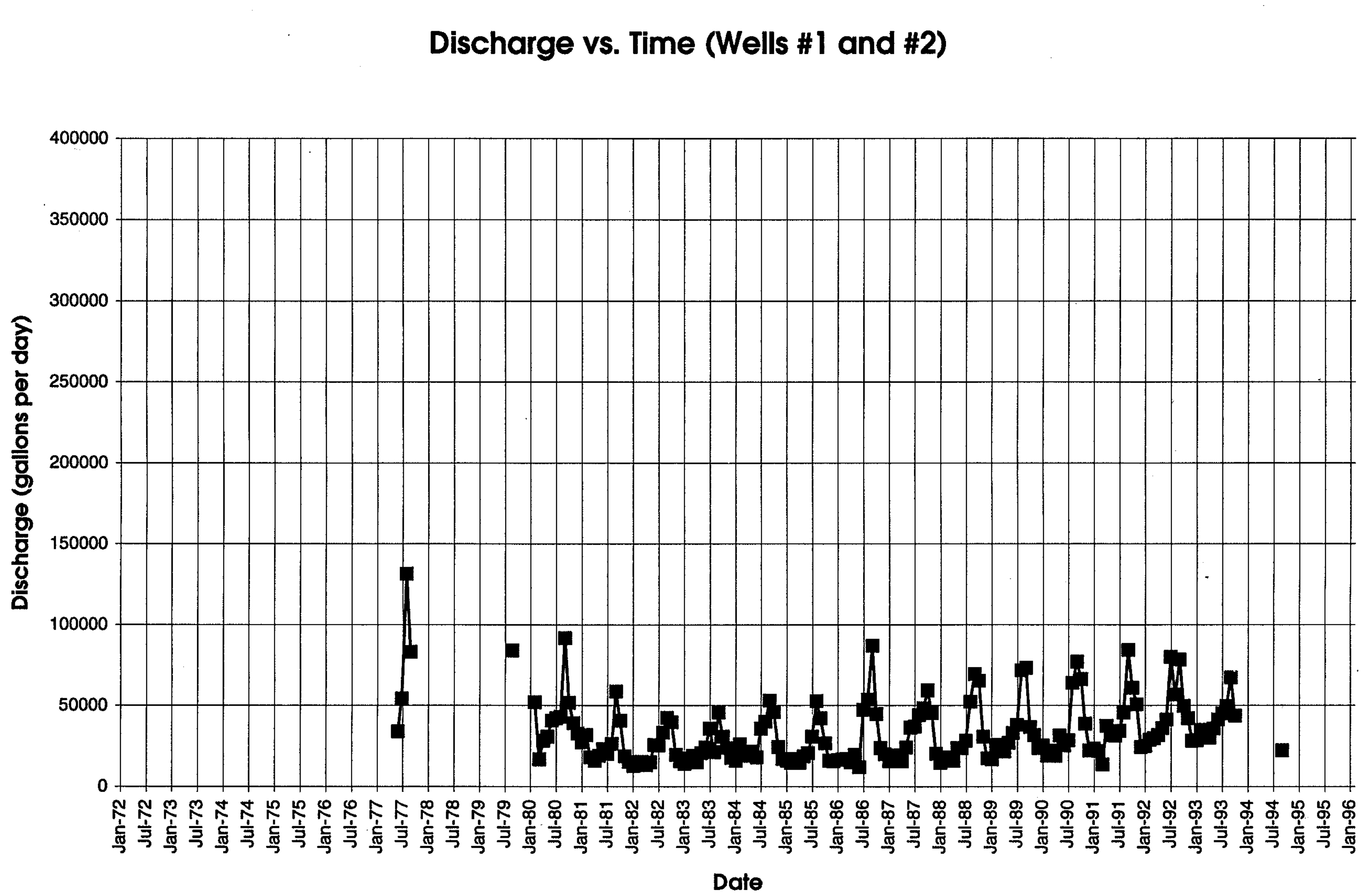


Figure 16 **Pumpage for Wells #1 and #2**

for Wells #1 and #2 with an average combined pumpage of about 30 thousand gallons per day. Presently, Well #2 is not used and Well #1 is only used to irrigate the ball park; pumpage in 1994 only occurred during September. **Figure 17** shows a repeated annual pumpage cycle from Well #3 from the early 1980's to 1993. Average daily pumpage throughout the year is approximately 65 thousand gallons. The large pumpage increase in the middle of 1994 was caused as a very dry summer led to increased demand for lawn and garden irrigation. **Figure 18** shows a change in the normal yearly pumpage cycle for Well #5 from August, 1993 through April, 1994. This change was caused by the closure of Wells #1 and #3; Well #5 was required to pump all of water for the city. A daily pumpage average for this Well #5 is approximately 82 thousand gallons.

Well Depths and Ground-Water Levels

A comparison of well depths to water levels in the study area indicates the average depths at which the local aquifers exist. **Figure 19** reveals the wide range of water level elevations in the Genesee area. The distribution shows a small number of deep wells with low water level elevations, a large number of wells that have water levels representative of the Wanapum Aquifer, and many wells that have high water levels attributable to the unconfined aquifer.

