GROUND WATER OPEN FILE REPORT

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IN THE ELLA BUTTE AREA
GILLIAM AND MORROW COUNTIES, OREGON

By

Michael J. Zwart

OPEN-FILE REPORT NO. 88-03

STATE OF OREGON
WATER RESOURCES DEPARTMENT

RESOURCE MANAGEMENT DIVISION

WILLIAM H. YOUNG
Director

G R O U N D   W A T E R

O P E N   F I L E   R E P O R T

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SALEM, OREGON

MARCH, 1988

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DEFINITIONS OF SELECTED TERMS

Acre-Foot (AF): The volume required to cover one acre to a depth of one foot. This is equal to 43,560 cubic feet or 325,851 gallons.

Alluvium: Detrital deposits of clay, silt, sand and gravel resulting from the erosion and/or deposition by modern rivers, thus including the sediments laid down in river beds, flood plains, lakes, fans at the foot of mountain slopes, and estuaries.

Anticline: A fold that is convex upward, in which strata dip away in opposite directions from a common ridge or axis. Its core contains stratigraphically older rocks.

Aquifer: A body of saturated rock, alluvium, or other naturally occurring material having sufficient permeability to store, transmit, and yield sufficient quantities of water to wells or springs so that they can serve as a practical source of water.

Aquitard: A geologic unit that is capable of absorbing water slowly but will not transmit it fast enough to furnish an appreciable supply for a well.

Artesian: Artesian is synonymous with confined. A geologic unit that contains water under sufficient hydrostatic pressure to cause the water level in a well to stand above the bottom of the overlying confining layer. When the water pressure is sufficient to raise the water level above land surface, a well penetrating the aquifer will flow.

Borehole: A circular hole made by boring or drilling.

Cascading Water: Ground water that enters a well bore and falls down the well.

Cone of Depression: The conical depression of a potentiometric surface or water table that forms around a well as a result of pumping.

Dewatering: Lowering of the potentiometric surface to below the top of the aquifer. This drains the aquifer thus changing the hydraulic properties of flow.

Geophysical Logging: The collection of data with respect to depth in wells or boreholes. Records of the data, called logs, commonly include temperature, caliper, flowmeter, natural gamma radiation, electrical resistivity, self-potential, and various other types of data.

Ground Water Reservoir: A designated body of standing or moving ground water having exterior boundaries which may be ascertained or reasonably inferred (ORS 537.515(4)).

Fault: A fracture or series of fractures in rock accompanied by a displacement of one side with respect to the other.

Fault Gouge: Clays that form between fault surfaces as a result of pulverization of the rock along the slippage face.

Hydraulic Conductivity: The volume of ground water flowing in unit time through a face of unit cross sectional area perpendicular to the direction of flow under a unit hydraulic gradient. It can be expressed as gallons per day per square foot or feet per day.

Hydraulic Gradient: The change in static head per unit distance in a given direction.

Interference: The lowering of the water level in a well or spring due to pumping of neighboring well(s).

Monocline: A local steepening or steplike bend in otherwise gently dipping strata.

Permeability: The ability of a rock or soil to transmit fluid such as water under a hydraulic gradient.

Porosity: The ratio of the total volume of voids in a rock or soil to its total volume, usually expressed as a decimal, fraction or percentage.

Porous: Containing voids, pores, interstices, or other openings that may or may not interconnect.

Potentiometric Head: The level to which water in an aquifer will rise by hydrostatic pressure, usually expressed as an elevation above sea level.

Scoriaceous: A textural term describing a coarsely vesicular, usually volcanic rock.

Specific Yield: The ratio of the volume of water which a saturated rock or soil will yield by gravity to the total volume of the rock or soil. It is usually equal to porosity minus specific retention.

Storage Coefficient: The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Syncline: A fold in rocks that is concave upward (u-shaped) in which strata dip inward from both sides toward the axis of the fold. Its core contains stratigraphically younger rocks.

Synoptic Measurements: A group of water level measurements taken at approximately the same time over an area to give a simultaneous display of conditions.

Total Head: The total head of a liquid at a given point is the sum of three components: (1) elevation head, which is the elevation of a point above a datum, (2) pressure head, which is the height of a column of static water that can be supported by the static pressure at the point, and (3) velocity head, which is the height the kinetic energy of the liquid is capable of lifting the liquid. In most ground water situations, velocity head is nil.

Transmissivity: The rate of flow at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient. It equals the hydraulic conductivity multiplied by the saturated thickness of the aquifer. It is usually expressed as gallons per day per foot, or square feet per day. In simple terms, the ability of an aquifer to transmit water.

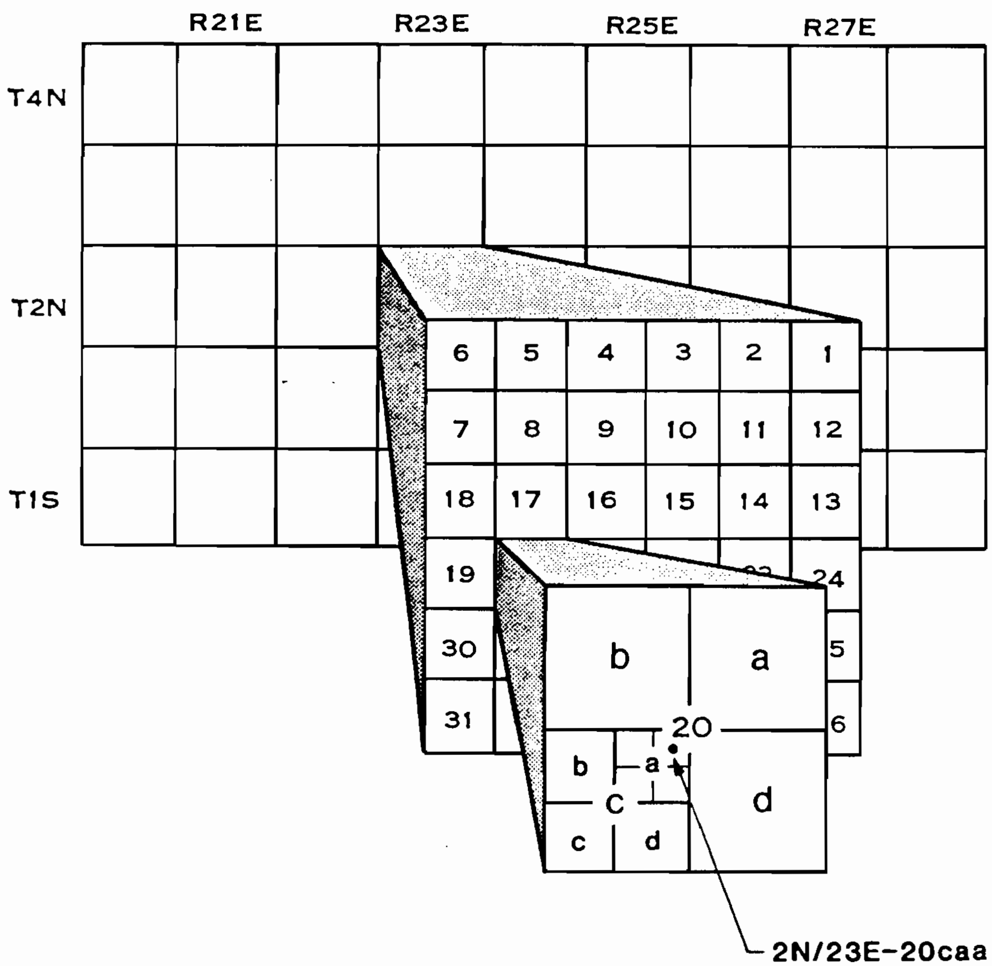
Vesicular: A textural term describing the many small cavities which are formed by the expansion of a bubble of gas or steam during the solidification of igneous rock.

Water Level: The distance from land surface to the top of the water column in a well. When the well is pumping, it is called a pumping water level. It is referred to as a static water level when a well has recovered from pumping.

Water Table Aquifer: Water table is synonymous with unconfined. A water-bearing geologic unit where the hydrostatic pressure at the upper surface of the water body is atmospheric.

WELL NUMBERING SYSTEM

The well and spring numbering system used in Oregon is based on the rectangular system used for subdivision of public land. Each well number indicates the geographic location of the well and describes the township, range, and section. For example, the well number 2N/23E-20caa indicates a well located within Township 2 North, Range 24 East, and Section 20. The letters following the section number indicate the well location within the section as shown below. The first letter (c) represents the quarter section (160 acres), the second letter (a) the quarter-quarter section (40 acres), and the third letter (a) the 10 acre tract. A series number is added following the third letter to distinguish two or more wells within a 10 acre tract.



EXECUTIVE SUMMARY

The Ella Butte area is located within the Umatilla Basin in north-central Oregon. It includes about 130 square miles in Morrow County and about 20 square miles in Gilliam County.

The climate of the area is semiarid with average annual precipitation less than 9 inches. Evaporation plus transpiration by plants exceeds average precipitation for all but the months of November through February.

The area is located within a region known as the Columbia Plateau. It is entirely underlain by basalt of the Columbia River Basalt Group. This rock was deposited during Miocene time, beginning about 16 to 17 million years ago. The basalt is also the most important ground water reservoir in the area. It is overlain in most places by younger sedimentary deposits. Only one of these younger deposits serves as an aquifer in a part of the area. Near Willow Creek, alluvium is of sufficient saturated thickness and extent to yield water to wells. Structural uplift of the Blue Mountains has folded the basalt bedrock in several places. Only one of the folds, the Willow Creek monocline, may be important in controlling the occurrence and movement of ground water within the Ella Butte area.

Ground water in the basalt occurs and moves primarily in the interflow zones between individual basalt flows. Most of the ground water occurs under confined conditions in this ground water reservoir. Natural recharge to the basalt is slight and occurs mostly in the higher elevations of the Blue Mountains to the south. Precipitation is greater there and more interflow zones are exposed at land surface. Estimates of natural recharge and pumpage for the larger Umatilla Basin indicate that the basalt ground water reservoir is overdrawn.

Ground water flows very slowly from areas of recharge to areas of discharge. Locally, it flows generally north and discharges naturally to the Columbia River. Water level data and aquifer test analysis indicate that an effective hydraulic barrier exists in the Ella Butte area. Its location approximately coincides with a geologic structure called the Willow Creek monocline.

Irrigated agriculture is an important part of the local economy. Irrigation from surface water sources is limited to the valley of Willow Creek, which is the only perennial stream in the area. Irrigation from ground water sources, primarily the basalt ground water reservoir, increased in the mid-1960's. At present, 16 water rights in the area use this source of ground water. These allow the primary and supplemental irrigation of about 9500 acres. Some of these rights are not currently exercised. Development of this ground water resource has resulted in water level declines in wells tapping the basalt.

The Director of the Oregon Water Resources Department initiated a proceeding for the determination of a critical ground water area in the Ella Butte area on January 31, 1985. This action was based on investigations which disclosed that water levels were declining and that the available supply of ground water was being overdrawn. This halted issuance of new permits for appropriation of water from the basalt ground water reservoir.

Water level declines have continued in much of the area since this action was taken. However, there have been recent water level rises in several wells. These rises are a result of several irrigation wells remaining idle for at least two years. Annual ground water pumpage in the area decreased sharply between 1980 and 1986. Pumpage in 1987 was higher than in the two previous years due to renewed pumping at several wells.

The administrative action taken in 1985 contemplated a contested case hearing required by the critical ground water area statutes (ORS 537.730 to 537.740). This procedure is administratively complicated and one that is often opposed by potentially affected parties. It is probably best reserved for areas in which reduced ground water use is mandatory to effect long-term stability in water levels.

The basalt ground water reservoir could be withdrawn, pursuant to ORS 536.410, or classified, pursuant to ORS 536.340. These instruments are simpler administrative processes than critical ground water area determinations. They are rulemaking functions, rather than contested case matters. Both of these may be used to halt all new appropriations of ground water, or to limit such appropriations to certain uses. However, neither can impose any restrictions on existing appropriations. The Water Resources Commission, at its October 9, 1987 meeting, directed the Department staff to pursue classification of the basalt ground water reservoir in the Ella Butte area as part of the Umatilla Basin planning process. It is anticipated that the classification could be accomplished in the spring of 1988.

INTRODUCTION

Location

The Ella Butte area includes about 150 square miles in north-central Oregon (Figure 1). It is located entirely within the Umatilla Basin in Morrow and Gilliam Counties, with all but about 20 square miles being in Morrow County. Its eastern boundary coincides with a portion of the western boundary of the proposed Butter Creek Critical Ground Water Area. A detailed legal description of the exterior boundaries of the area is given in Appendix A.

Purpose

The Ella Butte area is one of two areas in the Umatilla Basin affected by administrative actions taken by the Director of the Water Resources Department in January 1985. A hearing is required before the administrative action can be resolved. The purpose of this report is twofold. First is to summarize and update what is known about the ground water conditions in the basalt ground water reservoir in this area. Second is to inform the Water Resources Commission and parties potentially affected by this action. The report will also provide pertinent information for entry into any hearing record which would be established. A general description of the hydrogeology of the area is included. Compilations of information on such things as water rights, wells, water levels, water level trends, and ground water pumpage are also included. Several potential actions for future management of the ground water resource are described.

Previous Studies

The geology and ground water resources of the area have been described in various reports. Noteworthy earlier reports are by Wagner (1949), Hogenson (1964), Newcomb (1961, 1966, 1967 and 1970), and Robison (1968 and 1971). Reports by Shannon and Wilson, Inc. (1972) and Swanson and others (1981) include detailed regional geologic maps of the area. Farooqui and others (1981a and 1981b) described the Dalles group, which overlies the basalt in much of the Ella Butte area. In response to declining water levels in certain portions of the Umatilla Basin, the Oregon Water Resources Department has been involved in several investigations which have resulted in both published and unpublished reports. Sceva (1966) and McCall (1975) described ground water conditions in the Ordnance area. Bartholomew (1975) and Norton and Bartholmew (1984) described ground water conditions in the Butter Creek area. Oberlander and Miller (1981) and Zwart (1984) investigated more regional water level declines in the Umatilla Structural Basin.

In 1980, the Oregon Water Resources Department entered into a cooperative project with the U.S. Geological Survey to describe and quantify the basalt hydrology in the Umatilla Structural Basin with the use of a digital-flow model. Funding for this project was terminated in 1984, but the final report

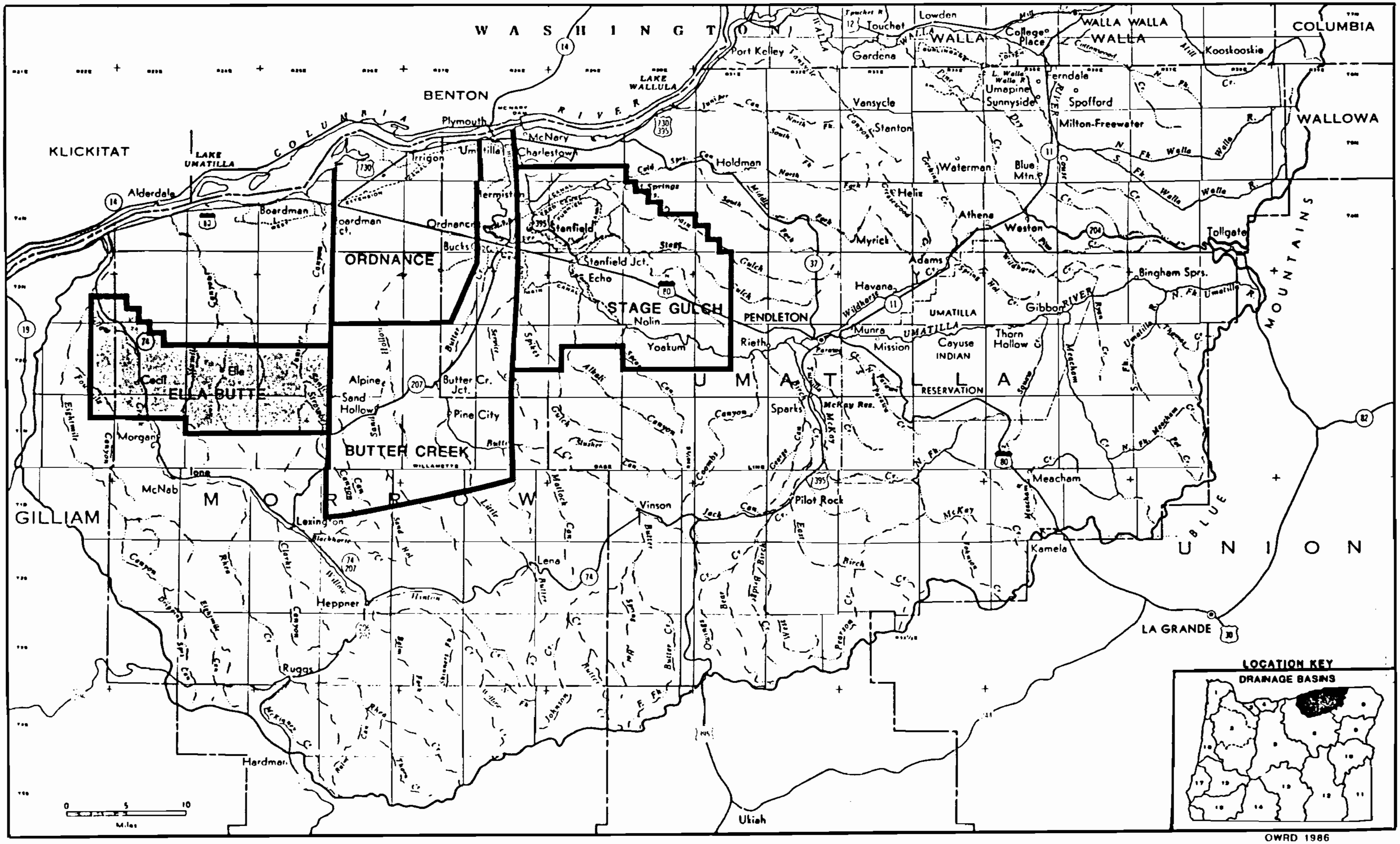


Figure 1. UMATILLA BASIN SHOWING LOCATION OF THE ELLA BUTTE AREA AND ITS RELATIONSHIP TO OTHER EXISTING AND PROPOSED CRITICAL GROUND WATER AREAS.

is presently undergoing review and should be forthcoming in 1988. The U.S. Geological Survey has also completed the data collection phase in 1985 for the Columbia Basin Regional Aquifer Systems Analysis (RASA) project in Oregon, Washington and Idaho. Twelve separate reports regarding the geology, hydrology, ground water pumpage, computer modeling, and other aspects of the RASA project are expected with a completion schedule continuing through 1988. The first of these reports, by Collins (1987), discusses 1984 pumpage in the Oregon portion of the RASA project area. The forthcoming reports should provide much additional information which will increase the knowledge of basalt ground water flow systems.

Ground Water Development

Extensive ground water development for irrigation began in the Umatilla Basin in the mid-1960's. This rapid development of the ground water resource was encouraged by several factors. They included new irrigation techniques, faster hard-rock drilling methods, favorable crop prices, and low cost electrical power for pumping. Although development was occurring at about the same time in the Ella Butte area, it was more concentrated to the east in what are now the Ordnance and Butter Creek Critical Ground Water Areas.