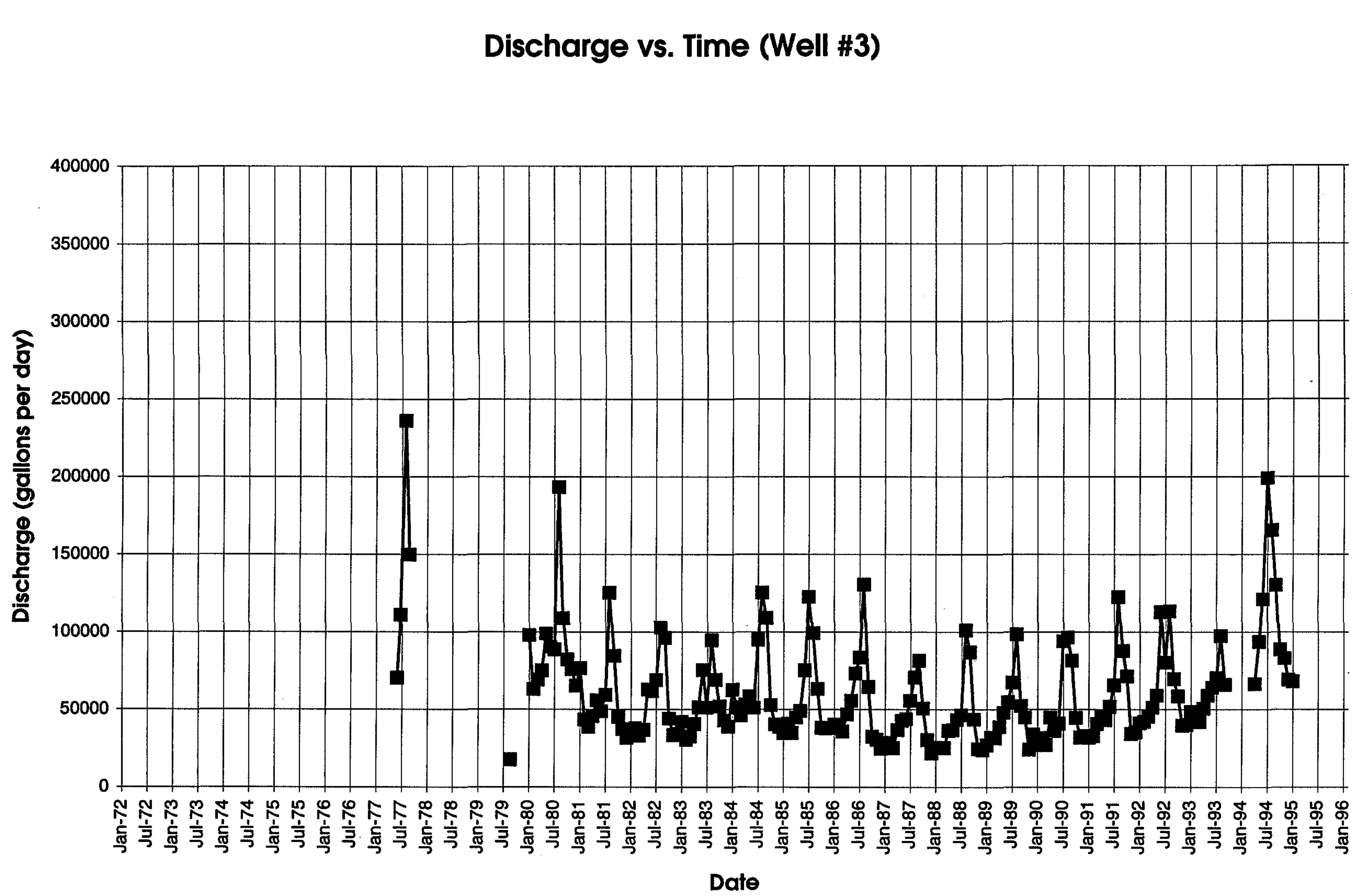


Figure 17   Pumpage for Well #3

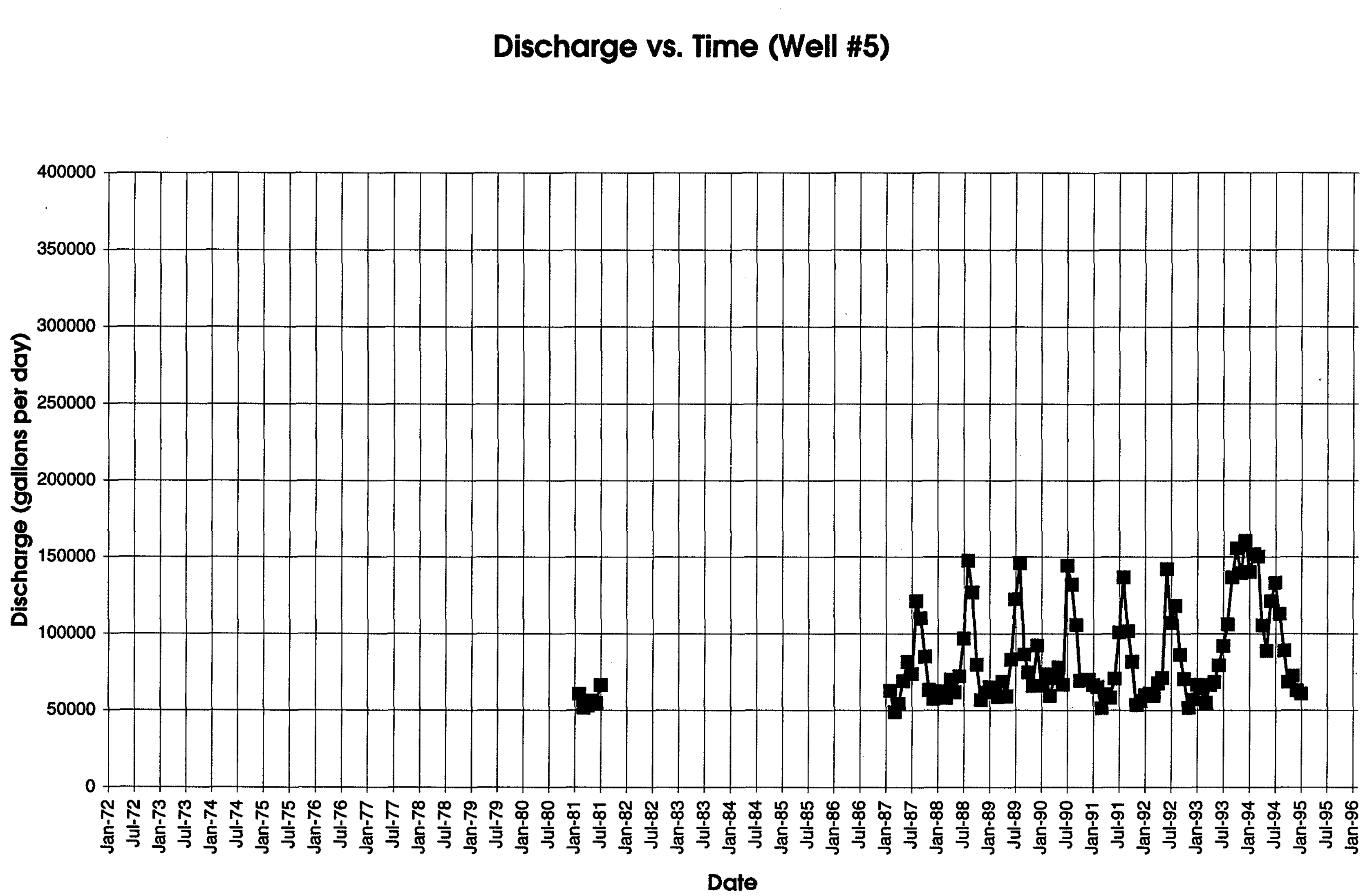


Figure 18 Pumpage for Well #5

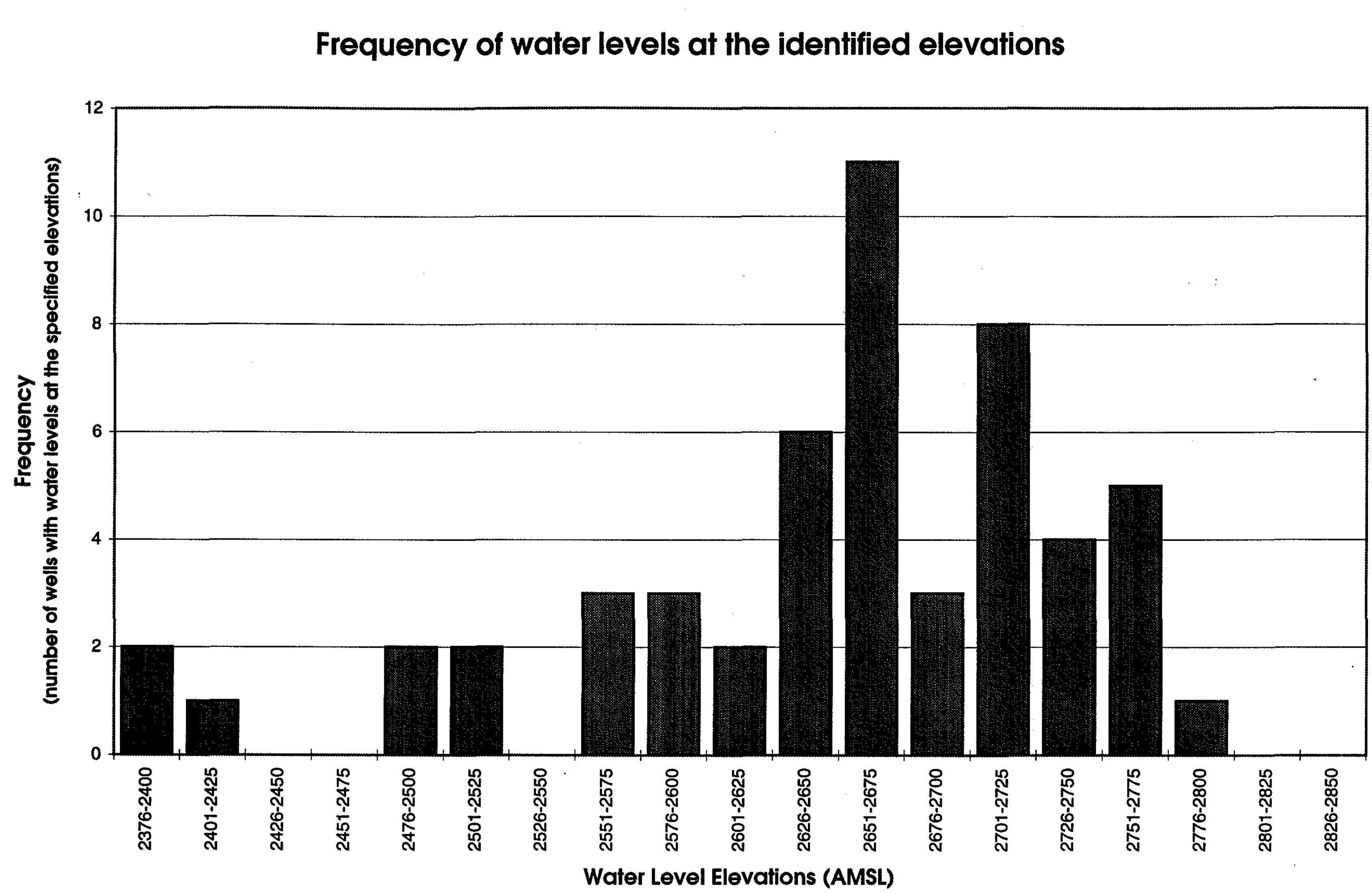


Figure 19 Frequency distribution of water level elevations in Genesee area wells

Water Level Decline

Recent static (non-pumping) water level elevations in Well #5 show that no long-term water level decline has occurred since 1992; static water level measurements from February to October, 1993 may not represent true water levels. The static and pumping water levels do indicate, however, that water level decline has occurred in years prior to 1992 as 1993-94 water levels are lower than the water levels shown by the few measurements in the 1980's and early 1990's (**figure 20**).