The Water Resources Department filed a total of 19 applications to appropriate water from the basalt ground water reservoir in the Ella Butte area between 1958 and 1983 (Table 1). Valid permits or certificates exist for 16 of the original applications. Primary and supplemental irrigation of over 9500 acres was permitted by these rights of record. There are additional ground water rights which allow irrigation from a shallow alluvial aquifer in the western part of the area. These additional rights are not tabulated in Table 1 and the alluvial aquifer will not be discussed in great detail in this report.

Water level declines have occurred in the area as irrigation development progressed. The declines continue in many wells. This is noteworthy, because in recent years less favorable economic conditions have led to reductions in the acreage under irrigation and the quantity of ground water pumped. Many of the rights of record are not presently being exercised and some of these have probably been idle for five or more years.

Administrative Action

William H. Young, the Director of the Oregon Water Resources Department, initiated a proceeding for the determination of a critical ground water area in the Ella Butte area on January 31, 1985 (Appendix A). This action was taken as a result of preliminary investigations which gave him reason to believe that ground water levels in the area were declining and had declined excessively and that the available ground water supply in the area was being overdrawn. The proceeding prohibits new ground water appropriations from the area and reservoir in question. Final resolution of the question of a critical ground water area determination could allow permit issuance. The Department suggested at the time of initiation that a contested case hearing would occur within two to four years, following collection and analysis of additional data.

The Oregon Legislature created the Water Resources Commission later in 1985. The Commission authority includes the ability to withdraw or classify ground water. These administrative processes were previously used principally to manage surface water resources. In March 1987, the Commission withdrew from further appropriation the "Main Ground Water Reservoir" in the Fort Rock Basin of south-central Oregon. This was the initial use of this instrument with regard to Oregon's ground water resources. The Commission authorized the Water Resources Department staff to proceed with classification in the Ella Butte area at its October 9, 1987 meeting. Classification is statutorily tied to the basin planning process. This process is ongoing in the Umatilla Basin and is scheduled to conclude in the spring of 1988.

Table 1. Basalt Ground Water Rights for the Ella Butte Area.

Relative Priority	Record Holder	Owner Well Number	Well Location	Priority Date	Application or Transfer Number	Permit Number	Certificate Number	Permitted Diversion (cfs)	Acreage*	Remarks
1	Estate of Sena Miller	1	2N/23E-35bdd	7/29/58	G-1121	G-1044	30121	0.03	10.1 P	
	George Miller, Admin.	2	2N/23E-35acc							
2	Hynd Bros. Co.		2N/23E-17ddd	6/08/64	G-2883	G-2702	38827	0.96	11.29 P, 174.71 S	
3	Lawrence D. and Corrine Lindsay		1N/25E-1bda	1/07/65	G-3012	G-2831	37811	1.00	324.1 P	
4	Hynd Bros. Co.		2N/23E-20ada	3/08/68	G-4269	G-4021	38828	1.62	20.9 P, 128.1 S	
5	David Cheney		2N/23E-17add	3/27/68	G-4300	G-4050	44992	2.79	223.3 S	
6	Krebs Bros., Inc.		2N/23E-29ddd	9/04/68	G-4498	G-4240	49878	1.32	232.6 S	
7	Lawrence D. and Corrine Lindsay		2N/25E-36abb	10/07/68	G-4628	G-4353	42329	3.34	878.4 P	
	Eric Anderson		1N/25E-14ddb	3/09/77	G-7901	G-7337		32.00	1280.0 P	CANCELED
8A	Franklin Lindstrom and Sons, Inc.		2N/24E-32cdc	9/25/69	G-5004	G-4722	45204	1.30	225.6 P	Certificate superceded by 49816 (corrected lands)
	Larry Douglas		2N/24E-32cdc	9/25/69	T-3709		48698	0.90	165.8	Certificate canceled by T-4471
8B	Clifford L. Douglas		2N/24E-32cdc	9/25/69	T-4471			0.90	165.8 P	Transfer of rights perfected under G-4722
8C	Franklin Lindstrom and Sons, Inc.		2N/24E-32add	9/25/69	G-5014	G-4727	46611	2.20	294.0 P	
	Eric Anderson		2N/24E-36dbc	7/25/76	G-7556	G-7023		7.80	626.7 S	CANCELED
9	Eric Anderson		2N/24E-36dbc	11/05/73	G-6342	G-5238	50853	7.30	583.8 P	Well limited to 7.3 cfs for all rights of record
	Proudfoot Ranches, Inc.		1N/24E-9abc	4/28/73	G-6010	G-5260		0.10	8.0 P	CANCELED
10	Eric Anderson	2	2N/24E-33ddb	3/29/74	G-6483	G-5239	52005	5.91	472.9 P	Well 1 limited to 7.3 cfs for all rights of record
		1	2N/24E-36dbc					4.63	370.5 P	
11A	Clifford L. Douglas		2N/24E-31daa	4/29/75	G-6920	G-9400		4.46	320.0 P	2 priority dates
14A				4/19/80					720.0 P+S	
11B	Clifford L. Douglas		2N/24E-31abb	4/29/75	G-6921	G-9401		5.57	320.0 S	2 priority dates
14B				4/19/80					720.0 P+S	
12	Art Lindstrom Ranch, Inc.		2N/24E-32add	8/10/77	G-8359	G-7355		1.70	140.0 P	
13	Fairview Ranch, Inc.		2N/23E-31abb	11/03/77	G-8519	G-7687		3.40	2500.0 P	
15	David Cheney	2	2N/23E-17add	4/4/83	G-10914	G-10135		2.00	485.25 P 333.62 S	Alluvial Well 1 also permitted

* P = Primary
S = Supplemental

GEOGRAPHIC SETTING

The Ella Butte area is located within the Columbia Plateau physiographic province. This is a large flood basalt province including many thousands of square miles in Oregon, Washington and Idaho. The basalt bedrock is resistant to erosion and controls the topography of the area. In this area, the basalts dip slightly to the north toward the Columbia River. Therefore, the topography of the area is similar, with higher average elevations to the south. Elevations in the area range from about 370 feet in the northwest corner, adjacent to Willow Creek, to over 1600 feet at Ella Butte. The area is moderately well dissected by several north flowing streams: Willow Creek, Sixmile Canyon, Juniper Canyon and their tributaries. Of these, only Willow Creek is perennial, and it can almost be completely diverted during the irrigation season.

The climate of the area is fairly typical of the arid continental climate east of the Cascade Range in Oregon. A permanent weather station is not presently located within the Ella Butte area. However, a former station has established a record of temperature and precipitation data for the period 1898 to 1914 (Johnsgard, 1963). Average annual precipitation at this station was 8.8 inches. Over half of the precipitation falls during the months of November through February. Johnsgard calculated average potential evapotranspiration to be less than average precipitation only during these same months.

Summers are usually warm and dry with July average daily maximum temperatures above 90°F. January average daily maximum temperature is about 40°F and average daily minimum is about 23°F. Proximity of the area to the Columbia River and its gorge to the west occasionally subjects the area to the moderating influence of the maritime climate of western Oregon. This results in slightly milder temperatures and a slightly longer growing season than would be expected for a continental type climate at this latitude. Periods of persistent winds are also occasionally a result of this proximity.

The population of the Ella Butte area is low, with probably less than 50 residents. No cities or towns are located in the area nor are there any population centers of note. The sites of Cecil and Ella, shown in Figure 1, are located near the Oregon Trail. They were previously post offices and Cecil was also a train station. They are now sites of ranches.

The economy of the area is based on agriculture. The principal crops are wheat (both dryland and irrigated), potatoes, corn and alfalfa. The latter is grown primarily in the Willow Creek area. Other crops are also grown and the variety has been greater in the past, when more acreage was under irrigation. Livestock is also important in the area.

Access to the area is provided by several state and county roads. State Highway 74 serves the western part of the area along Willow Creek valley. It connects Interstate Highway 84 with the towns of Heppner, Lexington and Ione. State Highway 207 and Bombing Range Road provide access to the eastern part of the area. In addition, numerous gravel and improved roads serve the area. The U.S. Navy Boardman Bombing Range occupies about 12 square miles of the northeast part of the area and public access is restricted there.

GEOLOGY

Stratigraphy

Basalt of the Columbia River Basalt Group underlies all of the Ella Butte Area. It also forms the most important ground water reservoir in the area. The Columbia River Basalt Group consists of a thick sequence of many individual flood basalt flows. They formed from eruptions over several million years (m.y.). The eruptions began during Miocene time (about 16 to 17 m.y. ago). Individual basalt flows may vary in thickness, texture, chemistry, magnetic polarity, and areal extent. Flows typically have a chilled and occasionally vesicular basal contact and are often vesicular and/or weathered at the top. Weathered or vesicular flow tops and bottoms are known as interflow zones. These zones are often more permeable than the more massive and dense central portions of the flows. Interbeds of sedimentary deposits often occur within the interflow zones between basalt flows.

In the Ella Butte area, the Columbia River Basalt Group is represented by three formations in order of decreasing age: Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountain Basalt (Figure 2). The basalts are generally only exposed at the surface in parts of some canyons and in road cuts. The Grande Ronde Basalt Formation crops out to the south of the Ella Butte area and is not exposed within the area. However, it has been tentatively identified in the subsurface on the basis of water well reports. It yields water to wells in the area. The Frenchman Springs Member of the Wanapum Basalt Formation overlies the Grande Ronde Basalt Formation. It is mapped at or near the surface over most of the Ella Butte area (Swanson and others, 1981). This member also yields water to wells in the area. The Saddle Mountains Basalt Formation is mapped only in the western part of the Ella Butte area, in or near Willow Creek Valley (Swanson and others, 1981 and Shannon and Wilson, Inc., 1972). Two members are represented in this area. The older Pomona Member is exposed as far south in the valley as Cecil. The younger Elephant Mountain Member is restricted to the higher elevations in the northwest corner of the Ella Butte area, near Dalreed Butte. These members are not important aquifers in this area. Both are limited in areal extent. The Elephant Mountain Member is not penetrated by any wells while the Pomona Member may be penetrated only in the near surface by a few wells near Willow Creek.

The Columbia River Basalt Group is overlain by younger unconsolidated and consolidated deposits in most of the Ella Butte area. The oldest of these deposits is identified as the Alkali Canyon Formation of the Dalles Group (Farooqui and others, 1981a and 1981b). Its lithology and thickness vary, but it generally consists of consolidated basaltic gravels, sands, and silts and vitric tuff (cemented ash). Deposition of these materials occurred in late Miocene to early Pliocene(?) time (about 10 to 4 m.y. ago). Alluvium of Quaternary age (2 m.y. or less), has been deposited in the valleys and flood plains of the creeks in the area. The alluvium is of sufficient thickness and extent to serve as an aquifer only in the Willow Creek Valley. There, one irrigation well and perhaps a few domestic wells produce ground water from this deposit.

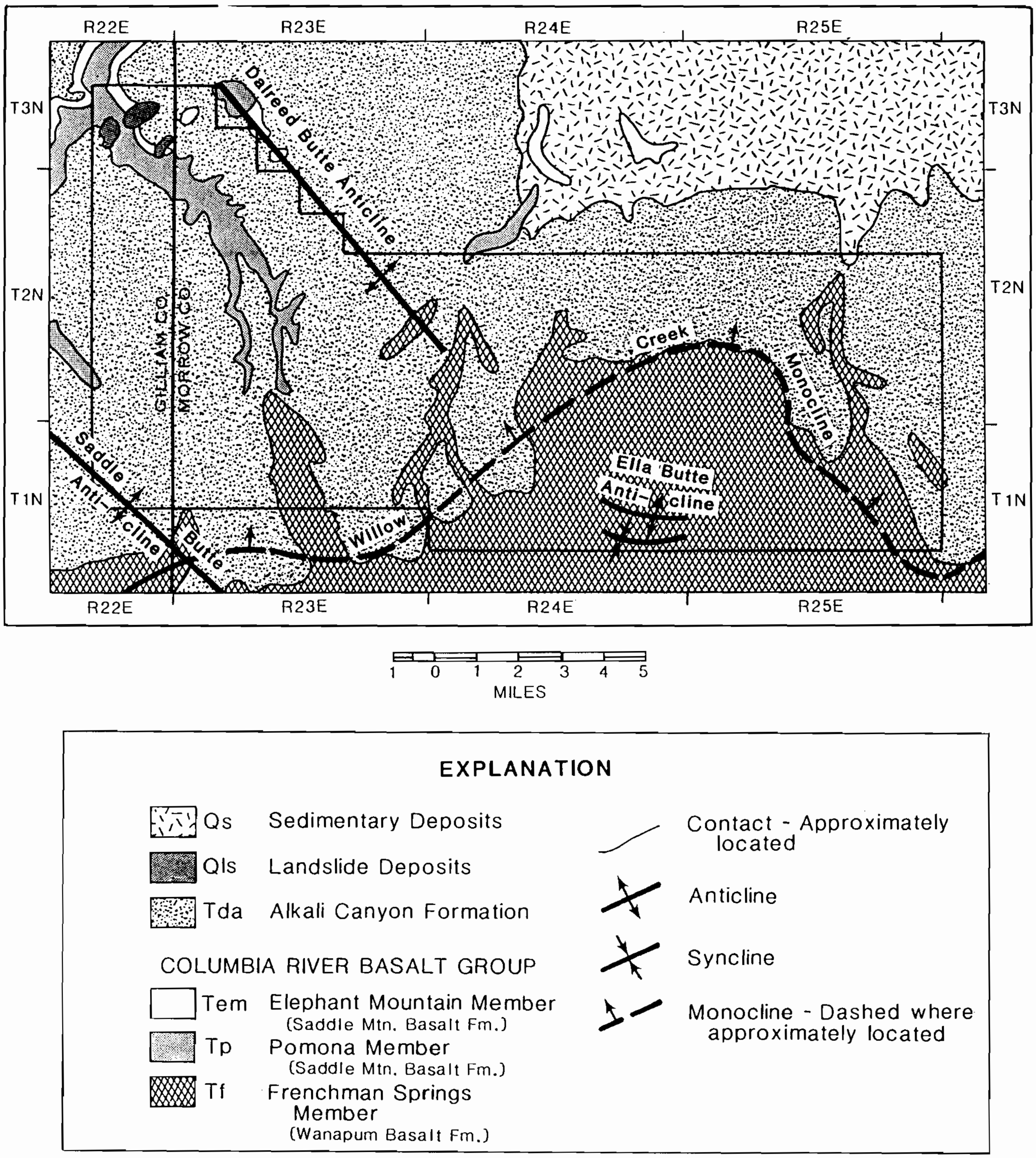


Figure 2. GENERALIZED GEOLOGIC MAP OF THE ELLA BUTTE AREA

(Modified after Shannon and Wilson, 1972, and Swanson and others, 1981.)
Alluvium (Qal) and Loess (Ql) are not shown on the map to better emphasize other units.

Several landslide deposits of Quaternary age are mapped in the northwest corner of the area. These are largely unstratified, unsorted mixtures of basaltic, sedimentary, and tuffaceous bedrock. A veneer of loess, windblown silt and fine sand, also of Quaternary age, mantles the land surface of nearly the entire area. The presence of the younger deposits has made geologic mapping of the basalt stratigraphy and any structures, such as folds or faults, difficult without detailed subsurface information. Neither the alluvium nor the loess are shown in Figure 2. This allows better illustration of the underlying geologic units.

Structure

The basalt of the Columbia River Basalt Group was a very fluid lava at the time of eruption. This allowed the individual flows to cover hundreds of square miles. The existing topography was important in controlling the areal extent and thickness of the flows. They are thickest in areas of topographic depressions and pinch out at higher elevations. During the relatively long period of deposition of the Columbia River Basalt Group, the uplift of the Blue Mountains to the south also occurred. This uplift continued until after the basalts were deposited, resulting in a slight dip of the basalts to the north in this area. The basalts are thickest, estimated to be over 5000 feet, near the Columbia River. The younger basalt flows generally do not extend as far south as older flows, due to the ongoing uplift.

The uplift, and associated downwarping, which occurred during and after deposition of the Columbia River Basalt Group has folded the basalts into broad anticlines and synclines. Many of these folds are regional in scale, having long fold axes and relatively slight dip on the flanks. These are predominately east-west to northeast-southwest trending folds, paralleling the trend of regional deformation. None of these more regional folds have been mapped by prior investigators in the Ella Butte area (Shannon and Wilson, Inc., 1972 and Swanson and others, 1981). However, shorter folds are also mapped which occasionally exhibit more steeply dipping beds and may be associated with faulting. They often occur as a sub-parallel set of an anticline and a syncline.

Two northwest-southeast trending anticlines have been mapped in the western part of the area (Figure 2). The Saddle Butte anticline crosses the extreme southwest corner of the area and the Dalreed Butte anticline skirts the boundary of the area between Dalreed Butte and Squaw Butte. The axes of these anticlines can be traced through a series of buttes, which is a common topographic expression of such structures in the Columbia Plateau. The Ella Butte anticline is mapped as a short east-west trending anticline and sub-parallel syncline near Ella Butte.

Shannon and Wilson (1972) mapped the Willow Creek monocline in the Ella Butte area (Figure 2). Its axis enters the area from the southwest several miles west of Ella Butte. It trends northeast, curves to the south, and exits the southeast corner of the area, where it continues easterly through the Butter Creek Critical Ground Water Area. The topographic expression of this structure is much more subtle than can be shown for other folds. Its location is inferred over much of its length. Other investigators have called it the Willow Creek Lineament and refined its location in some places with the use of water level data (Oberlander and Miller, 1981). Their work proposes that the structure may not be monoclinal over its entire length. Rather, it may be associated with unmapped faults or stratigraphic pinch outs of basalt flows.

Folds and faults are often important in controlling the occurrence and movement of ground water, as well as the response of nearby wells to pumping. In the Ella Butte area, it is apparent that only one of the previously mapped structures, the Willow Creek monocline, is important in this regard. This aspect will be discussed in greater detail later.

GROUND WATER

Hydrologic Cycle

The continuous circulation of water in all forms on the earth and in the atmosphere is known as the hydrologic cycle. The cycle has neither a beginning nor an end, but the oceans are conventionally presented as its origin. Radiation from the sun evaporates water from the oceans, lakes and land surface into the atmosphere. The water vapor rises, condenses to form clouds, and falls back to the earth's surface as precipitation. Precipitation that falls upon land areas is the source of essentially all fresh water supplies.

Some precipitation, after wetting the foliage and ground, runs off over the land surface to streams. Some of this runoff is stored in lakes, ponds, and swampy areas. Other water soaks into the soil. Much of the water that enters the soil is detained in the plant root zone and eventually is drawn back to the surface by plants or by soil capillarity. Some of it, however, infiltrates below the plant root zone and continues moving downward until it enters the ground water reservoir. Here, it percolates through the pores or fractures of saturated subsurface materials and may reappear at the surface in the form of springs and seeps. These discharges of ground water maintain the flow of streams in dry periods. The streams, carrying both surface runoff and ground water discharge, eventually lead back to the oceans.

The hydrologic cycle, then, is the system by which water circulates from the oceans through the atmosphere and returns both overland and underground back to the sea through diverse paths. The forces involved in this process include radiation, gravity, molecular attraction and capillarity. The time required for water to complete a circuit through the cycle can vary considerably, from a few minutes to many millenia, depending on the path taken. Ground water reservoirs contain an immense quantity of water in storage and may detain the water entering them for long periods of time before the same water is discharged to surface water bodies.