The analysis of available static and pumping water level data for Well #3 indicates no long-term water level decline (**figure 21**). The lower static water levels in September of 1994 are attributed to well interference from Well #1. Pumping water levels that show a decline of approximately 10 feet since 1985 resulted when discharge was increased from 190 gpm to 250 gpm. More recent adjustment of the turbine pump shaft has increased the yield to 270 gpm.

Data Reliability

The reliability of water level measurements in Wells #3 and #5 prior to May of 1994 is questionable due to sporadic measurements taken and the use of airline gauges; most air line gauges have poor accuracy and a limited precision to the nearest two feet. Airline readings for Well #3 were approximately 3 feet below actual before the gauge was replaced in June, 1994.

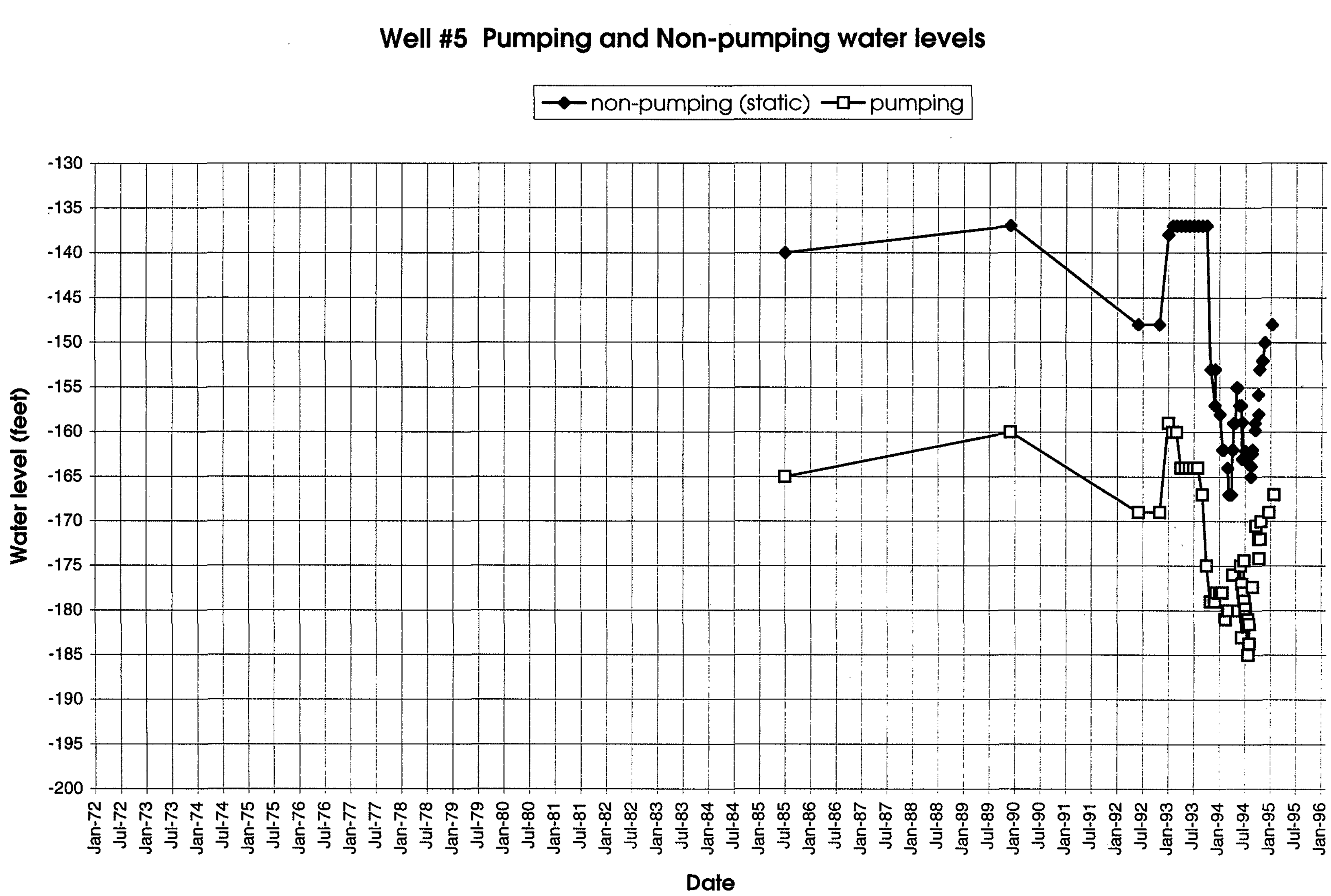


Figure 20 Water levels during pumping and non-pumping for Well #5

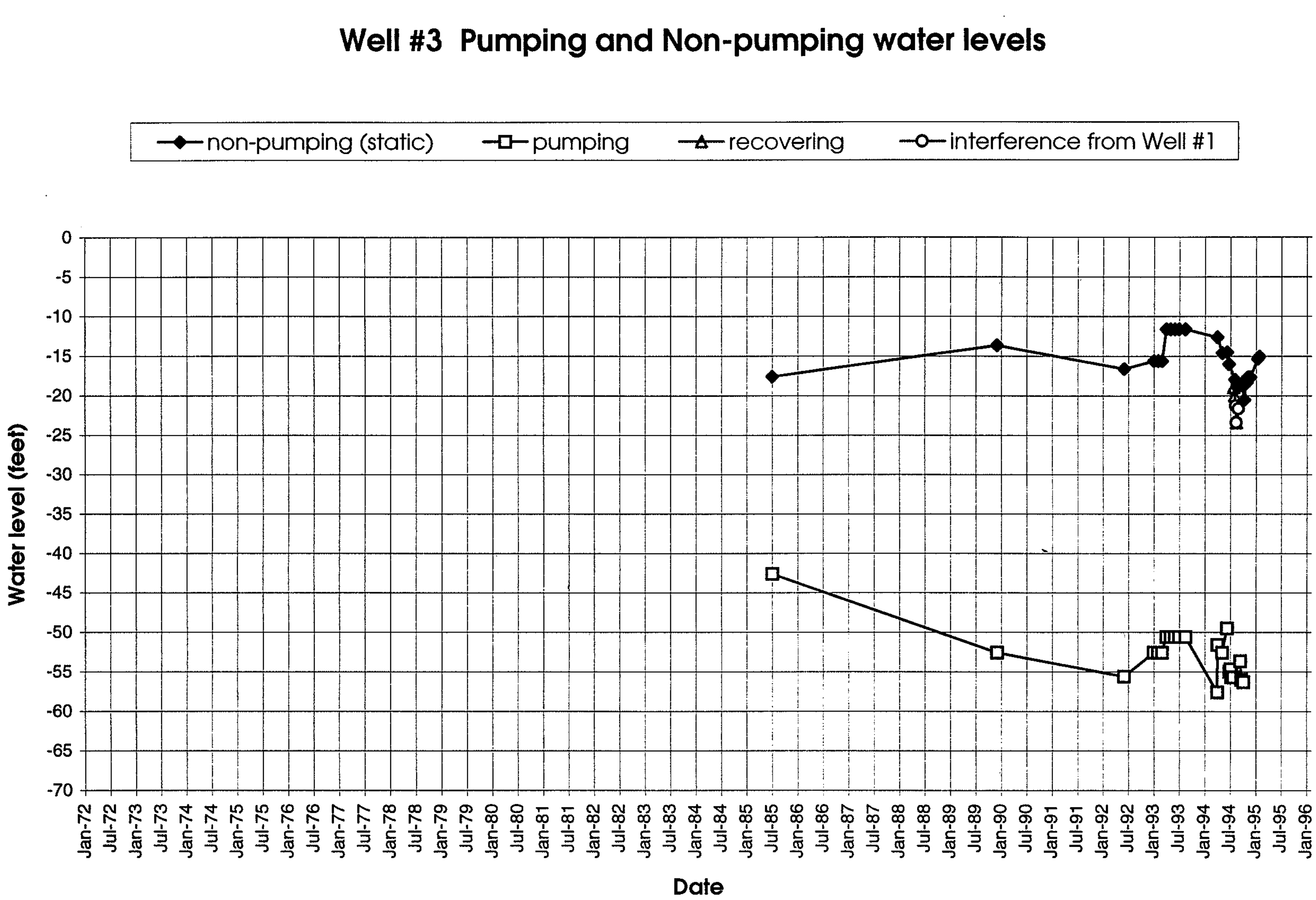


Figure 21 Water levels during pumping and non-pumping for Well #3

The new readings were about 10 feet low. A second replacement gauge currently reads about 13 feet below the actual depth to water from the top of the well casing. In Well #5 a correction of 4 to 6 feet must be added to airline measurements to approximate the actual depth to water from the top of the well casing.

Measurements taken with an electrical tape from May, 1994 to January, 1995 are assumed to be accurate to within 0.01 feet. The air line measurement data available for both wells is presented in its corrected form to represent electrical tape measurements.

Water Quality

The quality of Genesee's drinking water has been monitored since the late 1970's and has become a concern in the past few years. The two contaminants identified in the city water system and regulated by the Idaho DEQ are nitrates and tetrachloroethylene (PCE).

Nitrates have been monitored in the Genesee water system since 1978 (**figure 22**). Water quality tests have indicated concentrations in the 6 to 9 mg/l range. The nitrate levels have remained within the 10 mg/l maximum contaminant level (MCL) except for one sample taken in September of 1993; improper analysis is suspected as results from different labs indicated