Basalt Aquifers

Hydraulic Characteristics

Water that percolates below the soil moisture zone into the zone of saturation becomes ground water. The top of this zone is the water table. Unconfined ground water in the zone of saturation moves downgradient from areas of recharge to areas of discharge. The water table is not stationary, as its shape and elevation can change in response to many factors. Among these are variations in permeability of the rocks, precipitation, topography, and pumping from wells. As ground water in the zone of saturation moves in the more permeable materials, it may flow beneath less permeable overlying beds and become confined. Water in confined, or artesian, aquifers is under sufficient hydrostatic pressure to rise above the bottom of the overlying confining beds in properly constructed wells penetrating such aquifers. The potentiometric surface is an imaginary surface representing the total head in a confined aquifer, and is analogous to the water table in an unconfined aquifer.

Ground water in rocks of the Columbia River Basalt Group occurs and moves primarily in the interflow zones and any of the more permeable sedimentary interbeds. Most of the ground water is under confined conditions within these interflow zones. The dense flow centers of the basalt and low permeability interbeds act as the confining beds. Each interflow zone could be considered as a separate aquifer, with a unique potentiometric head. However, water wells commonly penetrate more than one interflow zone to produce the desired quantity of water. This makes it necessary, in this area, to treat the entire basalt thickness as a single ground water reservoir. Records for most wells which tap the basalt reservoir in the Ella Butte area are given in Appendix B.

Water level measurements for most deep basalt wells represent points on a composite, or regional, potentiometric surface for the various interflow zones penetrated. Plate 1 is a composite potentiometric surface map, prepared from water level measurements made in February 1987. Refinements to the map include additional data from water well reports and measurements taken at other times. Complete water level measurement data are compiled in Appendix C. Conversion of water levels to elevations above mean sea level uses estimated land surface elevations at wellheads. The configuration of the potentiometric surface is an indicator of some of the hydraulic properties of the ground water reservoir. The general south-north gradient suggests that the principal area of recharge is to the south of the Ella Butte area. In the higher elevations of the Blue Mountains, the precipitation is greater and more interflow zones are exposed at land surface. This allows greater opportunity for recharge to occur. Relatively closer spacing of the potentiometric contours is an indication of an area where the transmissivity of the interflow zones is low, the presence of a structural or stratigraphic barrier which impedes ground water movement, or possibly both. The location of the closely spaced 600 to 800 foot contours in the central part of the area (Plate 1) approximately coincides with the Willow Creek monocline.

Water Resources Department personnel have conducted aquifer tests at various locations within the Umatilla Basin. An aquifer test is a procedure in which a well is pumped for a period of time in a controlled fashion, usually several hours to several days. During the test, drawdown data are collected at the pumped well and, in most cases, one or more observation wells. Water level recovery data are also collected after pump shutdown. Other activities during aquifer tests include measurement of both water temperature and barometric pressure, and collection of water samples for analysis. Data interpretation allows calculations of the hydraulic characteristics of the aquifer (transmissivity and storage coefficient).

Department personnel conducted a test in the Ella Butte area (Miller and Strachen, 1980). The test was located in the central part of the area and included five observation wells (Plate 4). The transmissivity was calculated to range from 12,750 to 15,600 square feet per day, or about 95,300 to 116,700 gallons per day per foot. The storage coefficient was calculated to be about 0.00185. The hydraulic characteristics calculated from other aquifer tests in the basin indicated a fair amount of variability in the basalts. Transmissivity ranged from about 1,000 to over 35,000 square feet per day. The storage coefficients ranged from about 0.001 to 0.00001, and averaged about 0.0005, which is somewhat small for artesian aquifers, but fairly typical for basalts.

An interesting interpretation made during the aquifer test in the Ella Butte area was the presence of a hydraulic barrier. An observation well to the southeast of the pumped well did not respond to the pumping. A barrier to ground water flow was interpreted as possibly being a fault along an assumed east-northeast trend between these wells. This location and trend are approximately coincident with the Willow Creek monocline and the steep gradient of the potentiometric surface discussed earlier. The barrier is apparently quite efficient in this area, hydraulically isolating wells on one side from the effects of wells pumping on the other.

Recharge

Ground water recharge in the Ella Butte area is very low. The low vertical permeability of the basalt ground water reservoir and slight average annual precipitation prohibit any significant natural recharge within the area. On that basis, nearly all of the ground water available to wells in the area recharged the basalts to the south in the Blue Mountains. It is difficult to estimate the average annual recharge which would be available to wells in the area. However, the Ella Butte area is located within the larger Umatilla Structural Basin. Estimates of the average annual recharge for the entire structural basin range from a low of 10,000 acre-feet to over 64,000 acre-feet (Oberlander and Miller, 1981 and Zwart, 1984). Based on these estimates and estimated annual withdrawals from the basalt ground water reservoir in the Umatilla Structural Basin, it appears that the available ground water supply in the basin is overdrawn by at least 15,000 acre-feet per year and perhaps as much as 70,000 acre-feet per year. Regional data from carbon 14 ages of ground water indicate very slow rates of ground water movement from areas of recharge to areas of discharge. This is expected if either the recharge rate or average transmissivity is low, or a combination of both.

A carbon 14 age date is available from water pumped during the aquifer test in the Ella Butte area (Plate 4). The apparent age of the ground water was determined to be 25,180 years before present, suggesting a rate of flow of about five feet per year (Oberlander and Miller, 1981). This apparent age might be lowered using a carbon 13 correction factor. This factor accounts for additional "ancient" carbon dissolved by the migrating ground water. An estimated corrected age for this sample is 21,040 years before present, suggesting that the rate of ground water flow is about six feet per year from the Blue Mountains.

The annual recharge available to wells in the Ella Butte area can be estimated using the ground water flow rate (6 feet per year), specific yield of basalts (about 2 percent) and total area of the surface through which any recharge enters. This area was estimated to be about 20 miles long and 1200 feet wide, based on wells being no deeper than 1500 feet and average water levels of 300 feet. This calculation suggests that only about 350 acre-feet of annual recharge may be available in the Ella Butte area.

Discharge

Natural discharge of ground water in the Ella Butte area is also very low. No major springs are known to be presently issuing from the basalt. Well Spring (T2N, R25E, Section 28), once used by pioneers along the Oregon Trail, has not flowed in many years, and subsequently was developed into a well.

Ground water in the basalt reservoir of the Ella Butte area flows slowly to the north and ultimately discharges to the Columbia River (Plate 1). A portion of the ground water, which otherwise would flow out of the area, is intercepted by wells and is artificially discharged within the area. Totalizing flowmeters have been required by the Water Resources Department at most permitted wells in the Ella Butte area since 1980. Data from flowmeters and power meters at wells are the bases to estimate annual pumpage for the period 1980 to 1987 (Table 2). Pumpage for the late 1970's appears to have been approximately the same as that estimated for 1980 and 1981. The marked reduction of ground water pumped is largely due to a great reduction of acres under irrigation in this period. The sluggish farm economy of the mid 1980's has forced some irrigators out of business while others have voluntarily cut back their irrigated acreage, at least for the short term. Other factors, such as wetter than normal years or more efficient irrigation practices, appear to be of minor significance in the reduction of pumpage.

Table 2. Estimated annual pumpage, in acre-feet, for irrigation from basalt aquifers in the Ella Butte area.

Year:	1980	1981	1982	1983	1984	1985	1986	1987
Pumpage:	4940	4780	3630	1520	1470	1000	1090	2560

Ground water pumpage in the Ella Butte area may not remain at the low levels of 1985 and 1986. Current water rights, if exercised, would result in much greater pumpage. Three wells, idle for two or more years, were reactivated during the 1987 irrigation season and caused most of the estimated pumpage increase in 1987.

Water Level Declines

As ground water development progresses in any area, some water level declines in wells are necessary as the aquifer or ground water reservoir responds to the stress of pumping. The magnitude and areal extent of the declines are dependent on many factors. These include the hydraulic characteristics, well spacing, quantity of ground water pumped, and proximity to recharge and discharge areas. The water level declines will continue and the area affected by such declines will expand like the expansion of the cone of depression near a pumping well. Only when the area affected has expanded to intercept recharge or discharge areas will the water levels begin to equilibrate. The water levels will, in time, stabilize at a lower level when the additionally induced recharge or reduced discharge balances the quantity pumped. If pumpage is great enough to overdraft the aquifer, water level declines will continue without stabilizing.

The Ella Butte area appears distant from areas of natural recharge or discharge. The basalt ground water reservoir is typified by low vertical permeability. This limits the ability to induce any additional recharge within the area. Water levels in the area have declined as a result of ground water withdrawals for irrigation. Declines continue in most of the observation wells. Plate 2 shows water level declines in the area for the period 1965 to 1980. The configuration of the water level decline contours is modified slightly from Oberlander and Miller (1981). Three areas of greater than 50 feet of water level decline are shown. The area to the east is adjacent to the Butter Creek Critical Ground Water Area. No significant pumpage occurs in this part of the Ella Butte area. The declines documented in this area are likely the result of pumping in the Butter Creek area. The other areas of water level decline to the west are centered about the two principal areas of ground water development in the Ella Butte area. On the basis of these and subsequent declines, the Director concluded in 1985 that water levels in the Ella Butte area are declining and have declined excessively. This is one of the two criteria cited in the administrative action taken in January 1985 (Appendix A).

Plate 3 shows water level changes during the period 1980 to 1987. It is based on winter water level measurements, when most wells are idle. Water levels have continued to decline in most of the area. However, two areas of water level rise are also documented. These areas, represented by only four wells, include two irrigation wells which had been idle for two or more years during the latter part of this period. The three intervening wells were also idle for two or more years. Water level rises at these wells during recent years were not sufficient to offset declines during the early part of this period.

Hydrographs are graphical representations of water levels versus time in individual wells. Appendix D includes hydrographs of 20 selected wells in the Ella Butte area. Water level trends in wells, including the recent water level rises, are easily visualized with the use of hydrographs. Please note that the hydrographs use three different vertical scales. These scales include ranges of 100, 200, and 400 feet.

RESOURCE MANAGEMENT

The administrative action taken by the Water Resources Director in January 1985 initiated a proceeding for the determination of a critical ground water area. This action was supported by the belief that evidence satisfied two of the five criteria authorizing such action, under ORS 537.730. That evidence included documentation for declining water levels in the area. Also, studies indicated that the basalt ground water reservoir in the larger Umatilla Structural Basin was being overdrawn. Recent data presented in this report indicates that these criteria are still satisfied in the Ella Butte area.

If the Department were authorized to proceed with critical area determination, a contested case hearing would be required. Provided that the hearing record established 1) that the circumstances under which the critical area proceeding was initiated are true, and 2) that the public welfare, health and safety require that corrective controls be adopted, the Water Resources Commission would by order declare that the area is a critical ground water area (ORS 537.735). The order of the Commission may be a powerful, but very flexible tool. It may include one or more provisions which control use of the ground water resource. The order may control certain portions of a critical area with differing provisions as may be necessary to equitably distribute the available supply of ground water.

A critical ground water area determination is a complicated administrative procedure. The proposed order is often opposed by affected parties, as is evident in the Butter Creek Critical Ground Water Area adjacent to the east. However, it is the only regulatory tool available for reducing ground water use in an area.

The external boundaries of the Ella Butte area surround the three major areas of water level declines (Plate 2). In addition, a one to two mile wide "buffer zone" is included. This buffer zone was intended to limit the effect, of any future development of the ground water resource outside the area, on existing appropriators within the area. Plate 4 includes proposed additional boundaries for subareas within the Ella Butte area. These subareas are proposed as logical divisions of the area for separate management and controlled use of the ground water resource. Different provisions of a critical area order could be imposed in each subarea without affecting appropriations in adjacent subareas. The named subareas include all of the active wells in each area while the unnamed subarea is essentially the buffer zone.

The Northwest and Southeast Ella Butte subareas are separated by an east-northeast trending boundary line. This boundary is coincident with an inferred hydraulic barrier during an aquifer test, abrupt changes in water level elevations, and the inferred axis of the Willow Creek monocline. These two subareas include most of the wells where reduced pumpage and rebound in water levels have occurred. The Willow Creek subarea is separated from the Northwest Ella Butte subarea because of differences in water level elevations and the relatively great distance between the permitted wells. Pumpage and water level decline trends in this subarea have been relatively consistent in recent years. The East subarea includes valid water rights, despite minimal pumpage in recent years. Water level declines in this subarea are attributed primarily to pumpage in the Butter Creek Critical Ground Water Area.

At the time the proceeding was initiated in the Ella Butte area, the Department did not have any apparent option to the critical area process. The 1985 creation of the Water Resources Commission and its ground water withdrawal in the Fort Rock Basin clarified that the State now has two additional instruments to manage Oregon's ground water resource. The basalt ground water reservoir could be withdrawn from further appropriation pursuant to ORS 536.410 or classified for certain uses pursuant to ORS 536.340. These processes are administratively simpler than the critical area determination procedure. The required hearing is a rulemaking function rather than a contested case matter. Both processes can effectively stop or limit new appropriations. However, neither is capable of reducing permitted ground water use. The classification process appears to be statutorily tied to river basin planning. A planning team has been working in the Umatilla Basin in 1987 and should conclude in the spring of 1988.

Annual ground water pumpage in the Ella Butte area has dropped from levels of the early 1980's. Some reduction had occurred by the time the administrative action was taken in 1985. Further reduction in pumpage occurred in 1985 and 1986. These reductions resulted in localized rebound of water levels. More data are needed to clearly predict the annual pumpage in the subareas which would result in stable water levels. Further analysis of water level trends at reduced pumpage is required. Although pumpage in the area rose in 1987, annual pumpage in the area may stabilize at a quantity which results in stable water levels. For these reasons it appears that the withdrawal or classification process is, for the near term, the more appropriate instrument for resource management in the Ella Butte area. If annual pumpage in the area increases dramatically, or water level declines continue in some areas, a critical ground water area determination could be made then.

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APPENDIX A

ELLA BUTTE PROCLAMATION

BEFORE THE WATER RESOURCES DIRECTOR OF OREGON

GILLIAM AND MORROW COUNTIES

IN THE MATTER OF INITIATION OF A CRITICAL GROUND WATER AREA DETER- MINATION IN THE ELLA BUTTE AREA OF THE UMATILLA STRUCTURAL BASIN	))))	PROCLAMATION ELLA BUTTE

- - - - - - - - - - - - - - - - - - -

The initiation of a critical ground water area proceeding is hereby proclaimed pursuant to OAR 690-10-050 in the Umatilla Structural Basin. The proposed exterior boundaries of this area, which include parts of Gilliam and Morrow Counties, are described as follows:

> Beginning at the northeast corner of Section 13, Township 2 North, Range 25 East, WM; thence south along a line common with the proposed Butter Creek Critical Ground Water Area, on the east boundary of Township 25 East, to the southeast corner of Section 13, Township 1 North, Range 25 East, WM; thence west along the sectionline to the southwest corner of Section 18, Township 1 North, Range 24 East, WM; thence north to the northwest corner of Section 18, Township 1 North, Range 24 East, WM; thence west along the section line to the southwest corner of Section 11, Township 1 North, Range 22 East, WM; thence north along the section line to the northwest corner of Section 26, Township 3 North, Range 22 East, WM; thence east along the line to the northeast corner of Section 30, Township 3 North, Range 23 East, WM; thence south to the southeast corner of Section 30, Township 3 North, Range 23 East, WM; thence east to the northeast corner of Section 32, Township 3 North, Range 23 East, WM; thenc south to the southeast corner of Section 32, Township 3 North, Range 23 East, WM; thence east to the northeast corner of Section 4, Township 2 North, Range 23 East, WM; thence south to the southeast corner of Section 4, Township 2 North, Range 23 East, WM; thence east to the northeast corner of Section 10, Township 2 North, Township 23 East, WM; thence south to the southeast corner of Section 10, Township 2 North, Range 23 East, WM; thence east along the section line to the point of beginning.

The initiation of proceedings for the determination of a critical ground water area is brought, on the director's own motion, under ORS 537.730(a) and ORS 537.730(d). These statutes allow for such action when the director has reason to believe that

> "Ground water levels in the area in question are declining or have declined excessively" per ORS 537.730(a), or
>
> "The available ground water supply in the area in question is being or is about to be overdrawn" per ORS 537.730(d).

Preliminary investigation, as referenced in "Ground Water Conditions in the Umatilla Structural Basin, An Executive Summary", has disclosed that recharge is being exceeded by pumping demand. Such conditions result in water level declines which will not equilibrate in the future. Water level declines have occurred and are occurring at rates which reflect this condition. The information in the studies referenced in the executive summary is the basis for the director's belief that conditions cited in ORS 537.730(a) and (d) exist in the Ella Butte area.

The ground water reservoir covered by this proclamation is herein termed the "Basalt Ground Water Reservoir." This reservoir, as further described in the studies referenced in the executive summary, includes all water contained in basalts of the Columbia River Basalt Group as well as any interbedded sedimentary deposits.

Prior to completion of the proceeding for determination of a critical ground water area, no application for a permit to appropriate water from the Basalt Ground Water Reservoir will be approved or denied.

Dated at Salem, Oregon, this 31st day of January, 1985.

This proclamation is effective immediately.

WILLIAM H. YOUNG
Director

APPENDIX B

RECORDS OF WELLS
BASALT AQUIFERS

Location: T1N/R23E-9dbc

Owner: Gene Crowell   Completion Date(s): 10/09/78

Well Depth: 310 ft. Casing Size: 8 in. Casing Depth 30 ft.

Land Surface Elevation: 710 ft. Use: Domestic

Well Test: Air   Yield: 150 gpm Drawdown: --- ft.

Remarks:

Generalized Log:

	from	to		from	to
Topsoil	0	8	Black Basalt	25	125
Clay	8	18	Black Basalt and Green Shale (artesian)	125	138
Gravel (water-bearing)	18	25	Black Basalt	138	310

Location: T1N/R24E-1bba

Owner: Eric Anderson   Completion Date(s): 12/11/84

Well Depth: 705 ft. Casing Size: 8 in. Casing Depth 33 ft.

Land Surface Elevation: 1200 ft. Use: Domestic

Well Test: Air   Yield: 60 gpm Drawdown: 500 ft.

Remarks: No well inspections on file.

Generalized Log:

	from	to		from	to
Soil	0	25	Black and Brown Basalt	202	242
Gray Basalt	25	40	Gray and Black Basalt	242	573
Brown Basalt and Sandstone	40	55	Brown Basalt and Sandstone	573	620
Black Basalt	55	193	Gray, Red and Black Basalt	620	705
Green Clay	193	202			

Location: T1N/R24E-4aba

Owner: David Baker Completion Date(s): 10/05/77

Well Depth: 330 ft. Casing Size: 6 in. Casing Depth 34 ft.

Land Surface Elevation: 1025 ft. Use: Domestic

Well Test: Pump? Yield: 30 gpm Drawdown: 3 ft.

Remarks: Replacement well for 4baa; no log in Water Well Report.

Location: T1N/R24E-4baa

Owner: David Baker Completion Date(s): ?

Well Depth: 368 ft. Casing Size: 6? in. Casing Depth ? ft.

Land Surface Elevation: 980 ft. Use: Unused

Well Test: Yield: gpm Drawdown: ft.

Remarks: No Water Well Report in file; depth reported.

Location: T1N/R24E-9ab

Owner: Roy Lindstrom Completion Date(s): 08/09/69

Well Depth: 517 ft. Casing Size: 12/6 in. Casing Depth 70/116 ft.

Land Surface Elevation: 1090 ft. Use: Domestic

Well Test: Air? Yield: 60 gpm Drawdown: 90 ft.

Remarks: No well inspections on file.

Generalized Log:

	from	to
Sandy Brown Topsoil	0	8
Brown Rock	8	25
Brown and Black Broken Rock	25	70
Fine Cemented Gravel	70	127
Black Basalt	127	284
Broken Basalt and Green Shale	284	292
Black Basalt	292	318
Broken Basalt and Green Shale	318	327
Hard Gray Basalt	327	363
Black Porous Rock and Green Shale	363	380
Gray Basalt	380	398
Black Broken Basalt and Brown Rock	398	412
Gray Basalt	412	475
Broken Black Basalt	475	481
Hard Gray Basalt	481	495
Porous Black Rock and Green Shale	495	502
Gray Basalt	502	577

Location: T1N/R24E-16dd

Owner: V.R. Rietmann Completion Date(s): ?, 12/29/67

Well Depth: 640 ft. Casing Size: ? in. Casing Depth ? ft.

Land Surface Elevation: 1270 ft. Use: Domestic

Well Test: Bailer Yield: 10 gpm Drawdown: 0 ft.

Remarks: No well inspections on file. Log below is for deepening and reconditioning of existing well. No Water Well Report on file for prior construction.

Generalized Log:

	from	to
Hard Black Rock	567	587
Hard Gray Rock (SWL = 467')	587	608
Soft Black Rock	608	620
Medium Black Rock (SWL = 400')	620	640

Location: T1N/R25E-1bda

Owner: Lawrence D. and Corrine Lindsay Completion Date(s): 06/22/64, 08/14/80

Well Depth: 380 ft. Casing Size: 8 in. Casing Depth 65 ft.

Land Surface Elevation: 929 ft. Use: Stock

Well Test: Air Yield: 300 gpm Drawdown: 240 ft.

Remarks: Originally drilled to 205 feet. Deepening log may include material caved or settled to bottom.

Generalized Log:

	from	to		from	to
Soil	0	2	Medium Brown Rock	156	162
Soil and Gravel	2	48	Medium Black Rock	162	193
Brown Clay	48	51	Soft Black Rock (water-bearing)	193	205
Clay and Gravel (water-bearing)	51	90	Brown Rock and Yellow Claystone (water-bearing)	190	202
Medium Black Rock	90	98	Brown Rock	202	224
Black Sand (water-bearing)	98	99	Basalt	224	337
Medium Black Rock	99	118	Brown Rock and Yellow and Blue Claystone (water-bearing)	337	365
Soft Black Rock (water-bearing)	118	122			
Medium Black Rock	122	156	Basalt	365	380

Location: T1N/R25E-6db

Owner: Leo Gorger Completion Date(s): 08/06/69

Well Depth: 1100 ft. Casing Size: 16 in. Casing Depth 77 ft.

Land Surface Elevation: ft. Use: Unused

Well Test: Pump Yield: 0 gpm Drawdown: --- ft.

Remarks: Report of no yield is unlikely, but yield is probably too low to have been measured by the test equipment. No well inspections on file.

Generalized Log:

	from	to		from	to
Top Soil	0	12	Gray Lava and Green Sediment	719	762
Basalt	12	430			
Porous Basalt	430	436	Basalt	762	1035
Basalt	436	578	Gray Lava	1035	1090
Porous Basalt	578	584	Basalt	1090	1100
Basalt	584	719			

Location: T1N/R25E-10cdd

Owner: Charles A. Marquardt Ranch   Completion Date(s): 8/30/63, 10/05/75

Well Depth: 227 ft. Casing Size: 8 in. Casing Depth 18 ft.

Land Surface Elevation: 1002 ft. Use: Stock

Well Test: Flow   Yield: 75 gpm Drawdown: --- ft.

Remarks:

Generalized Log:

	from	to		from	to
Soil	0	8	Brown rock	105	108
Gravel	8	12	Hard gray rock	108	128
Hard gray rock	12	95	Medium blue rock	128	155
Black sand (water bearing	95	96	Hard gray rock	155	205
Soft red rock (water bearing)	96	105	Soft brown rock (artesian flow)	205	227

Location: T1N/R25E-13

Owner: Jack Barak   Completion Date(s): 01/28/74

Well Depth: 295 ft. Casing Size: 6 in. Casing Depth 21 ft.

Land Surface Elevation: ? ft. Use: Domestic

Well Test: Air   Yield: 150 gpm Drawdown: 165 ft.

Remarks: No well inspections on file; not field located.

Generalized Log:

	from	to
Topsoil	0	3
Claystone	3	11
Basalt	11	289
Brown rock and yellow claystone (water bearing)	289	295

Location: T1N/R25E-13cdd

Owner: Jack L. Barak   Completion Date(s): 05/11/62

Well Depth: 237 ft. Casing Size: 8 in. Casing Depth 41 ft.

Land Surface Elevation: 1110 ft. Use: Domestic

Well Test: Bailer   Yield: 15 gpm Drawdown: 15 ft.

Remarks: No well inspections on file.

Generalized Log:

	from	to
Sandy soil	0	22
Gravel, rock and clay	22	34
Basalt	34	146
Basalt and clay seams	146	155
Brown basalt (water bearing)	155	160
Basalt	160	220
Basalt and clay seams (water bearing)	220	237

Location: T2N/R23E-6ddb

Owner: Richard V. Patton   Completion Date(s): 02/21/77

Well Depth: 319 ft. Casing Size: 6 in. Casing Depth 181 ft.

Land Surface Elevation: 485 ft. Use: Domestic

Well Test: Air   Yield: 30 gpm Drawdown: 55 ft.

Remarks: No well inspections on file.

Generalized Log:

	from	to
Soil	0	17
Clay and gravel	17	38
Blue, gray and yellow clay	38	176
Basalt	176	319

Location: T2N/23E-8bcc

Owner: David Cheney   Completion Date(s): 05/31/77

Well Depth: 199 ft. Casing Size: 12 in. Casing Depth 135 ft.

Land Surface Elevation: 515 ft. Use: Irrigation

Well Test: Air   Yield: 100 gpm Drawdown: 50 ft.

Remarks: Casing perforated from 20 to 134 feet. This well penetrates some basalt but is considered to be producing water from the alluvium.

Generalized Log:

	from	to
Sand	0	15
Gravel	15	50
Clay	50	92
Clay and gravel	92	110
Clay	110	118
Gravel	118	125
Clay	125	137
Basalt and sandstone	137	199

Location: T2N/R23E-17add

Owner: David Cheney   Completion Date(s): 07/24/68, 06/04/77

Well Depth: 685 ft. Casing Size: 12 in. Casing Depth 90 ft.

Land Surface Elevation: 560 ft. Use: Irrigation

Well Test: Air   Yield: 500 gpm Drawdown: 400 ft.

Remarks: Well originally drilled to 478 feet.

Generalized Log:

	from	to
Sandy soil	0	33
Gravel clay (SWL=45')	33	80
Basalt and clay interbedded (SWL=40')	80	170
Basalt	170	325
Basalt and clay interbedded	325	368
Basalt	368	400
Basalt and clay interbedded	400	475
Basalt (SWL=54')	475	478
Basalt	478	618
Basalt and sandstone interbedded	618	630
Basalt	630	663
Basalt and sandstone interbedded	663	685

Location: T2N/23E-17ddd

Owner: David Cheney Completion Date(s): 04/16/64, 05/18/77

Well Depth: 440 ft. Casing Size: 8 in. Casing Depth 72 ft.

Land Surface Elevation: 563 ft. Use: Irrigation

Well Test: Pump Yield: 350 gpm Drawdown: 10 ft.

Remarks: Well was reamed and possibly deepened on 05/18/77. No log for deepening. Water level is not measureable at present.

Generalized Log:

	from	to
Soil	0	12
Gravel and sand	12	32
Clay	32	72
basalt	72	425

Location: T2N/R23E-20ada

Owner: David Cheney Completion Date(s): 5/15/68

Well Depth: 265 ft. Casing Size: 10 in. Casing Depth 35 ft.

Land Surface Elevation: 575 ft. Use: Irrigation

Well Test: Pump Yield: 850 gpm Drawdown: 35 ft.

Remarks:

Generalized Log:

	from	to
Top soil	0	3
Clay and soil	3	31
Basalt	31	60
Blue shale	60	62
Basalt	62	194
Basalt and shale (water-bearing)	194	198
Basalt	198	210
Soft basalt (water-bearing)	210	213
Basalt	213	222
Basalt (water-bearing)	222	225
Basalt	225	263
Soft basalt (water-bearing)	263	265

Location: T2N/R23E-20dda

Owner: Krebs Brothers, Inc. Completion Date(s): 11/10/77

Well Depth: 420 ft. Casing Size: 12 in. Casing Depth 30 ft.

Land Surface Elevation: 587 ft. Use: Unused

Well Test: Air Yield: 1200 gpm Drawdown: 249 ft.

Remarks:

Generalized Log:

	from	to
Top soil	0	15
Cemented gravel	15	25
Basalt	25	68
Basalt and blue claystone	68	98
Basalt	98	232
Basalt and blue claystone (water-bearing)	232	277
Basalt	277	393
Broken basalt (water-bearing)	393	420

Location: T2N/R23E-29ddd

Owner: Krebs Brothers, Inc. Completion Date(s): 6/21/68, 6/30/78

Well Depth: 665 ft. Casing Size: 12 in. Casing Depth 53.8 ft.

Land Surface Elevation: 630 ft. Use: Irrigation

Well Test: Air Yield: 800 gpm Drawdown: 300 ft.

Remarks: Originally drilled to 425 feet. Water level is not measureable at present.

Generalized Log:

	from	to
Soil	0	3
Clay and Gravel	3	41
Basalt	41	44
Gravel	44	52
Basalt	52	125
Green clay (SWL=14')	125	129
Basalt (SWL=38')	129	162
Basalt (SWL=115')	162	283
Basalt (SWL=120')	283	425
Basalt and sandstone	425	447
Basalt	447	545
Basalt and sandstone (water-bearing)	545	625
Basalt	625	665

Location: T2N/R23E-30ccc

Owner: Fairview Ranch, Inc. Completion Date(s): 6/7/77

Well Depth: 1016 ft. Casing Size: 10/8 in. Casing Depth 362/610 ft.

Land Surface Elevation: 1045 ft. Use: Irrigation/domestic

Well Test: Air Yield: 300 gpm Drawdown: - ft.

Remarks:

Generalized Log:

	from	to
Silt	0	2
Clay and gravel	2	96
Blue claystone	96	348
Basalt	348	372
Blue Claystone	372	604
Basalt (water-bearing)	604	1012
Broken basalt and soapstone	1012	1016

Location: T2N/R23E-31baa

Owner: Fairview Ranch, Inc. Completion Date(s): 9/23/77

Well Depth: 935 ft. Casing Size: 12 in. Casing Depth 470 ft.

Land Surface Elevation: 1000 ft. Use: Irrigation

Well Test: Air Yield: 1200 gpm Drawdown: 215 ft.

Remarks:

Generalized Log:

	from	to
Top soil	0	140
Claystone and gravel	140	332
Basalt	332	349
Claystone	349	465
Basalt	465	657
Basalt and Claystone (water-bearing)	657	678
Basalt	678	791
Basalt (water-bearing)	791	815
Basalt	815	889
Basalt and claystone (water-bearing)	889	935

Location: T2N/R23E-35acc

Owner: George Miller   Completion Date(s): ?

Well Depth: 347 ft.   Casing Size: 6 in.   Casing Depth ? ft.

Land Surface Elevation: 940 ft.   Use: Unused

Well Test: ______   Yield: ______ gpm   Drawdown: ______ ft.

Remarks: No Water Well Report in file. Well depth reported.

Location: T2N/R23E-35bdd

Owner: George Miller   Completion Date(s): ?

Well Depth: 494 ft.   Casing Size: 10 in.   Casing Depth ? ft.

Land Surface Elevation: 955 ft.   Use: Irrigation/domestic

Well Test: ______   Yield: ______ gpm   Drawdown: ______ ft.

Remarks: No Water Well Report in file. Well depth reported.

Location: T2N/R24E-18dad

Owner: ?   Completion Date(s): ?

Well Depth: ? ft.   Casing Size: ? in.   Casing Depth ? ft.

Land Surface Elevation: 710 ft.   Use: Unused

Well Test: ______   Yield: ______ gpm   Drawdown: ______ ft.

Remarks: One well inspection on file. No Water Well Report on file.

Location: T2N/R24E-25adb

Owner: Charles Doherty   Completion Date(s): ?

Well Depth: 103.5 ft.   Casing Size: 6 in.   Casing Depth ? ft.

Land Surface Elevation: 913 ft.   Use: Unused

Well Test: ______   Yield: ______ gpm   Drawdown: ______ ft.

Remarks: Water level recorder on well from March 1977 to October 1981. No Water Well Report in file.

Location: T2N/R24E-26bba

Owner: Helen Crawford Completion Date(s): ?

Well Depth: 400 ft. Casing Size: 8 in. Casing Depth ? ft.

Land Surface Elevation: 881 ft. Use: Domestic

Well Test: Yield: gpm Drawdown: ft.

Remarks: No Water Well Report in file. Well depth is reported.

Location: T2N/R24E-27bbd

Owner: Charles Doherty Completion Date(s): 1/15/73, 6/6/79

Well Depth: 485 ft. Casing Size: 8 in. Casing Depth 20 ft.

Land Surface Elevation: 805 ft. Use: Domestic

Well Test: Air Yield: 280 gpm Drawdown: 268 ft.

Remarks: Originally drilled to 280 feet.

Generalized Log:

	from	to
Top soil	0	6
Claystone and gravel	6	12
Basalt	12	93
Basalt and claystone	93	100
Basalt	100	135
Basalt and claystone	135	168
Basalt	168	215
Basalt and claystone (water-bearing)	215	227
Basalt	227	269
Porous basalt (water-bearing)	269	280
Basalt	280	309
Basalt and claystone (water-bearing)	309	314
Basalt	314	340
Basalt and claystone (water-bearing)	340	345
Basalt	345	460
Basalt and claystone (water-bearing)	460	480
Basalt	480	485

Location: T2N/R24E-27cbc

Owner: Helen Crawford Completion Date(s): ?

Well Depth: 140 ft. Casing Size: 6 in. Casing Depth ? ft.

Land Surface Elevation: 860 ft. Use: Stock

Well Test: Yield: gpm Drawdown: ft.

Remarks: No Water Well Report in file. Well depth reported.

Location: T2N/R24E-31abb

Owner: Larry Douglas Completion Date(s): 6/26/81

Well Depth: 700 ft. Casing Size: 16 in. Casing Depth 32 ft.

Land Surface Elevation: 790 ft. Use: Irrigation

Well Test: Air Yield: 1000 gpm Drawdown: 675 ft.

Remarks: No Water Well Report in file. Owner's copy transcribed during well inspection on 7/19/83.

Generalized Log:

	from	to
Soil	0	4
Gravel	4	16
Basalt	16	262
Basalt and claystone	262	283
Basalt	283	420
Basalt and claystone	420	430
Basalt	430	480
Basalt and claystone	480	490
Basalt	490	510
Basalt and claystone	510	528
Basalt	528	570
Basalt and claystone	570	588
Basalt	588	630
Basalt and claystone	630	665
Basalt	665	700

Location: T2N/R24E-31daa

Owner: Larry Douglas Completion Date(s): 3/1/78

Well Depth: 1111 ft. Casing Size: 14 in. Casing Depth 50 ft.

Land Surface Elevation: 930 ft. Use: Irrigation

Well Test: Pump Yield: 1500 gpm Drawdown: ft.

Generalized Log:

	from	to
Soil	0	0
Clay	21	36
Basalt	36	350
Broken basalt (water-bearing)	350	370
Basalt	370	1012
Broken basalt (water-bearing)	1012	1111

Location: T2N/R24E-31dda

Owner: Larry Douglas   Completion Date(s): 12/19/71, ?

Well Depth: 555 ft. Casing Size: 8 in. Casing Depth 40 ft.

Land Surface Elevation: 940 ft. Use: Unused

Well Test: Bailer   Yield: 8 gpm Drawdown: 15 ft.

Remarks: Originally drilled to 320 feet. No Water Well Report in file for deepening. Well depth reported. Tools reported lost in borehole.

Generalized Log:

	from	to
Soil	0	12
Basalt	12	80
Red cinders (SWL=60')	80	86
Basalt	86	285
Broken basalt (SWL=295')	285	320

Location: T2N/R24E-32add

Owner: Art Lindstrom   Completion Date(s): 12/14/69, 3/21/77

Well Depth: 945 ft. Casing Size: 18/16 in. Casing Depth 25 ft.

Land Surface Elevation: 940 ft. Use: Irrigation

Well Test: Pump   Yield: 1100 gpm Drawdown: 125 ft.

Remarks: Well #2

Generalized Log:

	from	to		from	to
Soil	0	21	Basalt	513	771
Basalt	21	154	Broken basalt (SWL=331')	771	793
Basalt and claystone	154	157	Basalt (SWL=333')	793	893
Basalt	157	240	Basalt	893	929
Basalt and claystone	240	252	Broken basalt (SWL=336')	929	945
Basalt	252	501			
Basalt and cinders	501	513			

Location: T2N/R24E-32cdc

Owner: Larry Douglas Completion Date(s): 3/4/70, 1/26/77

Well Depth: 1086 ft. Casing Size: 18 in. Casing Depth 42 ft.

Land Surface Elevation: 965 ft. Use: Irrigation

Well Test: Air Yield: 2000 gpm Drawdown: - ft.

Remarks: Originally drilled to 525 feet.

Generalized Log:

	from	to		from	to
Soil	0	22	Broken basalt and soapstone	652	670
Basalt	22	337	Basalt	670	970
Porous basalt and green clay (SWL=265')	337	360	Broken basalt (water-bearing)	970	1040
Basalt	360	493	Broken basalt and (water-bearing)	1040	1086
Porous basalt and green clay (SWL=265')	493	517			
Basalt	517	652			

Location: T2N/R24E-33ddb

Owner: Eric Anderson Completion Date(s): 3/7/78

Well Depth: 1370 ft. Casing Size: 20 in. Casing Depth 72 ft.

Land Surface Elevation: 1025 ft. Use: Irrigation

Well Test: Pump Yield: 4184 gpm Drawdown: 104 ft.

Remarks: Well drilled in two stages, with work temporarily stopped on 12/2/76 at 537 feet. Water level not measureable at present. Well being repaired.

Generalized Log:

	from	to		from	to
Top soil	0	20	Basalt (SWL=329')	1045	1210
Clay and gravel	20	30	Conglomerate (water-bearing)	1210	1235
Basalt	30	190	Basalt	1235	1247
Clay	190	195	Basalt (water-bearing, SWL=277')	1247	1290
Basalt, sometimes clayey (water-bearing at 450 to 460, SWL=445')	195	537	Basalt	1290	1350
Basalt, sometimes clayey	537	630	Basalt (water-bearing)	1350	1365
Basalt (water-bearing, SWL=357')	630	700	Basalt (SWL=251')	1365	1370
Basalt	700	865			
Conglomerate	865	905			
Basalt	905	985			
Gray shale	985	1045			

Location: T2N/R24E-36dbc

Owner: Eric Anderson Completion Date(s): 5/9/75

Well Depth: 1350 ft. Casing Size: 16 in. Casing Depth 67.75 ft.