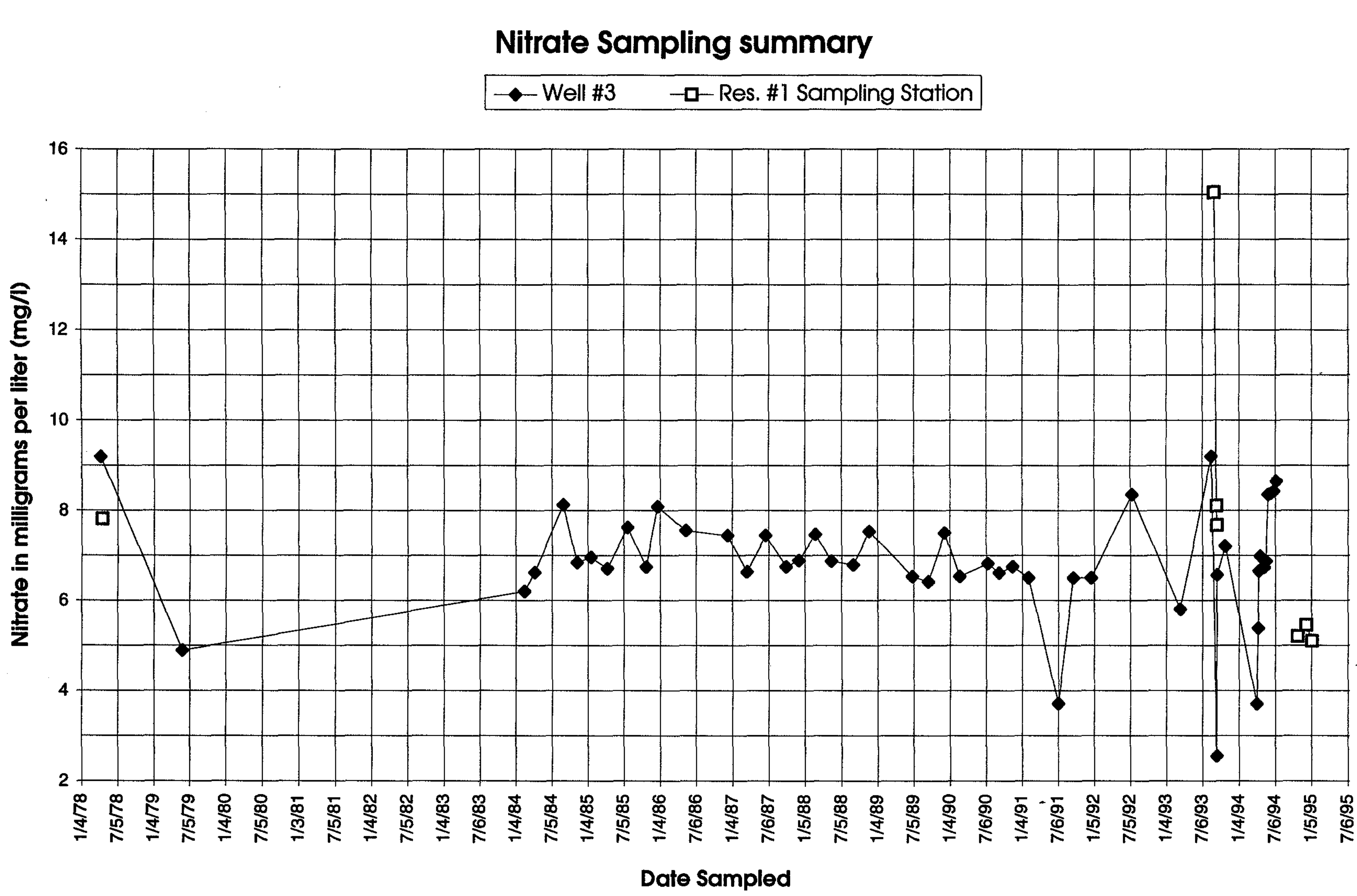


Figure 22 Nitrate sampling summary ('78-'94)

different levels of contamination. **Table 2** summarizes the nitrate sampling for the city of Genesee. The source for the nitrate is unknown.

Tetrachloroethylene contamination is present in several municipal wells (**Table 3**). **Figure 23** shows the PCE test results in water samples from 1989 to 1994. Contamination levels have occasionally tested above the 5 parts per billion (ppb) MCL, but due to limited total water supply, required shut down has been temporarily waived by the DEQ. The source of PCE contamination is believed to be a site next to City Hall where a dry cleaning service was located (Luedke, 1994). A plume of PCE appears to have moved southward where it intercepts City Wells #1, #2, #3, and #7.

Genesee nitrate sampling summary

Lab analyses detection limit (nitrate) = 0.1 mg/l

n/d = no data

Date	Nitrate(mg/l) Well #3	Well #5	Res #1 Samp.Station	Date	Nitrate(mg/l) Well #3	Well #5	Res #1 Samp.Station
4/11/78	9.19	n/d	n/d	11/15/90	6.75	n/d	n/d
4/18/78	n/d	n/d	7.81	2/5/91	6.5	n/d	n/d
5/29/79	4.89	n/d	n/d	7/7/91	3.71	n/d	n/d
10/15/80	n/d	0.16	n/d	9/20/91	6.5	n/d	n/d
2/17/84	6.2	n/d	n/d	12/20/91	6.5	n/d	n/d
4/8/84	6.62	n/d	n/d	7/15/92	8.35	n/d	n/d
8/31/84	8.12	n/d	n/d	3/16/93	5.8	n/d	n/d
11/9/84	6.84	n/d	n/d	8/16/93	n/d	1.1	n/d
1/18/85	6.96	n/d	n/d	8/20/93	9.2	n/d	n/d
4/12/85	6.71	n/d	n/d	9/2/93	n/d	n/d	15.04
7/25/85	7.62	n/d	n/d	9/14/93	2.55	n/d	n/d
10/25/85	6.74	n/d	n/d	9/14/93	n/d	n/d	8.1
12/23/85	8.08	n/d	n/d	9/16/93	6.56	n/d	7.67
5/15/86	7.55	n/d	n/d	10/28/93	7.2	n/d	n/d
12/12/86	7.44	n/d	n/d	2/14/94	n/d	0.41	n/d
3/19/87	6.63	n/d	n/d	4/4/94	3.7	n/d	n/d
6/22/87	7.44	n/d	n/d	4/11/94	5.38	n/d	n/d
10/2/87	6.75	n/d	n/d	4/14/94	6.65	n/d	n/d
12/4/87	6.89	n/d	n/d	4/21/94	6.98	n/d	n/d
2/26/88	7.46	n/d	n/d	5/11/94	6.73	n/d	n/d
5/16/88	6.87	n/d	n/d	5/20/94	6.87	n/d	n/d
9/2/88	6.79	n/d	n/d	5/31/94	8.35	n/d	n/d
11/23/88	7.53	n/d	n/d	6/14/94	8.38	n/d	n/d
6/27/89	6.53	n/d	n/d	6/27/94	8.43	n/d	n/d
9/18/89	6.41	n/d	n/d	7/11/94	8.65	n/d	n/d
12/8/89	7.5	n/d	n/d	10/10/94	n/d	n/d	5.7
2/21/90	6.53	n/d	n/d	10/25/94	n/d	n/d	5.2
7/13/90	6.82	n/d	n/d	12/8/94	n/d	n/d	5.45
9/7/90	6.61	n/d	n/d	1/6/95	n/d	n/d	5.1