Land Surface Elevation: 1215 ft. Use: Irrigation

Well Test: Pump Yield: 1791 gpm Drawdown: 43 ft.

Remarks: Water level not measureable at present.

Generalized Log:

	from	to
Top soil and gravel	0	20
Broken basalt and clay	20	65
Basalt	65	291
Clay and shale	291	322
Basalt	322	370
Basalt (water-bearing, SWL=354')	370	435
Basalt	435	665
Basalt and clay	665	720
Basalt	720	770
Basalt and soapstone	770	790
Basalt	790	975
Basalt (water-bearing, SWL=355')	975	985
Basalt	985	1000
Basalt (water-bearing)	1000	1040
Basalt	1040	1115
Porous basalt and clay	1115	1125
Basalt (SWL=355')	1125	1340
Basalt and clay	1340	1350

Location: T2N/R25E-20ccc

Owner: ? Completion Date(s): ?

Well Depth: ft. Casing Size: 6 in. Casing Depth ? ft.

Land Surface Elevation: 855 ft. Use: Unused

Well Test: Yield: gpm Drawdown: ft.

Remarks: No Water Well Report in file. Reportedly flowed in past.

Location: T2N/R25E-25aa

Owner: Michael and Sally Ingraham Completion Date(s): 12/5/79

Well Depth: 362 ft. Casing Size: 8 in. Casing Depth 106 ft.

Land Surface Elevation: ? ft. Use: Domestic

Well Test: Air Yield: 400 gpm Drawdown: 172 ft.

Remarks: No well inspections on file. Not field located.

Generalized Log:

	from	to
Top soil	0	6
Claystone	6	79
Claystone and basalt interbedded	79	150
Basalt	150	187
Basalt and claystone (water-bearing)	187	200
Basalt	200	347
Broken basalt (water-bearing)	347	362

Location: T2N/R25E-28bbb

Owner: ? Completion Date(s):

Well Depth: ? ft. Casing Size: ? in. Casing Depth ? ft.

Land Surface Elevation: 845 ft. Use: Unused

Well Test: Yield: gpm Drawdown: ft.

Remarks: No Water Well Report on file. This is a shallow well (est. 35-36 feet) at the site of Well Spring.

Location: T2N/R25E-30abc

Owner: Charles Doherty Completion Date(s): 7/29/74

Well Depth: 295 ft. Casing Size: 8 in. Casing Depth 32 ft.

Land Surface Elevation: 880 ft. Use: Stock

Well Test: Air Yield: 110 gpm Drawdown: 120 ft.

Generalized Log:

	from	to
Top soil	0	20
Claystone	20	27
Basalt	27	288
Basalt (water-bearing)	288	295

Location: T2N/R25E-32bcc

Owner: John Proudfoot Completion Date(s): 8/-/53

Well Depth: 469 ft. Casing Size: 8 in. Casing Depth 27 ft.

Land Surface Elevation: 1140 ft. Use: Domestic

Well Test: Pump Yield: 20 gpm Drawdown: 0 ft.

Remarks: No well inspections on file. The report of no drawdown is not possible, but was probably too little to be detected during the test. Water Well Report in name of Leo Gorger.

Generalized Log:

	from	to
Soil	0	12
Hardpan	12	24
Basalt	24	285
Clay	285	298
Broken basalt and shale seams (water-bearing)	298	310
Basalt	310	455
Broken basalt (water-bearing)	455	466
Basalt	466	469

Location: T2N/R25E-36abb

Owner: Lawrence and Corrine Lindsay Completion Date(s): 10/22/69, 11/2/70

Well Depth: 1081 ft. Casing Size: 16 in. Casing Depth 130 ft.

Land Surface Elevation: 985 ft. Use: Unused

Well Test: Pump Yield: 2000 gpm Drawdown: 369 ft.

Remarks: Well originally drilled to 846 feet.

Generalized Log:

	from	to
Soil	0	4
Clay	4	80
Sand and gravel	80	123
Clay	123	130
Basalt	130	180
Clay	180	185
Basalt (SWL=130')	185	603
Basalt (SWL=140')	603	690
Basalt (SWL=160')	690	928
Basalt (SWL=165')	928	1010
Basalt	1010	1070
Basalt (water-bearing, SWL=188')	1070	1081

Location: T3N/R22E-36ccb

Owner: Dick Krebs

Completion Date(s): 3/13/69

Well Depth: 406 ft. Casing Size: 12 in. Casing Depth 230 ft.

Land Surface Elevation: 430 ft. Use: Unused

Well Test: Pump Yield: 160 gpm Drawdown: 165 ft.

Generalized Log:

	from	to
Top soil	0	3
Sandy clay	3	14
Gravel and clay	14	54
Clay	54	230
Basalt	230	290
Blue Clay	290	322
Basalt	322	406

APPENDIX C

WATER LEVEL DATA

All water levels are in feet below land surface datum unless preceded by a "+", which denotes above land surface datum.

Key to abbreviations

(?)	Questionable measurement
(C)	Monthly high interpreted from continuous record
(E)	Estimated
(F)	Flowing
(P)	Pumping
(R)(R?)	Recovering, known and suspected
(Rep.)	Reported measurement
(W)	Water Well Report

1N/23E-9dbc

10/09/78	(F,W)
03/17/84	+106.26
08/14/85	+110.90
05/16/86	+110.88 (R)

1N/23E-13ac

01/22/70	145.00 (W)

1N/24E-1bba

12/11/84	396.00 (W)

1N/24E-4aba

06/08/76	128.82	06/06/78	172.23	02/13/85	178.11
09/09/76	153.02	11/28/78	178.43	02/11/86	175.54
12/03/76	153.67	08/28/79	190.00	05/15/86	174.05
03/08/77	153.13	02/12/80	186.33	07/24/86	175.07
06/02/77	161.32	02/10/81	189.85	11/05/86	174.50
09/15/77	169.37	02/24/82	187.65	02/18/87	172.16
10/05/77	166.00 (W)	02/15/83	187.70	07/30/87	170.80
11/29/77	167.55	02/09/84	181.07		
03/07/78	168.74	07/18/84	181.20		

1N/24E-4baa

04/03/73	337.02	09/15/75	355.79	06/02/77	Dry
07/11/73	346.03	12/08/75	358.42	11/29/77	Dry
09/11/73	348.60	03/08/76	358.43	03/07/78	365.26
12/13/73	339.59	06/08/76	366.86	06/06/78	Dry
03/01/74	342.00	08/09/76	363.42		
12/18/74	347.66	12/03/76	Dry		
06/02/75	357.10	03/08/77	359.94		

1N/24E-9ab

08/09/69	205.00

1N/24E-16dd

12/29/67	400.00 (W)

1N/25E-1bda

06/22/64	25.00 (W)
08/14/80	130.00 (W)
02/05/83	164.45
02/10/84	170.18
02/16/85	178.29
02/11/86	189.57
02/17/87	192.22

1N/25E-6db

07/16/69	408.00 (W)

1N/25E-10cdd

08/30/63	68.00 (W)
10/05/71	(F,W)
03/20/78	+92.40
07/25/86	+64.70 (R)

1N/25E-13

01/28/74	10.00 (W)

1N/25E-13cdd

05/11/62	160.00 (W)

2N/23E-6ddb

02/21/77	239.00 (W)

2N/23E-17add

07/24/68	54.00 (W)
06/02/77	119.24
06/04/77	120.00 (W)
11/29/77	128.24
03/07/78	123.85
11/28/78	143.68
02/14/80	144.10
02/25/80	145.92
08/05/80	236.04 (P)
12/12/80	156.78
02/13/81	155.02
02/21/82	160.27
02/14/83	169.00
07/18/83	248.05 (P)
03/17/84	169.51
07/10/84	237.66 (P)
07/16/84	321.97 (?,P)
02/11/85	167.20
02/11/86	172.98
07/23/86	268.84 (P)
11/06/86	169.51
02/18/87	175.86
07/30/87	259.60 (P)

2N/23E-17ddd

04/16/64	25.00 (W)	11/29/66	41.30	06/03/70	57.60
06/30/64	31.72	03/15/67	40.13	12/03/70	63.59
09/29/64	31.59	06/01/67	40.32	11/29/71	71.33
03/30/65	31.47	11/21/67	43.54	09/10/74	71.60
06/29/65	33.13	12/18/68	53.31	06/02/75	90.61
09/28/65	35.17	06/04/69	49.96	09/12/75	105.00 (Rep.)
03/02/66	34.50	12/10/69	58.25	02/21/82	161.20
06/14/66	44.20 (P)	03/11/70	55.72		

2N/23E-20ada

05/15/68	65.00 (W)	11/28/78	159.06	02/11/85	76.69
06/10/74	35.46 (?)	08/05/80	86.50	02/11/86	78.42
11/29/77	142.54	03/17/84	74.26	11/06/86	83.04
03/07/78	138.45	07/16/84	78.42	02/18/87	84.20

2N/23E-20dda

11/10/77	151.00 (W)	02/11/86	197.85
02/16/85	196.82	07/23/86	204.13
05/16/85	195.55	11/06/86	205.24
08/14/85	197.50	02/18/87	202.38
		07/30/87	210.48

2N/23E-29ddd

06/21/68	120.00 (W)	02/24/71	132.50	09/15/75	118.72 (?)
12/18/68	123.00	06/09/71	138.50	12/08/75	168.35
02/19/69	120.00	09/08/71	144.00	03/08/76	165.94
06/04/69	118.50	11/29/71	142.00	06/08/76	169.57
09/08/69	131.50 (R)	03/06/72	141.00	09/09/76	175.44
12/10/69	128.00	06/28/72	143.00	12/03/76	172.57
03/11/70	125.00	10/03/72	146.00	09/15/77	191.84
06/03/70	126.00	06/10/74	158.13	06/30/78	210.00 (W)
08/26/70	135.00	09/10/74	135.00 (?)		
12/03/70	133.50	03/12/75	161.83		

2N/23E-30ccc

06/07/77	675.00 (W)
02/17/83	657.00 (Rep.)

2N/23E-31baa

09/23/77	685.00 (W)
02/17/83	657.00 (Rep.)

2N/23E-35acc

08/13/80	Dry or obstructed
02/15/83	Dry or obstructed
02/09/84	Dry or obstructed

2N/23E-35bdd

02/10/81	329.65	02/12/85	313.40
02/09/84	318.00	02/11/86	320.31
08/14/84	318.00	02/18/87	314.53
08/31/84	316.40		

2N/24E-18dad

03/21/78	50.40

2N/24E-25adb

06/01/71	31.00	07/--/78	72.80 (C)	08/--/80	86.40 (C)
10/19/74	39.00	08/--/78	74.30 (C)	09/--/80	87.80 (C)
06/02/75	43.27	09/--/78	75.70 (C)	10/--/80	88.70 (C)
09/15/75	48.50	10/--/78	76.30 (C)	11/--/80	88.40 (C)
12/08/75	48.37	11/--/78	76.00 (C)	12/--/80	88.50 (C)
03/08/76	48.06	12/--/78	75.70 (C)	01/--/80	87.80 (C)
06/08/76	53.21	01/--/79	75.10 (C)	02/--/81	87.20 (C)
09/08/76	58.74	02/--/79	75.50 (C)	03/--/81	87.30 (C)
12/03/76	60.64	03/--/79	74.90 (C)	04/--/81	87.30 (C)
03/--/77	57.50 (C)	04/--/79	74.70 (C)	05/--/81	87.50 (C)
04/--/77	59.30 (C)	05/--/79	75.00 (C,E)	06/--/81	88.20 (C)
05/--/77	61.60 (C)	06/--/79	76.30 (C,E)	07/--/81	88.30 (C)
06/--/77	63.60 (C)	07/--/79	77.40 (C)	08/--/81	88.30 (C)
07/--/77	65.50 (C)	08/--/79	78.80 (C)	09/--/81	88.30 (C)
08/--/77	67.50 (C)	09/--/79	79.90 (C)	10/--/81	88.20 (C)
09/--/77	68.90 (C)	10/--/79	81.00 (C,E)	02/10/84	88.35
10/--/77	70.00 (C)	11/--/79	82.40 (C)	02/13/85	89.46
11/--/77	70.80 (C)	12/--/79	82.90 (C)	05/15/86	88.84
12/--/77	71.20 (C)	01/--/80	82.00 (C,E)	07/24/86	88.83
01/--/78	70.80 (C)	02/--/80	81.60 (C)	11/05/86	88.77
02/--/78	70.00 (C)	03/--/80	81.00 (C)	02/19/87	88.69
03/--/78	69.30 (C)	04/--/80	80.70 (C)		
04/--/78	69.00 (C)	05/--/80	81.30 (C)		
05/--/78	68.70 (C)	06/--/80	83.10 (C)		
06/--/78	70.40 (C)	07/--/80	84.70 (C)		

2N/24E-26bba

12/10/71	226.63	12/03/76	271.35	02/06/78	280.76
09/10/73	249.84	03/08/77	269.24	11/28/78	284.10
06/02/75	260.18	06/02/77	274.27	08/28/79	288.25
12/08/75	265.23	08/19/77	273.75	02/14/80	289.83
03/08/76	263.99	09/15/77	276.72	08/05/80	289.60
06/08/76	268.37	11/29/77	279.13	02/10/84	300.35
09/09/76	269.16	03/07/78	276.95		

2N/24E-27bbd

01/15/73	166.00 (W)	09/09/76	196.45 (R)	08/04/80	225.00 (P)
04/03/73	164.07	12/03/76	196.72	02/10/81	222.07 (R)
07/11/73	162.83	03/08/77	195.06	12/02/81	227.91
09/10/73	175.36	06/02/77	193.97	02/23/82	226.57
03/01/74	165.48	09/15/77	196.23	02/16/83	229.50
12/18/74	177.72	11/29/77	245.21 (P)	02/10/84	215.90 (?)
03/18/75	177.49	03/07/78	194.60	08/14/84	226.22
06/02/75	182.91	06/06/78	202.30	02/13/85	227.17
09/15/75	180.12	11/28/78	205.18	02/12/86	227.11
12/08/75	185.80	06/06/79	192.00 (W)	02/19/87	226.41
03/08/76	187.91	08/28/79	217.90 (P)		
06/08/76	201.49 (R)	02/16/80	215.60		

2N/24E-27cbc

09/09/76	18.37	11/29/77	16.21	08/04/80	8.10
12/03/76	16.87	03/07/78	14.33	07/24/86	10.39
03/08/77	15.98	06/06/78	13.02		
06/02/77	17.18	11/28/78	12.47		
09/15/77	16.87	08/28/79	9.60		

2N/24E-31abb

06/30/81	212.00 (W)	07/01/84	217.51	05/16/86	214.05
02/24/82	219.82	08/14/84	222.13	07/24/86	209.43
02/15/83	218.67	08/31/84	223.29	11/06/86	205.96
07/19/83	216.36	02/12/85	216.36	02/18/87	211.16
02/09/84	215.78	02/11/86	211.74	07/30/87	223.86

2N/24E-31daa

03/01/78	318.00 (W)	07/01/84	372.48	11/06/86	348.98
04/09/80	336.04	02/13/85	356.94	02/18/87	348.34
02/24/82	362.56	02/11/86	350.83		
02/09/84	352.55	07/24/86	349.26		

2N/24E-31dda

12/19/71	295.00 (W)
03/21/78	85.90
04/09/80	179.05

2N/24E-32add

12/14/69	272.00 (W)	08/15/77	323.33 (Rep.)	02/09/84	354.44
11/07/72	219.00 (?)	08/19/77	334.20	02/13/85	354.35
09/15/75	318.50	11/29/77	333.71	08/14/85	346.40
09/09/76	320.00	03/07/78	329.58	02/11/86	355.06
12/03/76	328.23	02/14/80	346.08	05/15/86	354.22
03/21/77	336.00 (W)	04/09/80	344.00	07/24/86	354.19
04/15/77	322.00 (Rep.)	08/13/80	497.00 (P,E)	11/05/86	353.71
04/24/77	323.00 (Rep.)	02/10/81	349.15	02/18/87	353.59
				07/30/87	412.94 (P)

2N/24E-32cdc

03/04/70	265.00 (W)	01/26/77	326.00 (W)	08/13/80	407.53 (P)
11/07/72	312.00 (Rep.)	08/18/77	360.00 (Rep.)	03/08/84	385.99
03/01/74	325.14	11/29/77	352.25	02/13/85	368.67
12/18/74	336.22	03/07/78	347.50	02/11/86	383.88
06/02/75	339.39	11/28/78	366.00	07/24/86	369.35
09/15/75	345.36	12/20/79	364.50	02/19/87	381.12
12/03/76	349.01	04/09/80	362.25		

2N/24E-33ddb

12/02/76	445.00 (W)	12/13/80	399.62	02/09/84	323.71
03/07/78	251.00 (W)	02/10/81	375.25	07/18/84	317.19
02/12/80	357.75	12/06/81	395.12	08/14/84	314.75
04/09/80	347.13 (R)	02/24/82	366.02	02/13/85	310.13
08/13/80	404.30 (P)	02/15/83	379.88		

2N/24E-36dbc

05/09/75	354.00 (W)	04/07/80	427.00 (P,Rep.)	08/14/84	483.04 (P)
09/09/76	446.00 (P)	04/13/80	396.05	08/31/84	411.43
12/03/76	384.00	08/13/80	453.01 (P)	02/13/85	409.12
03/08/77	381.00	02/10/81	391.80	02/11/86	406.81
09/15/77	467.00 (P)	12/06/81	401.04 (?)	11/05/86	411.43
03/07/78	392.00	02/24/82	397.57	02/17/87	413.16
02/12/80	449.97 (?)	02/15/83	401.61		
04/02/80	395.00 (Rep.)	02/09/84	403.92		

2N/25E-20ccc

03/21/78	16.60

2N/25E-25aa

12/05/79	190.00 (W)

2N/25E-28bbb

12/06/72	21.25	12/13/73	Dry
04/03/73	25.21	03/01/74	Dry
07/11/73	30.72	12/18/74	Dry
09/11/73	29.19		

2N/25E-30abc

07/29/74	30.00 (W)	03/08/77	32.03	02/10/84	76.85
08/30/74	14.00 (Rep.)	06/02/77	40.87	07/18/84	84.15
06/02/75	18.17	09/15/77	47.82	08/14/84	84.19
09/15/75	23.60	11/29/77	48.20	08/31/84	84.12
12/08/75	23.41	03/07/78	43.51	02/13/85	81.10
03/08/76	22.21	06/06/78	47.82	02/12/86	78.47
06/08/76	31.47	11/28/78	52.46	07/24/86	85.50
09/09/76	36.68	08/28/79	59.18	11/05/86	85.24
12/03/76	34.78	08/05/80	67.80	02/19/87	83.39
				07/30/87	89.20

2N/25E-32bcc

08/--/53	255.00 (W)

2N/25E-36abb

10/22/69	160.00 (W)	03/22/78	402.50 (E)	02/11/86	411.12
11/02/70	188.00 (W)	08/13/80	424.50	05/16/86	423.66
12/05/71	343.00	02/11/81	396.00	07/25/86	436.64
12/06/72	346.00	02/23/82	401.15	11/05/86	441.23
12/17/74	357.05	02/05/83	405.71	02/17/87	420.60
12/15/77	365.93	02/10/84	406.33	07/30/87	447.87
05/10/77	394.19	02/16/85	410.91		