Table 2 Nitrate sampling summary for Genesee

Genesee Tetrachloroethylene (PCE) sampling summary - parts per billion (micrograms per liter)								
				n/d = no data				
Date	Well 1	Well 3	Well 5	Res #1	Walnut & Fir	318 Laurel	Hall's Bar	Well 7
11/13/89	8.8	7.32	0	n/d	n/d	n/d	n/d	n/d
2/20/90	0	0	0	n/d	n/d	n/d	n/d	n/d
6/18/90	17.1	4.02	0	n/d	n/d	n/d	n/d	n/d
9/17/90	10.5	8.84	0	n/d	n/d	n/d	n/d	n/d
3/26/91	8.36	4.58	n/d	n/d	n/d	n/d	n/d	n/d
9/30/91	n/d	n/d	n/d	3.48	4.52	3.81	n/d	n/d
11/26/91	6.63	3.28	n/d	n/d	n/d	n/d	n/d	n/d
7/17/92	6.1	3.5	n/d	n/d	n/d	n/d	n/d	n/d
11/13/92	4.9	5.4	n/d	5.4	n/d	n/d	n/d	n/d
11/26/92	6.69	3.3	n/d	n/d	n/d	n/d	n/d	n/d
12/17/92	5.3	7.9	n/d	n/d	n/d	n/d	n/d	n/d
2/23/93	4.3	7.6	n/d	4.4	n/d	5.9	6.2	n/d
8/30/93	n/d	n/d	n/d	7.2	n/d	n/d	n/d	n/d
4/21/94	n/d	6.1	n/d	9.1	n/d	n/d	n/d	n/d
6/6/94	n/d	n/d	n/d	7.3	n/d	n/d	n/d	n/d
7/20/94	n/d	n/d	n/d	2.01	n/d	n/d	n/d	n/d
9/20/94	n/d	2.67	n/d	n/d	n/d	n/d	n/d	n/d
10/14/94	n/d	n/d	n/d	n/d	n/d	n/d	n/d	4.9
12/8/94	n/d	n/d	n/d	1.4	n/d	n/d	n/d	n/d

Table 3 PCE sampling summary for Genesee

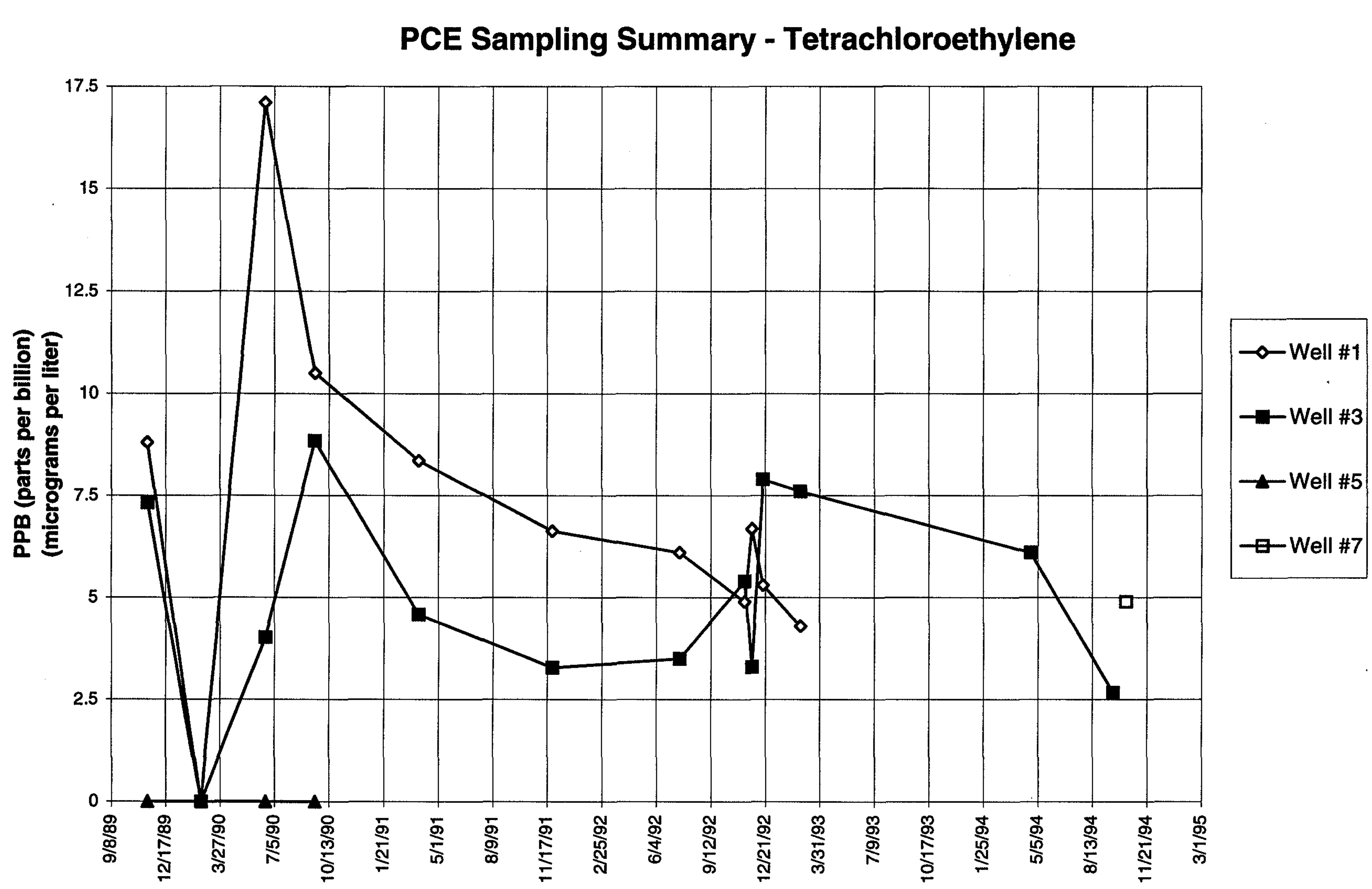


Figure 23 PCE sampling summary ('89-'94)

CHAPTER 5

ANALYSIS OF THE GROUND-WATER-FLOW SYSTEM

Introduction

The ground-water-flow system in the Genesee area is separated vertically into three layers corresponding to the study area aquifers. These layers consist of an alluvium and loess surface layer, a Wanapum Basalt middle layer, and a Grande Ronde Basalt bottom layer. The similar lateral and vertical flow characteristics of these layers are discussed in the following paragraphs.

Flow Characteristics

Water levels in wells penetrating the upper aquifer throughout the study area are contoured in **figure 11**. Lateral ground-water flow in the Wanapum Basalt is shown to occur to the south and west. Lateral flow in the surface and bottom layers also appear to be to the south and west as interpreted from the directions of streamflow and regional dip, respectively. Lateral flow is an important mechanism of recharge and discharge in the ground-water-flow system.

The lower water level elevations in **figure 11** correlate to water levels in wells that are completed below the Wanapum Basalt and indicate a downward gradient in the basalts. This gradient provides an explanation for vertical recharge to and discharge from each layer in the system. This portion of the report describes ground-water recharge and discharge characteristics.

Ground-Water Recharge

Recharge from streams and infiltration of precipitation account for ground-water recharge in the study area. Recharge from streams is dependant on the head gradient between the stream and the underlying ground-water system. It is not known if the streams in the Genesee area are recharging or draining the surface layer of the ground-water-flow system. A comparison of stream elevations with adjacent ground-water elevations indicates that recharge from streams probably only occurs during high streamflow events. The quantity of recharge to the surface layer from streams is unknown, but is believed to be small if it does exist.

Recharge to the ground-water system in the study area is believed to be primarily from infiltration of precipitation. Lum and others (1990) observed that the infiltration of precipitation occurs predominantly in valleys between rolling loess hills. Recharge occurs in these areas because precipitation and accumulated runoff exceeds soil moisture storage capacity. This water drains below the root zone and becomes recharge to the underlying basalt aquifer.

Recharge to the Wanapum and Grande Ronde basalts in the ground-water-flow system is believed to be primarily from infiltration due to the downward hydraulic gradient in the basalts. Using the Bauer and Vaccaro water balance methodology (1989) Lum and others (1990) calculated an average total recharge to the basalts of about 3 inches per year (in/yr) in the Moscow-Pullman area (**figure 24**). About 2.2 inches of recharge is estimated for the study area by applying a comparison of average annual precipitation for Genesee and Moscow to the general interpretations of Lum and others. This is based on the assumption that all other factors impacting recharge are constant in the two areas.

The amount of recharge to the basalt layers is unknown, but can be estimated by applying the 2.2 inch value over the 120 square mile study area. Using a recharge area of this size, the calculated recharge is approximately 12.5 million gallons per day (gal/d). This value does not seem reasonable; the recharge area used in the calculations may be too large or the amount of recharge is overestimated. A more representative size of a recharge area may be within a four mile radius from Genesee. For this size area, recharge is calculated to be approximately 5.2 million gal/d. This estimate is still nearly 25 times

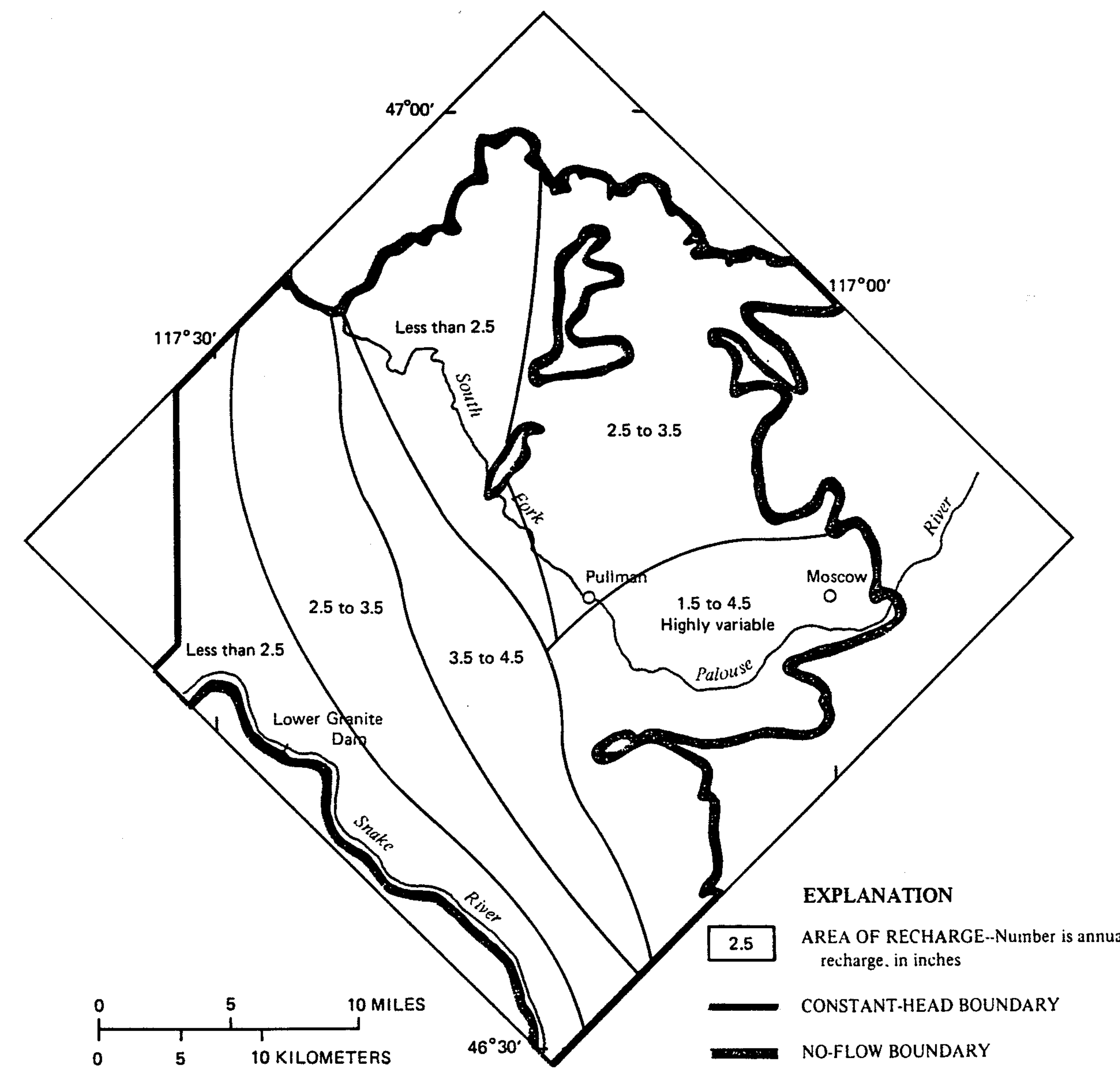


Figure 24 **Areal distribution of recharge for the Moscow -Pullman area** (from Lum and others, 1990).

greater than the 200 thousand gal/d average pumpage in Genesee; estimates of recharge are still significantly greater than pumpage.

Ground-Water Discharge

Some discharge within the ground-water-flow system occurs as infiltration to the lower basalt layers. Lum and others (1990) conclude from model simulation that the amount of water discharging to the Grande Ronde Basalt in the Moscow-Pullman ground-water system is approximately 0.7 times the amount calculated to recharge the entire system. Based on this calculation, about 1.5 inches is estimated to discharge to the Grande Ronde Basalts in the study area as infiltration from the overlying Wanapum Basalts.

Discharge out of the ground-water system from the surface layer may occur as discharge to Cow Creek and its tributaries and as lateral outflow to the west. During the late summer and fall, discharge from the shallower ground-water systems probably is the sole source of streamflow (Lum and others, 1990). No estimate for the volume of water discharging to streams or flowing to the west is available for the study area.

Discharge out of the ground-water system from the Wanapum and Grande Ronde Basalts may occur as drainage to seeps and springs, as pumpage, and also as lateral outflow to the west.

Evidence of discharge is present in Hatwai Canyon in the form of seep lines and springs that are marked by vegetation. Some of these seep lines are near the elevation of the top of the Wanapum Formation. Most of the water in these discharge areas is evapotranspired by the vegetation; no flowing water was found. Further investigation of Hatwai Canyon did not provide evidence of seeps at the base of the Wanapum Formation.

An estimate of the volume of water calculated to discharge as evapotranspiration to the canyons is approximately 30 thousand gal/d. This calculation was based on the Blaney-Criddle method of estimating the potential evapotranspiration (PET); this value is about 40 inches per year (in/yr) in the study area. This method is based on average monthly temperatures, monthly percentage of annual daylight hours, and the size of the area covered by vegetation (estimated as approximately 20 acres). The estimated volume of discharge to seeps is less than one-sixth the volume pumped daily by the city; discharge to seeps accounts for only a small portion of the total discharge.

Discharge due to pumpage is the only mechanism that can be quantified for the study area. The amount of discharge as pumpage is known for the Wanapum Aquifer, but can not be quantified for the surface layer or Grand Ronde Aquifer because no water is pumped from these aquifers by the city.