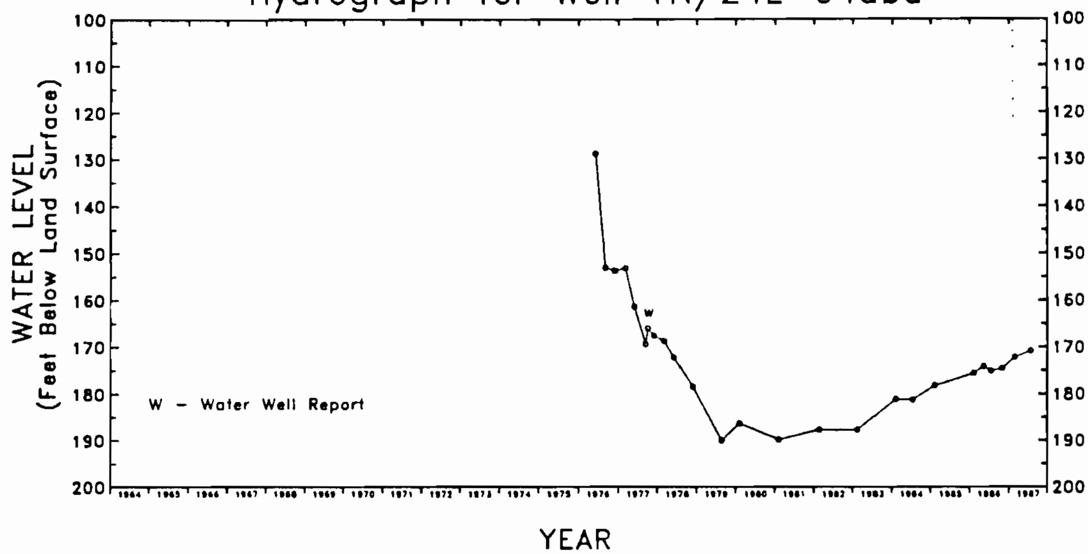
3N/22E-36ccb

03/13/69	225.00 (W)
07/23/86	179.85
11/06/86	179.78
02/18/87	179.63

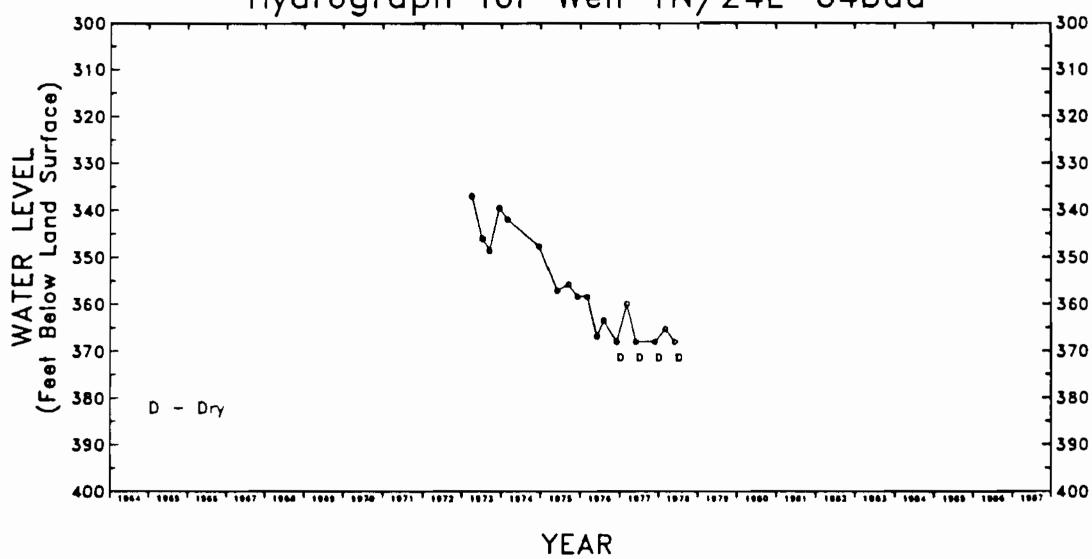
APPENDIX D

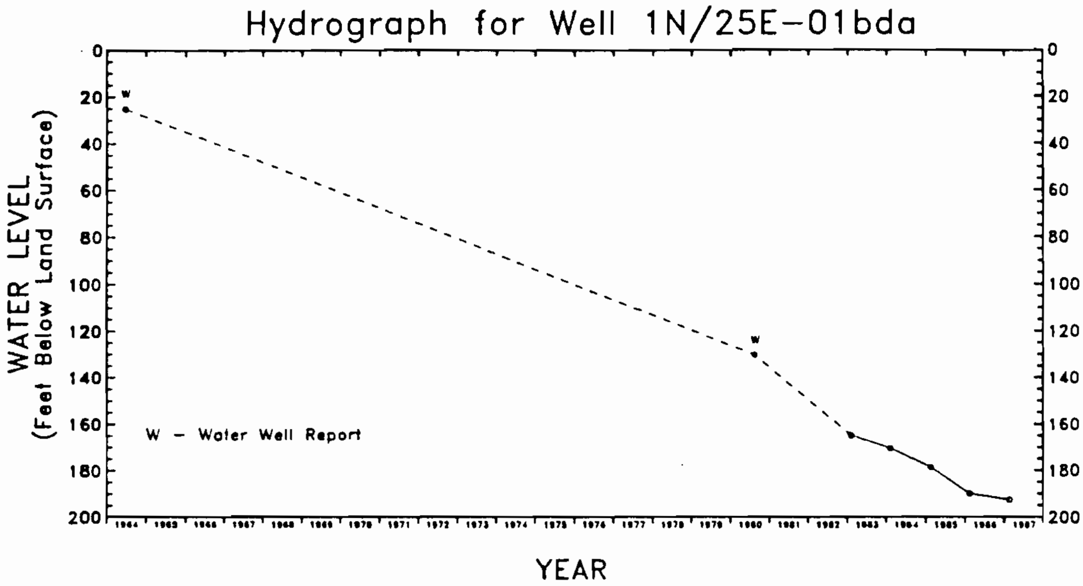
HYDROGRAPHS OF SELECTED WELLS

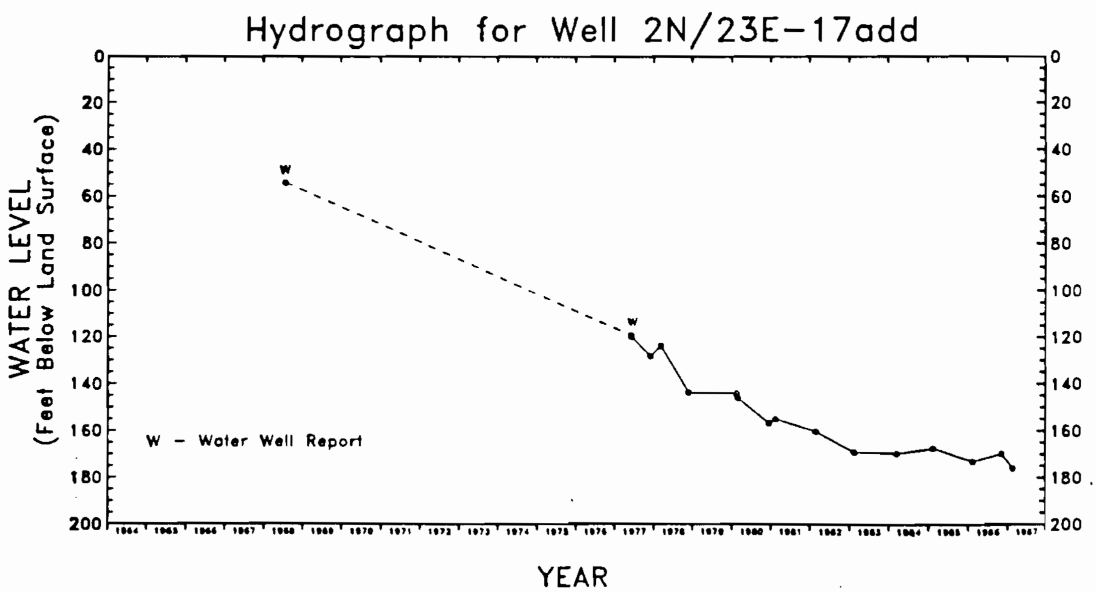
Hydrograph for Well 1N/24E-04aba



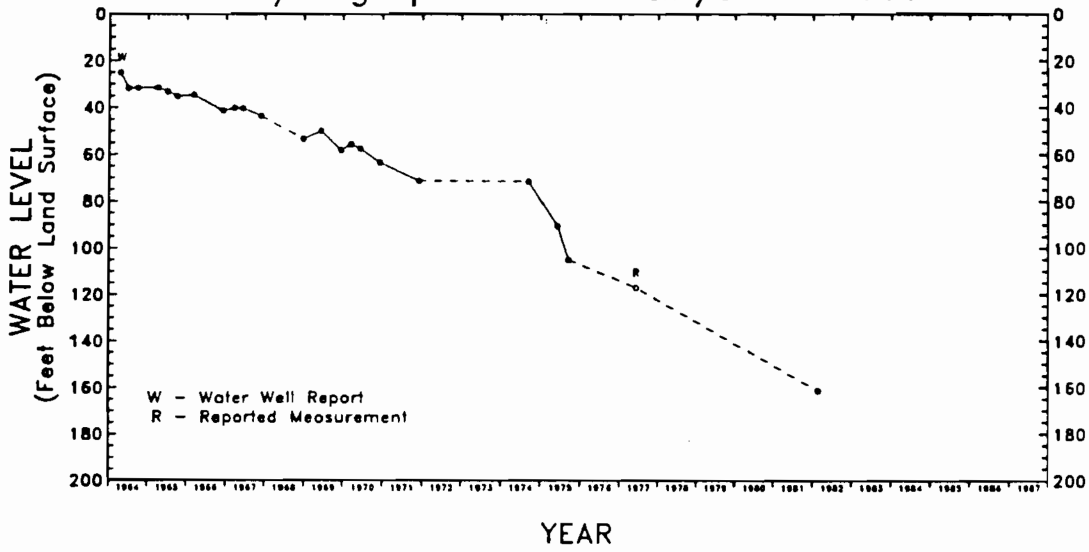
Hydrograph for Well 1N/24E-04baa



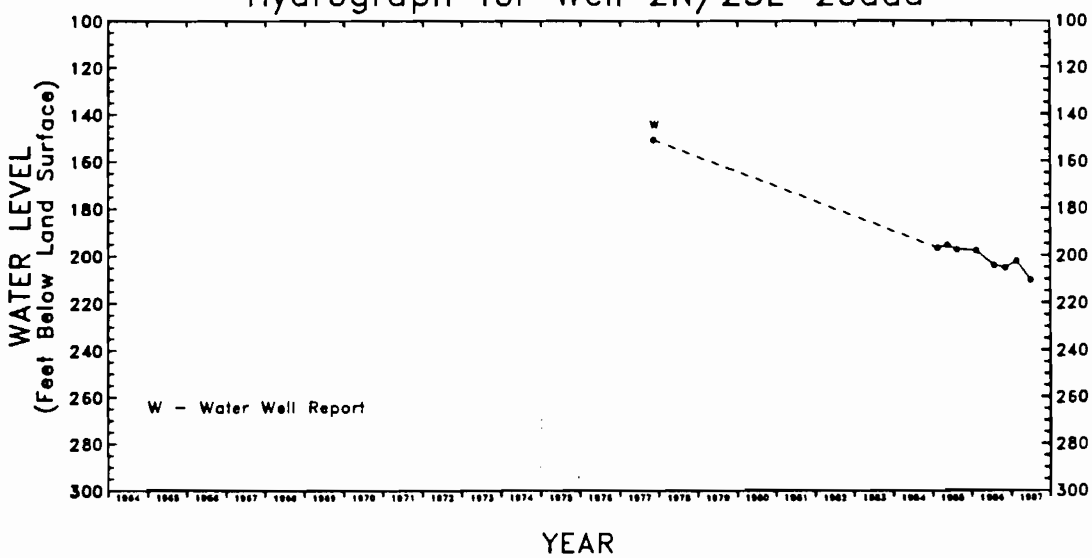

Hydrograph for Well 1N/25E-01bda
WATER LEVEL
(Feet Below Land Surface)
W - Water Well Report
YEAR

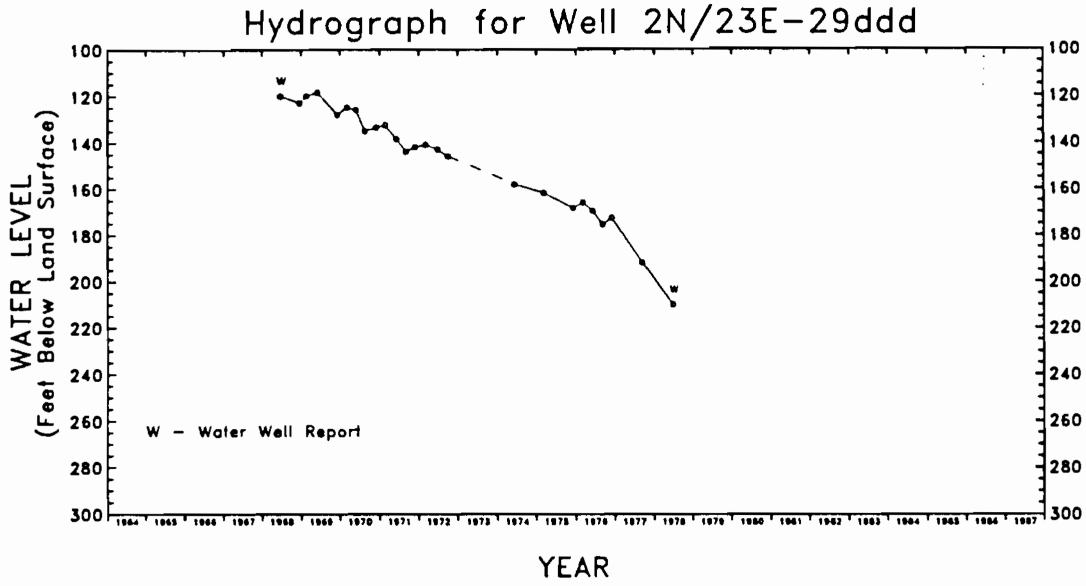

Hydrograph for Well 2N/23E-17add
WATER LEVEL
(Feet Below Land Surface)
W - Water Well Report
YEAR

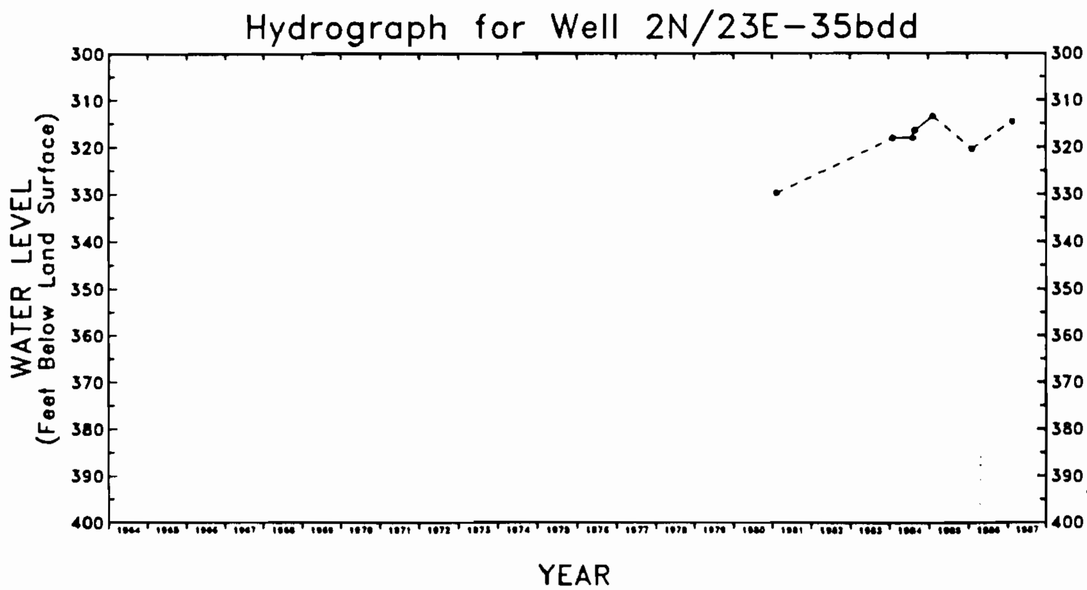
Hydrograph for Well 2N/23E-17ddd

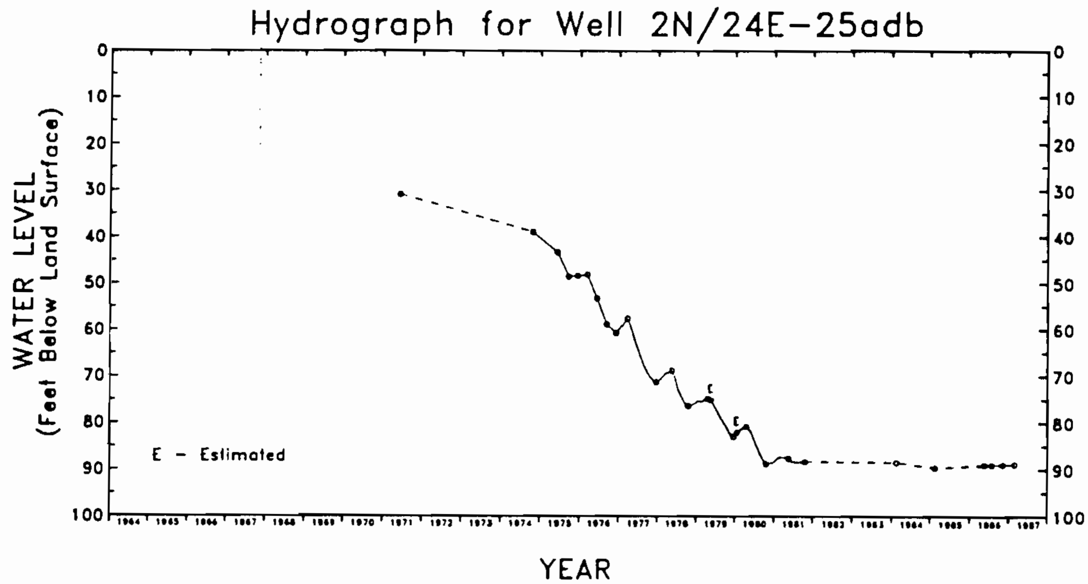


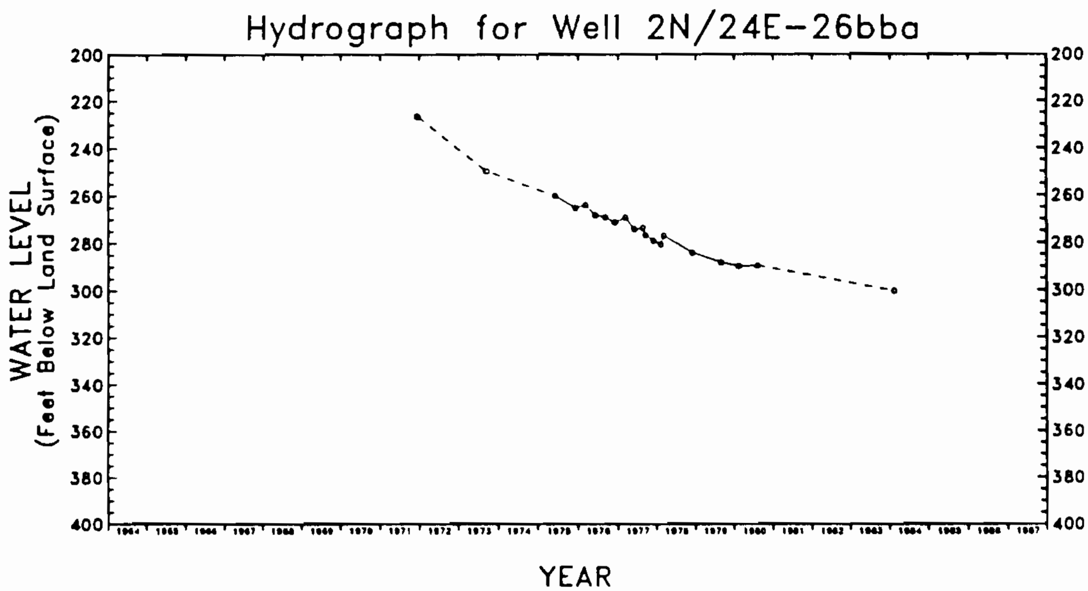
Hydrograph for Well 2N/23E-20dda

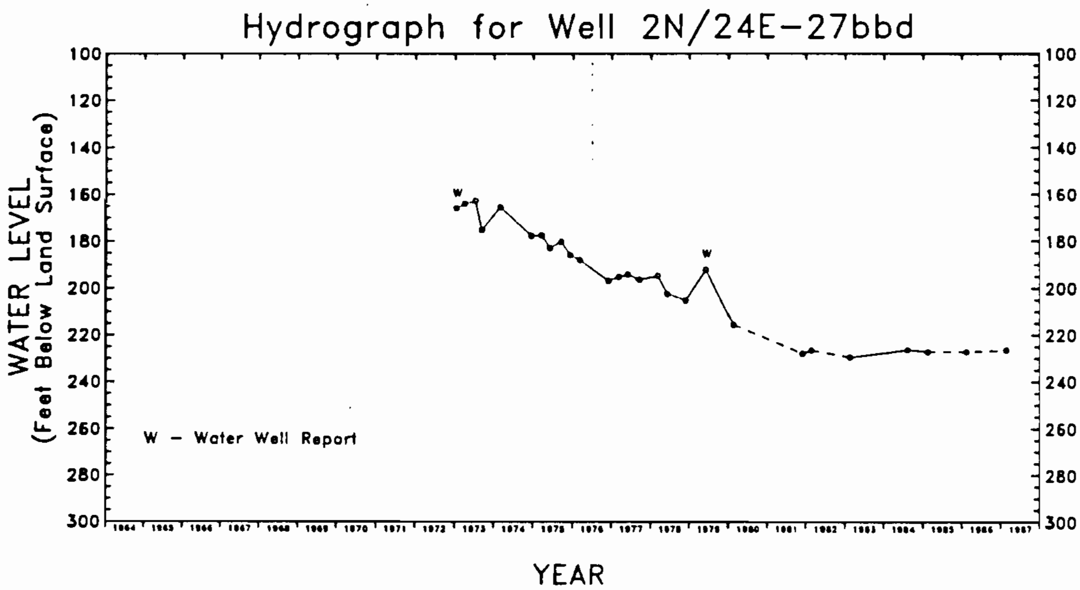


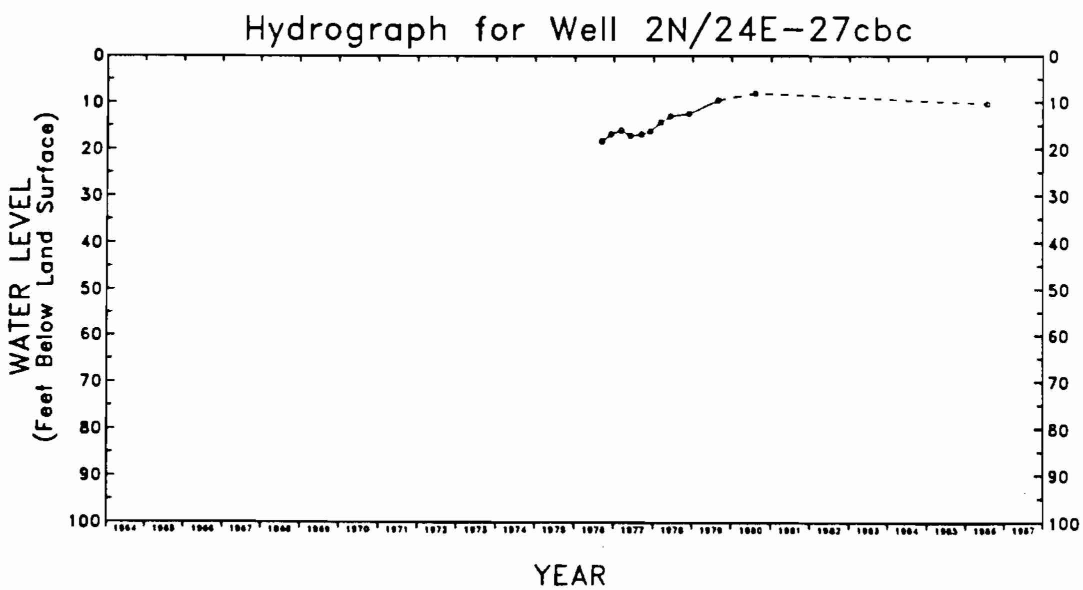

Hydrograph for Well 2N/23E-29ddd
WATER LEVEL (Feet Below Land Surface)
W - Water Well Report
YEAR


Hydrograph for Well 2N/23E-35bdd
WATER LEVEL (Feet Below Land Surface)
YEAR

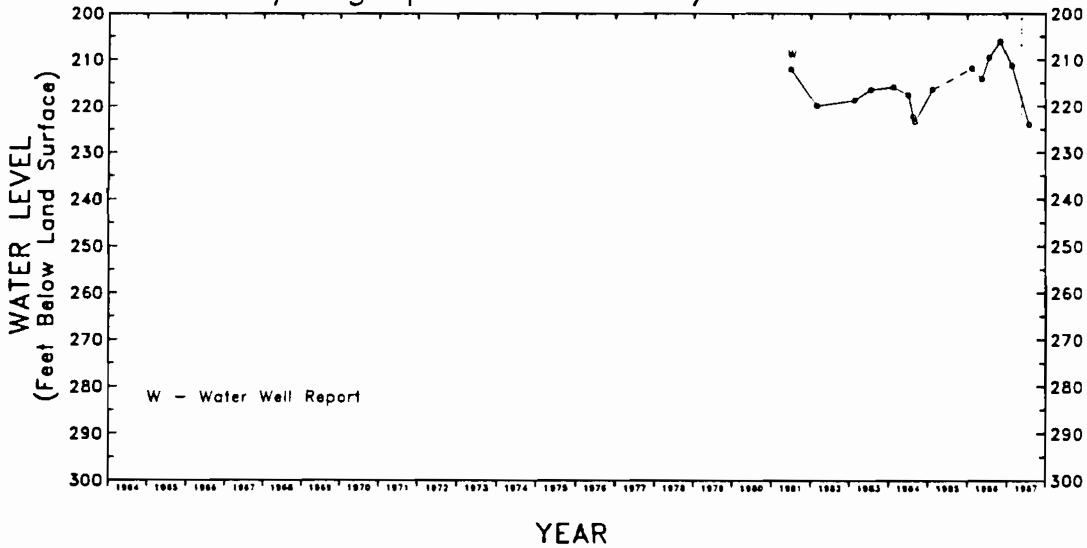

Hydrograph for Well 2N/24E-25adb
WATER LEVEL
(Feet Below Land Surface)
YEAR
E - Estimated


Hydrograph for Well 2N/24E-26bba
WATER LEVEL
(Feet Below Land Surface)
YEAR

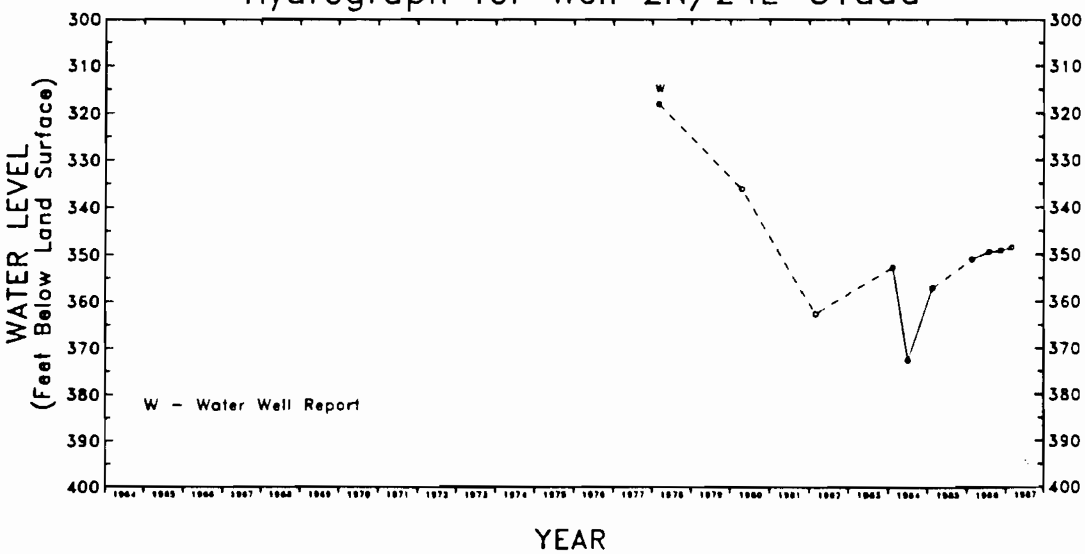

Hydrograph for Well 2N/24E-27bbd
WATER LEVEL
(Feet Below Land Surface)
W - Water Well Report
YEAR


Hydrograph for Well 2N/24E-27cbc
WATER LEVEL
(Feet Below Land Surface)
YEAR

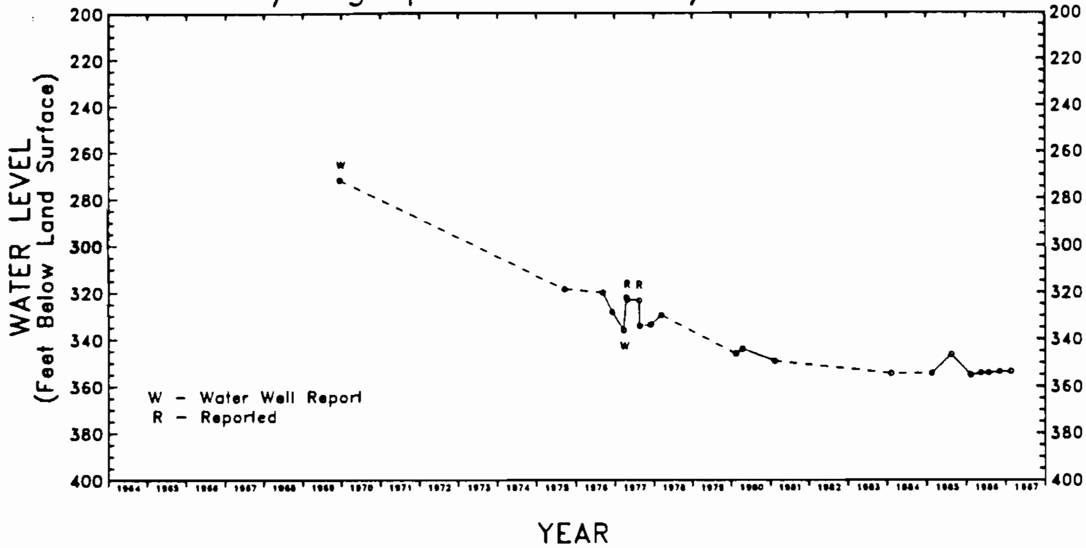
Hydrograph for Well 2N/24E-31abb



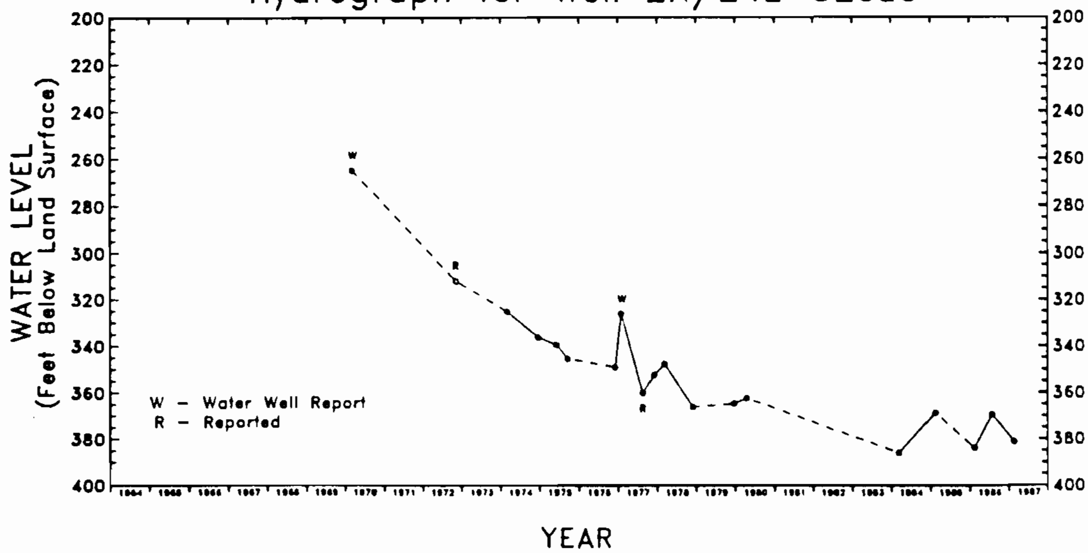
Hydrograph for Well 2N/24E-31daa

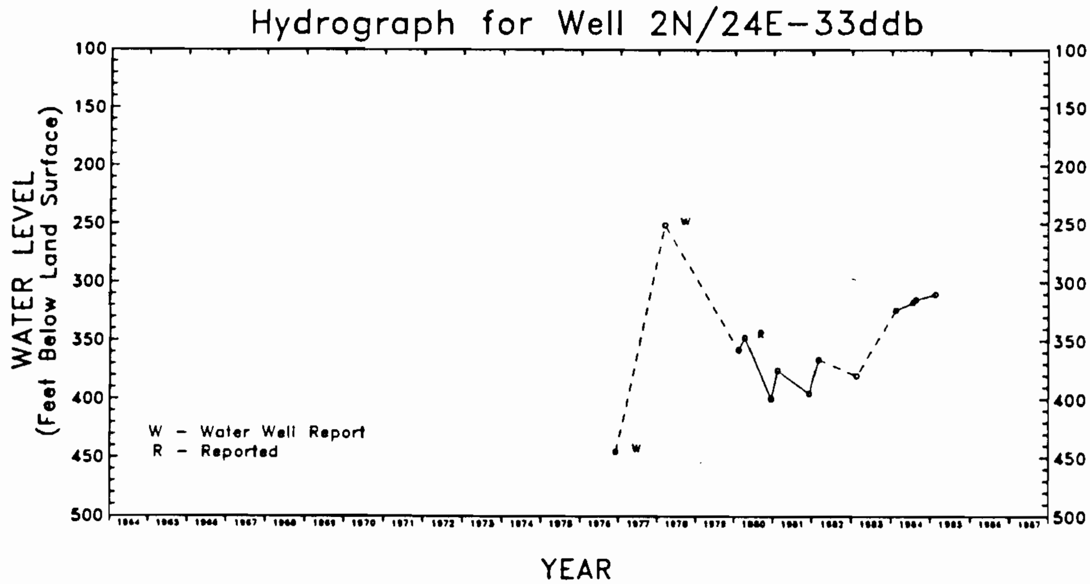


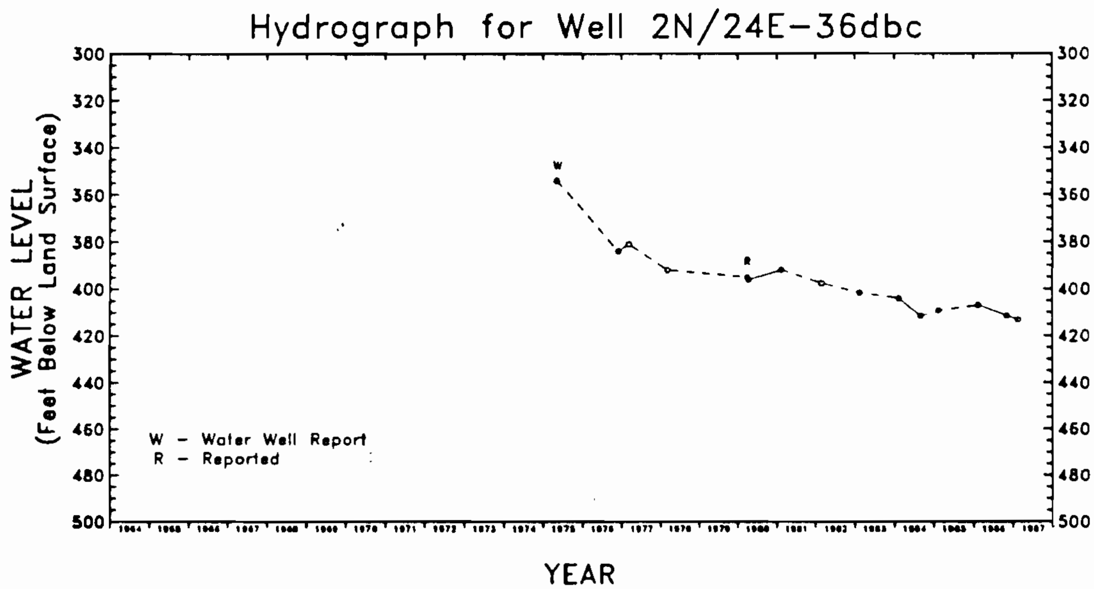
Hydrograph for Well 2N/24E-32add



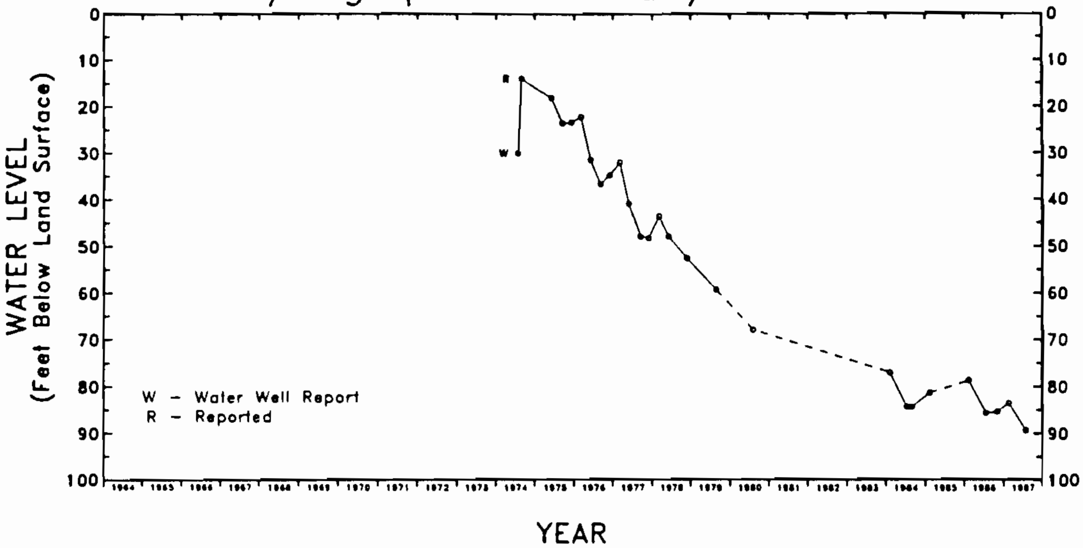
Hydrograph for Well 2N/24E-32cdc



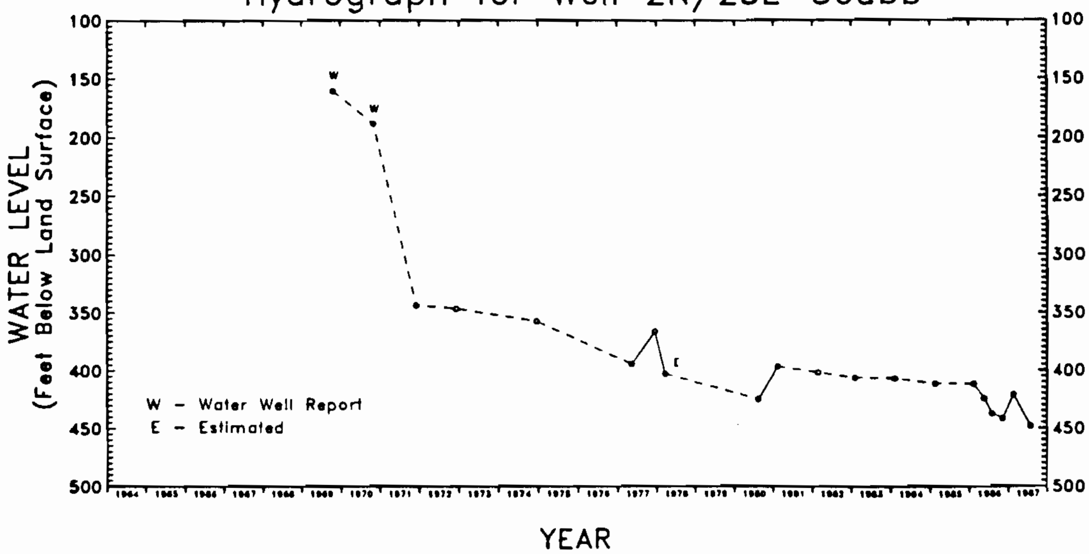

Hydrograph for Well 2N/24E-33ddb
WATER LEVEL
(Feet Below Land Surface)
W - Water Well Report
R - Reported
YEAR