Discharge as westward lateral flow of ground water from the

Wanapum Aquifer was calculated by Lum and others (1990) and Barker (1979) to be about 8.4 million gal/d. This value fits the recharge/discharge water balance model for the study area if the recharge is greater than 8.7 million gal/d; pumpage, seepage, and discharge to the Grande Ronde comprise the other 0.3 million gal/d. Ralston (1994) indicated that the computer model is relatively insensitive to the recharge rate. The model will work equally as well if the calculated amounts of recharge and discharge are reduced significantly. The available information in the Genesee area indicate that the amount of ground water moving through the area are much smaller than estimated.

CHAPTER 6

WELL DEVELOPMENT POTENTIAL

INTRODUCTION

Two alternative targets for well development exist for the City of Genesee, Idaho. The first alternative is to further develop the upper aquifer which currently supplies all of the water for the city. The second alternative is to develop a deeper aquifer which exists in other areas of northern Idaho and eastern Washington but has not yet been developed in the Genesee area. A brief summary of the aquifers present in the study area and the two alternatives are described in the following sections.

Knowledge of Aquifers

Two aquifers are interpreted to exist in the study area that are capable of supporting municipal wells, thus making them potential targets for development. The upper Wanapum Aquifer has been developed to a large extent; the ground-water flow characteristics of this aquifer are understood fairly well. The flow characteristics and occurrence of water in the lower Grande Ronde Aquifer are unknown because development of this aquifer has not occurred in the Genesee area.

From the data gathered and interpreted for the Wanapum Aquifer in Genesee, no significant long-term water level decline has been observed for the period of record. The lack of long-term water level decline is consistent with the conclusion that recharge is much greater than present pumpage. Water quality problems are present in this aquifer. These problems may be caused by movement of contaminated water from near surface zones to the aquifer through poorly sealed wells.

Little knowledge of the Grande Ronde Aquifer and its water-bearing characteristics are available for the Genesee area. The Grande Ronde Aquifer is assumed to be present beneath Genesee based on comparisons to other areas that have similar geological settings.

ALTERNATIVE #1 -- UPPER AQUIFER

All of the current city wells and almost all of the wells in the area surrounding Genesee obtain water from producing zones in the Wanapum Basalts. These zones collectively constitute the upper aquifer.

Five questions are pertinent with respect to construction of an additional city well in the upper aquifer. 1) What will be the yield of the new well? 2) Is the long-term yield of the upper aquifer sufficient to support the construction of a new well? 3) Can the water quality problems experienced in some of the existing city wells be avoided in a new well? 4) Will the new well impact the production from the present wells? 5) How can costs be minimized in the construction of additional well(s) in the upper aquifer? These questions are addressed in the following paragraphs.

Data from existing city wells shows a major variation in well yield from the upper aquifer within the city. This variation is interpreted to result from compositional changes within the Wanapum Basalts in the general Genesee area. Specifically, areas where the basalt was deposited in small lakes, ponds, or streams are believed to have more fracturing and thus higher well yields. There is no known way to identify these buried zones of higher hydraulic conductivity other than by a review of yields from the existing wells. This makes yield a major question for any new well.

All of the available information indicates that present pumpage by the City of Genesee and the surrounding users is only a small percentage of the total recharge to the upper aquifer. Thus, it appears that long-term yield from the aquifer is not a constraint on additional well development in the upper aquifer by the city.

Water quality problems experienced in city wells #1, #2, #3 and #7 most likely result from a specific contamination source. Poor seals around the casing on some of the old wells may allow interconnection of contaminated, shallow ground water with the upper aquifer. Construction of a new city well in the upper aquifer can avoid the water quality problems by locating away from the contaminated area.

Interference between wells can be a significant problem. Pumpage from one well can cause water level decline and associated decreases in yield in a second well. This can be avoided by locating any new city wells completed in the upper aquifer at a sufficient distance from the existing wells.

Costs for new well construction in the upper aquifer can be minimized in two ways. First, any new wells should be located at low elevations within the city. The aquifer is relatively flat lying; each foot higher in land elevation requires a greater well depth and a greater pumping lift. Second, test wells should be drilled at each new site with conversion to production wells if the target yields are obtained.

Because of the uncertainty in well yields, the city should budget for three wells if the decision is made to explore water production in the upper aquifer. Based on the present data base, at least one of the wells should provide a yield of 100 gpm or more for the city.

Information useful to siting new wells in the upper aquifer is presented on **figure 25**. Exclusion of the areas shown on the map result from contamination, elevation, well interference, and low yield considerations. Areas excluded due to possible

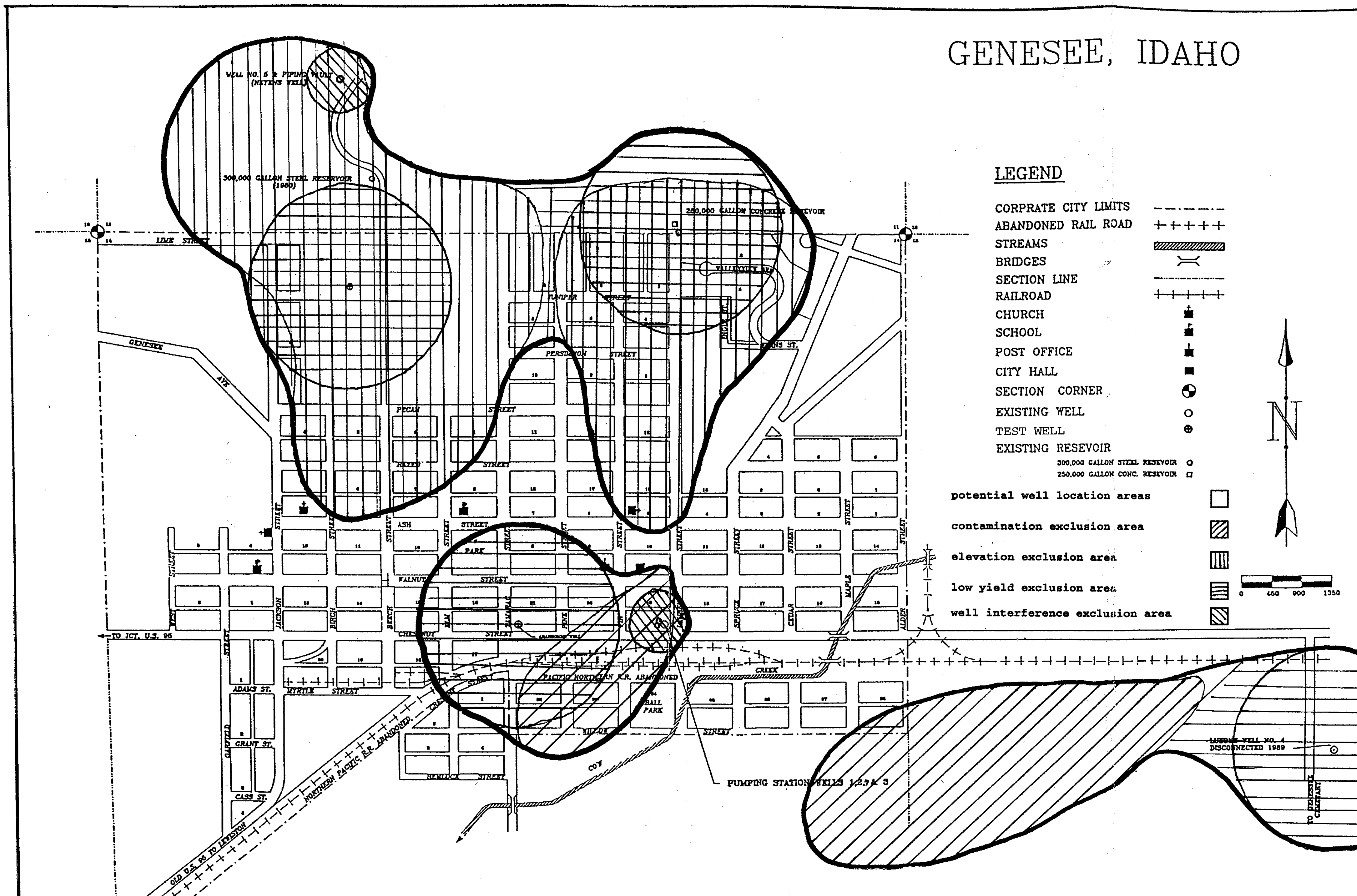


Figure 25 Map showing areas for development of new upper aquifer wells (modified from Wyatt-Jaykim Engineers and Ralston, 1986).

contamination extend down-gradient from known contamination sites. Areas excluded due to high elevation are marked to prevent unnecessary cost of well construction; each foot higher elevation results in another foot of drill depth. Areas excluded due to well interference are circles with radii of approximately 450 feet; to prevent additional draw-downs and water level declines. Areas excluded due to low yield have radii of approximately 1350 feet; to account for the lateral changes in geological composition away from areas that are known to have low yields.