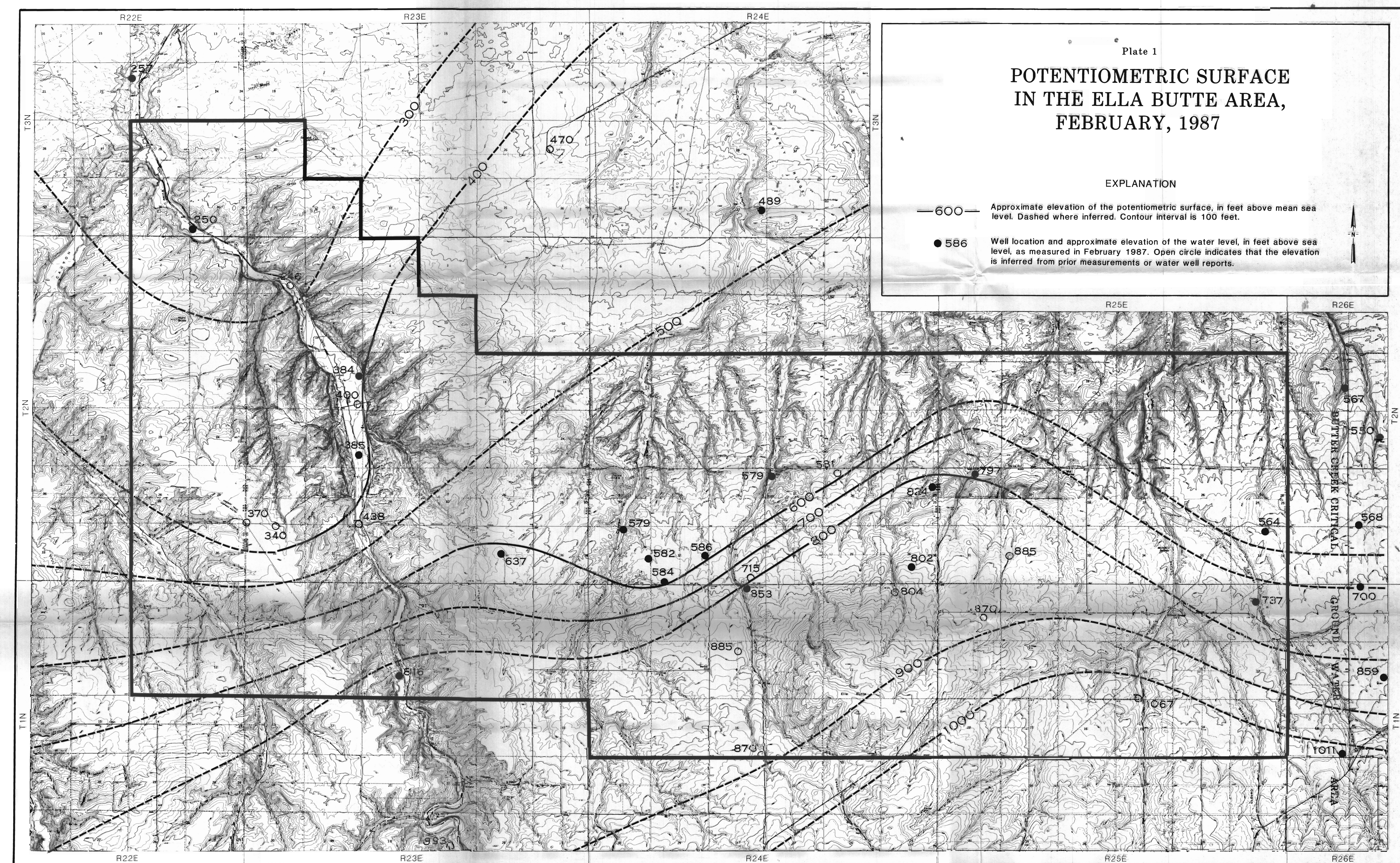

Hydrograph for Well 2N/24E-36dbc
WATER LEVEL
(Feet Below Land Surface)
W - Water Well Report
R - Reported
YEAR

Hydrograph for Well 2N/25E-30abc



Hydrograph for Well 2N/25E-36abb

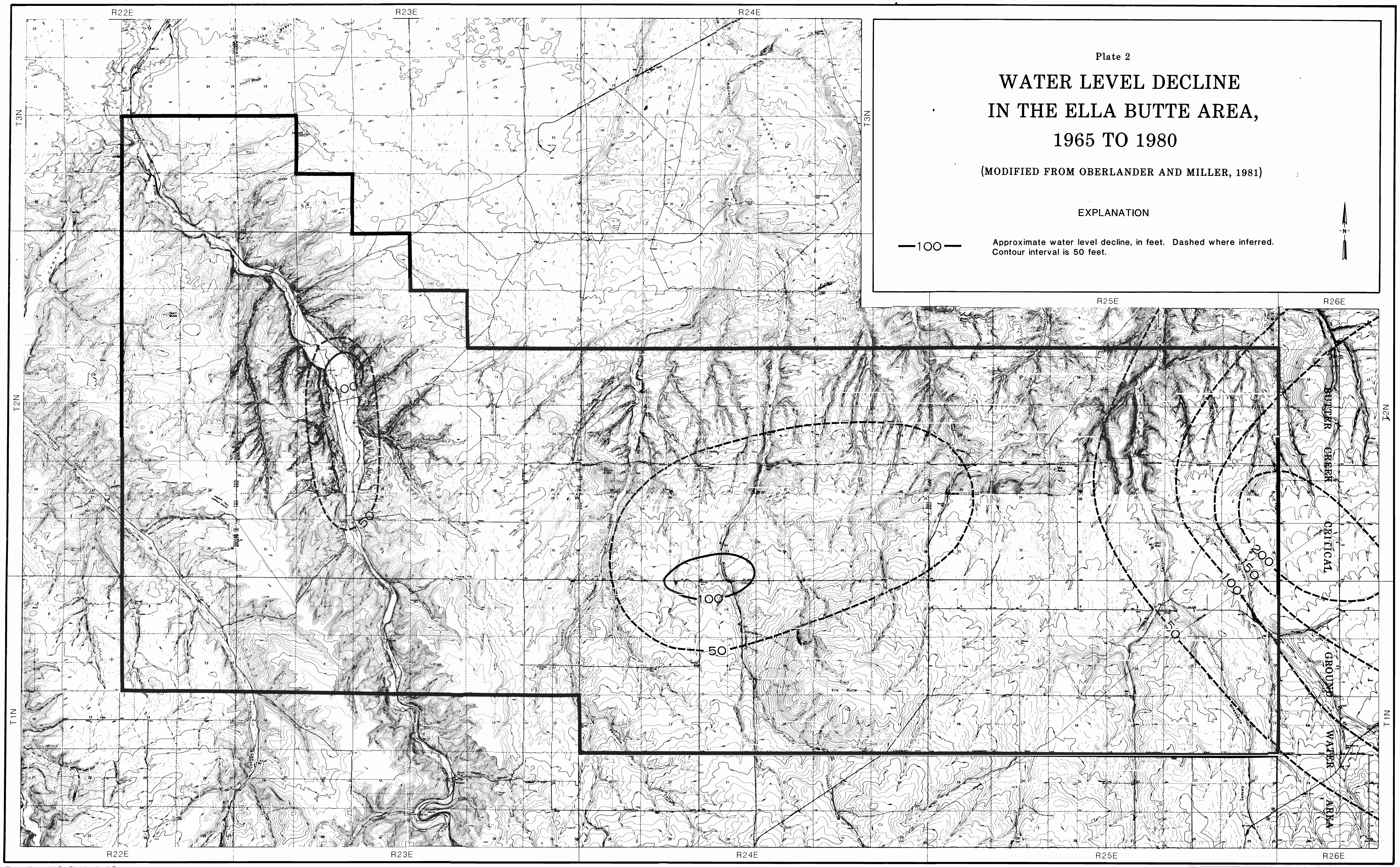




Base from U.S. Geological Survey
1:24000 Quadrangle Maps

SCALE 1:63,360
One Inch equals One Mile
1 0 1 2 3
CONTOUR INTERVAL 10 and 20 FEET

Oregon Water Resources Department 1988
Open File Report No. 88-03



Base from U.S. Geological Survey
1:24,000 Quadrangle Maps

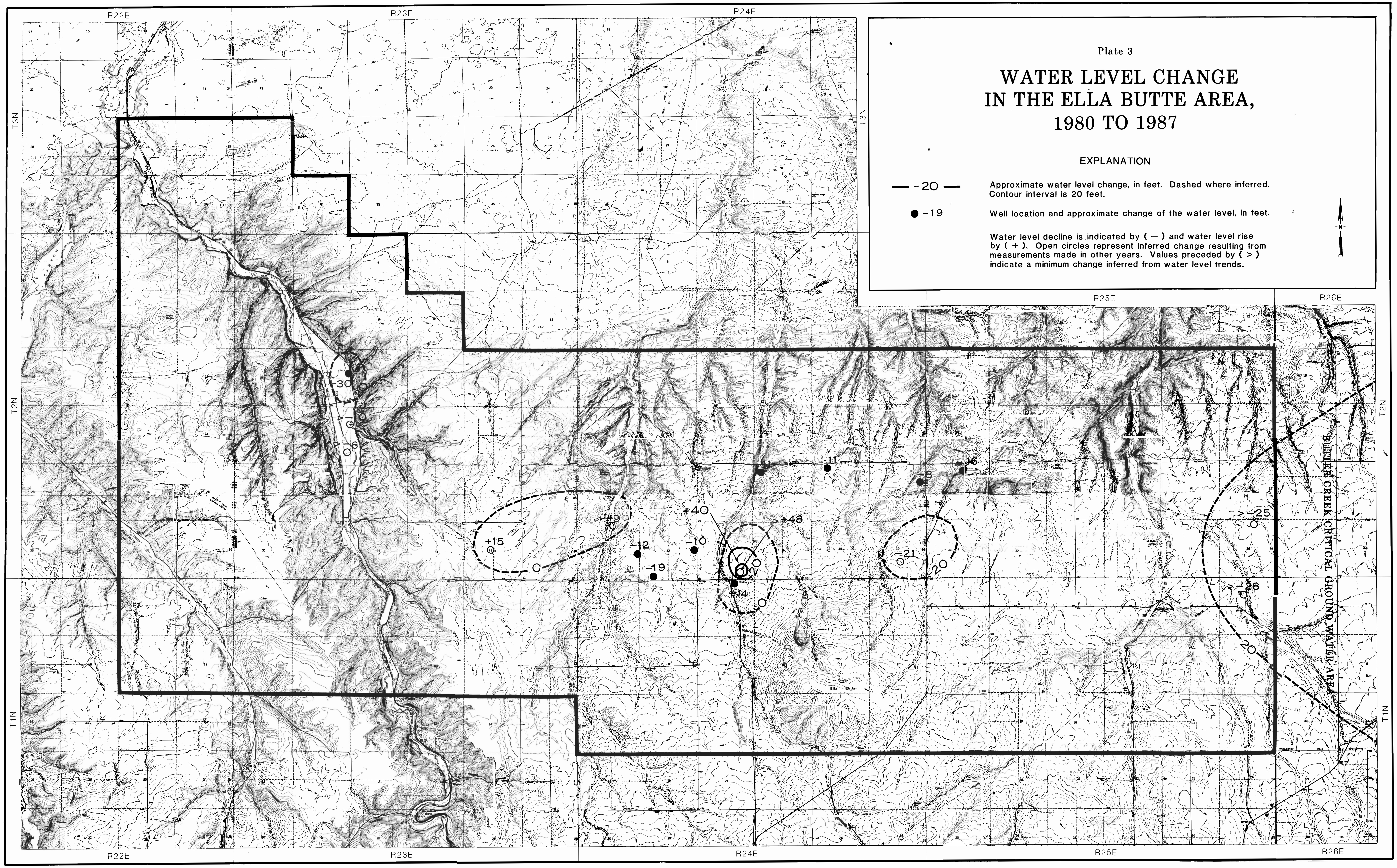
SCALE: 1:63,360
One Inch equals One Mile

CONTOUR INTERVAL: 10 and 20 FEET

Oregon Water Resources Department 1988
Open File Report No. 88-03

Plate 3

WATER LEVEL CHANGE IN THE ELLA BUTTE AREA, 1980 TO 1987



Base from U.S. Geological Survey
1:24,000 Quadrangle Maps

SCALE 1:63,360
One Inch equals One Mile

1 0 1 2 3

CONTOUR INTERVAL: 10 and 20 FEET

Oregon Water Resources Department 1988
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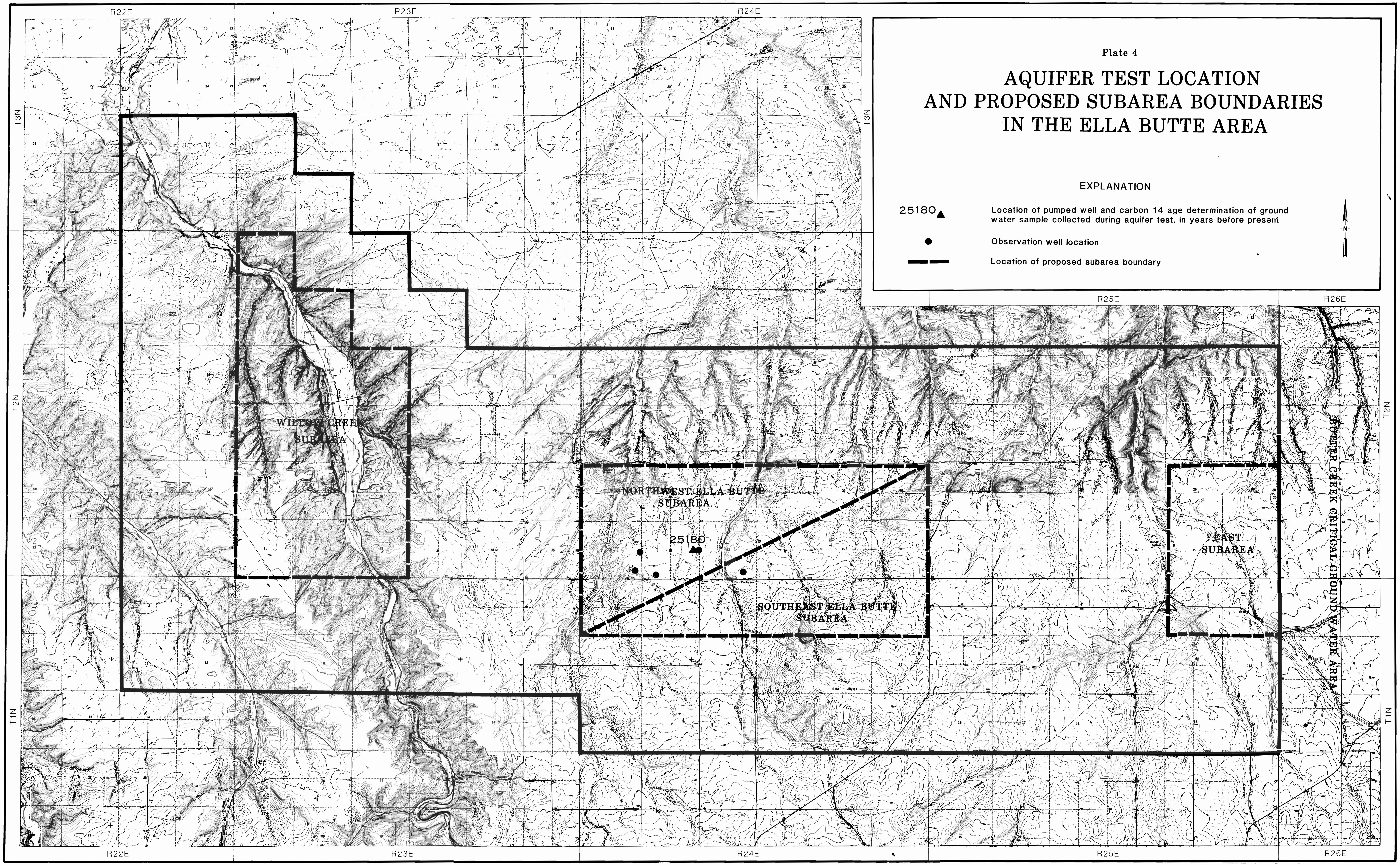

Base from U.S. Geological Survey
1:24,000 Quadrangle Maps

SCALE: 1:63,360
One Inch equals One Mile
1 0 1 2 3

CONTOUR INTERVAL: 10 and 20 FEET

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