ALTERNATIVE #2 -- LOWER AQUIFER

None of the existing Genesee city wells penetrate the lower aquifer in the Grande Ronde Basalts. The aquifer is postulated to underlie the city based on information from wells in Moscow, Pullman, Lewiston, and Clarkston and from geologic mapping in the Genesee area.

The primary questions with respect to development of the lower aquifer are as follows. 1) How deep would the well need to be? 2) Where should the well be located? 3) How should the well be constructed to avoid creating problems with the upper aquifer? These questions are addressed in the following paragraphs.

Data from other wells completed in the Grande Ronde Basalts indicate that the target depth of a well in the Genesee area should be about 1,200 +/- 200 feet. This is based on locating the well at a low elevation and not on a hill.

The selection of well location should be based on land elevation, land ownership, and proximity to the water distribution system rather than on aquifer hydrogeology. Not enough information exists on the hydrogeology of the deep aquifer to suggest that any site is better than any other site.

The depth to water in the lower aquifer will be significantly greater than the depth to water in the upper aquifer based on information on deep wells in Moscow, Pullman, Lewiston, and Clarkston. Thus, a poorly sealed deep well has the potential to allow water drainage from the upper aquifer to the lower aquifer. This would cause water level declines in the upper aquifer. This problem can be avoided by proper sealing of the well above the lower aquifer.

Development Options

The City of Genesee has the options of continuing to rely on the shallow aquifer for a water supply or exploring the potential of the lower aquifer. The drilling decision for the city should be based on long term anticipated water needs for the city. The upper aquifer alternative probably is preferable if additional yields in the 100 to 200 gpm range is needed to meet new demands for the city. Conversely, the lower aquifer alternative is best if larger yields will be needed in the future. **Figure 26** shows general designs for wells in either the upper or lower aquifers in the Genesee area.

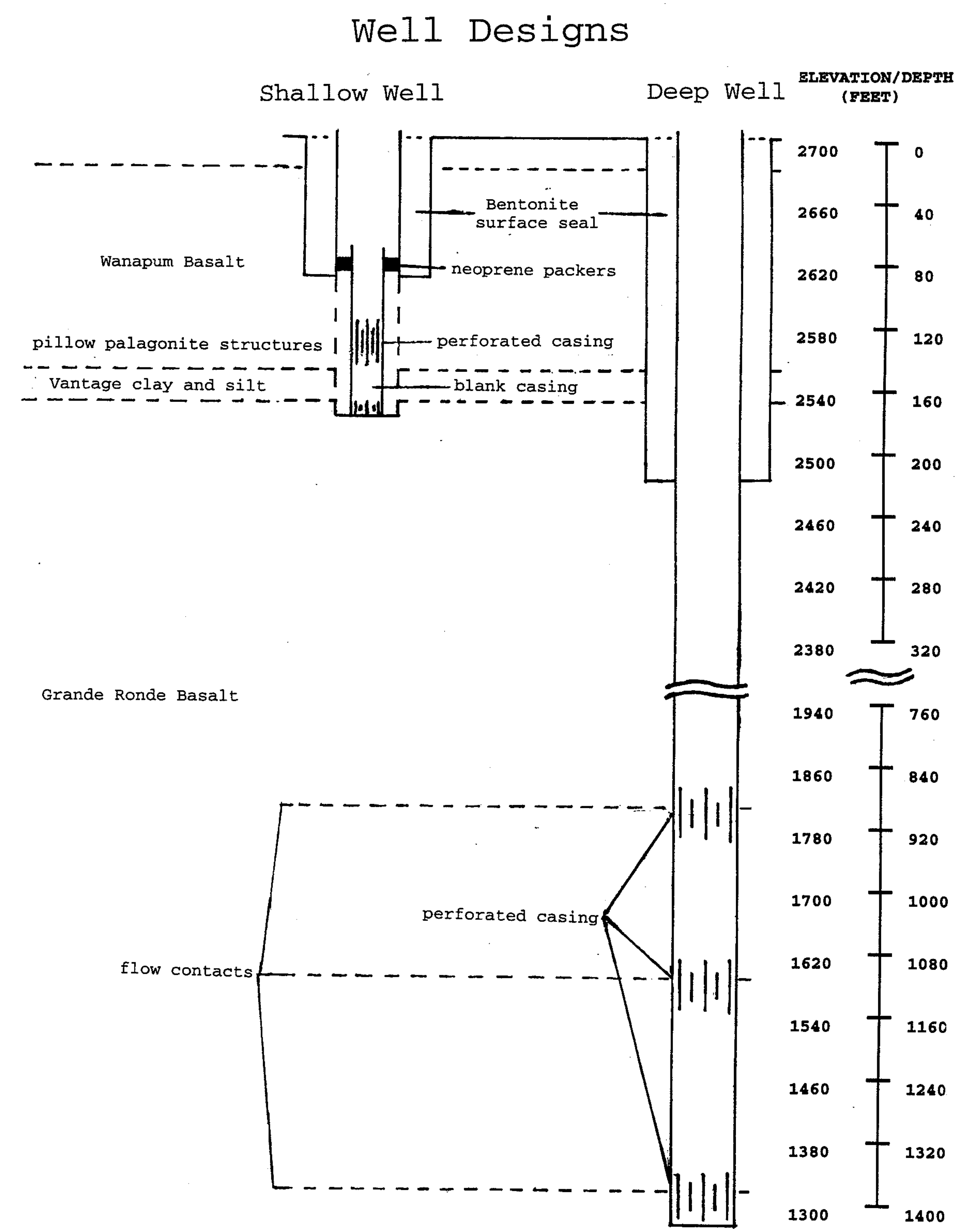


Figure 26 **Well construction designs for the city of Genesee.**

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

General Conclusions

The ground water development potential for the city of Genesee is good. Two target aquifers are available for the city. Variable yields of upper aquifer wells in the Genesee area suggests a need to budget for three wells to obtain a target of 100 to 150 gpm from a single well. Careful location of these wells will avoid water quality and well interference problems. To explore the lower aquifer will require budgeting for a single well of about 1,200 feet in depth. The yield from this well is unknown but can be as great as 1,000 to 1,500 gpm.

Specific Conclusions

The following specific conclusions are drawn from this study:

1) Yields of wells in the Wanapum Aquifer are related to the presence of the pillow-palagonite structures and are thus poorly predictable in the Genesee area.
2) The hydrogeologic conceptual model of the Wanapum Aquifer within the study area indicates that present

development of the aquifer by the city of Genesee has not depleted the aquifer.

3) Contamination of the Wanapum Aquifer in the vicinity of Wells #1, #2, #3, and #7 suggests that a hydraulic connection exists between the surface water and the Wanapum Aquifer via poorly sealed well casings.

4) The recharge to the Wanapum Aquifer in the Genesee area probably is much greater than annual pumpage. The recharge value of 2.25 inches per year extrapolated from Lum and others (1990) probably is an overestimate.

5) Water discharges from the Wanapum Aquifer as outflow to the west of the study area, as small amounts of seepage observed in Hatwai Canyon, and as pumpage.

6) Evaluation of the Grande Ronde Aquifer is not possible due to the lack of available information in the study area and limited application of knowledge from the surrounding areas.

Recommendations

1) Detailed geologic and hydrologic data should be collected during construction of any new wells.

2) Water level, pumpage, and water quality data should continue to be collected and compiled for all city wells. These data should be reviewed every five years or when a problem occurs.

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