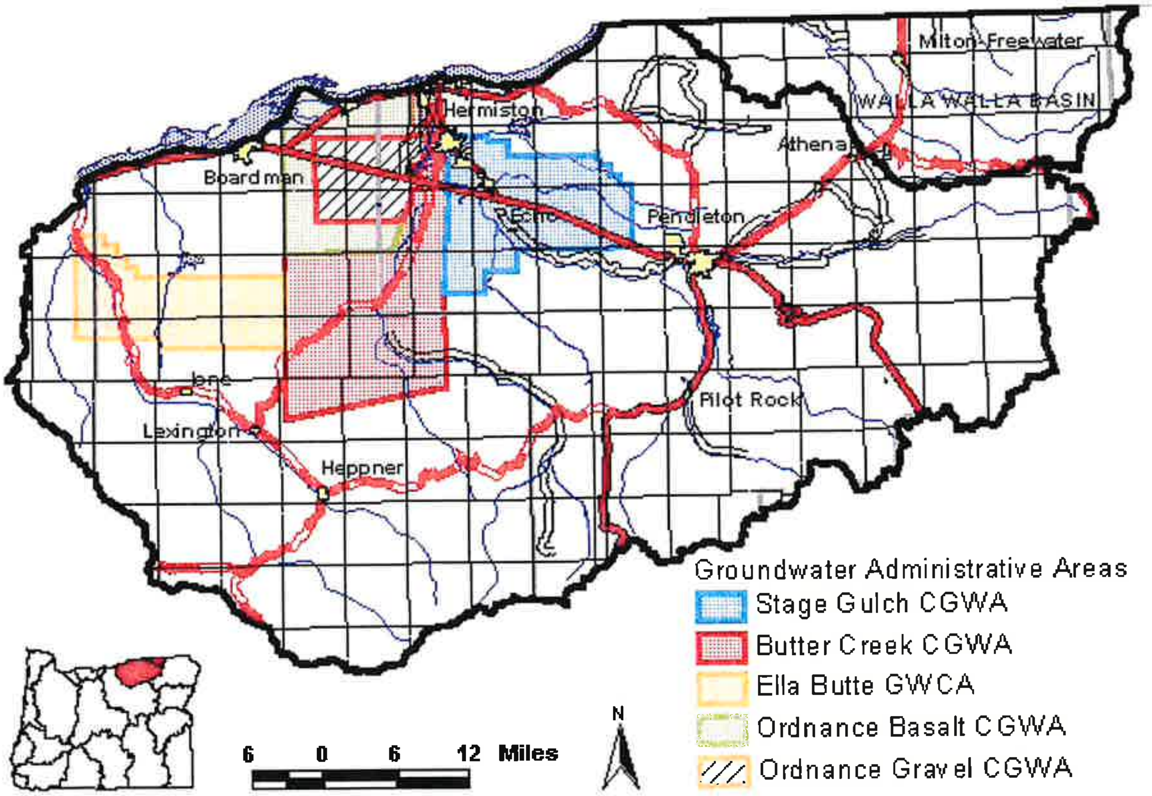
Ground Water Supplies in the Umatilla Basin



presented by
Oregon Water Resources Department
Ground Water Section
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GROUND WATER SUPPLIES IN THE UMATILLA BASIN

Introduction

Virtually every economic venture in the Umatilla Basin relies on a dependable water supply. Water is essential to farming and dairy operation, power generation, food processing and a variety of other industrial and commercial endeavors. Water is also essential for municipal expansion as well as rural residential development.

New appropriations of water from surface water sources in the Umatilla Basin are restricted or limited by available supplies or endangered and threatened species concerns. New water supplies from existing storage reservoirs and artificial recharge projects are also not currently available. Consequently, ground water is the logical alternative for meeting new water supply demands.

Oregon ground water statutes require that the Water Resources Commission and Water Resources Department manage ground water as a renewable resource. Overdraft, excessive water level declines, unstable water levels, and substantial interference with senior rights are to be prevented. Continued economic growth reliant on ground water supplies is unrealistic given these water management objectives. If the Basin is to continue growing, some very difficult decisions will have to be made relative to water resource management in the Basin. To be effective, those decisions need to be based on a thorough understanding of the conjoined ground water/ surface water system. A comprehensive Basin—wide ground water study is being planned to provide the necessary understanding.

This report provides a synopsis of our current understanding of ground water resources in areas of the Umatilla Basin. Appendices to the report provide background information on ground water concepts *(Appendix A)* and the geology of the Umatilla Basin *(Appendix B)*.

CURRENT STATUS OF GROUND WATER SUPPLIES IN THE BASIN

Since the late 1960s, it has been apparent that development and management of ground water resources in the Umatilla Basin would require careful attention. Overdraft, unstable water levels, excessive declines, and other ground water problems exist or are developing in the basin.

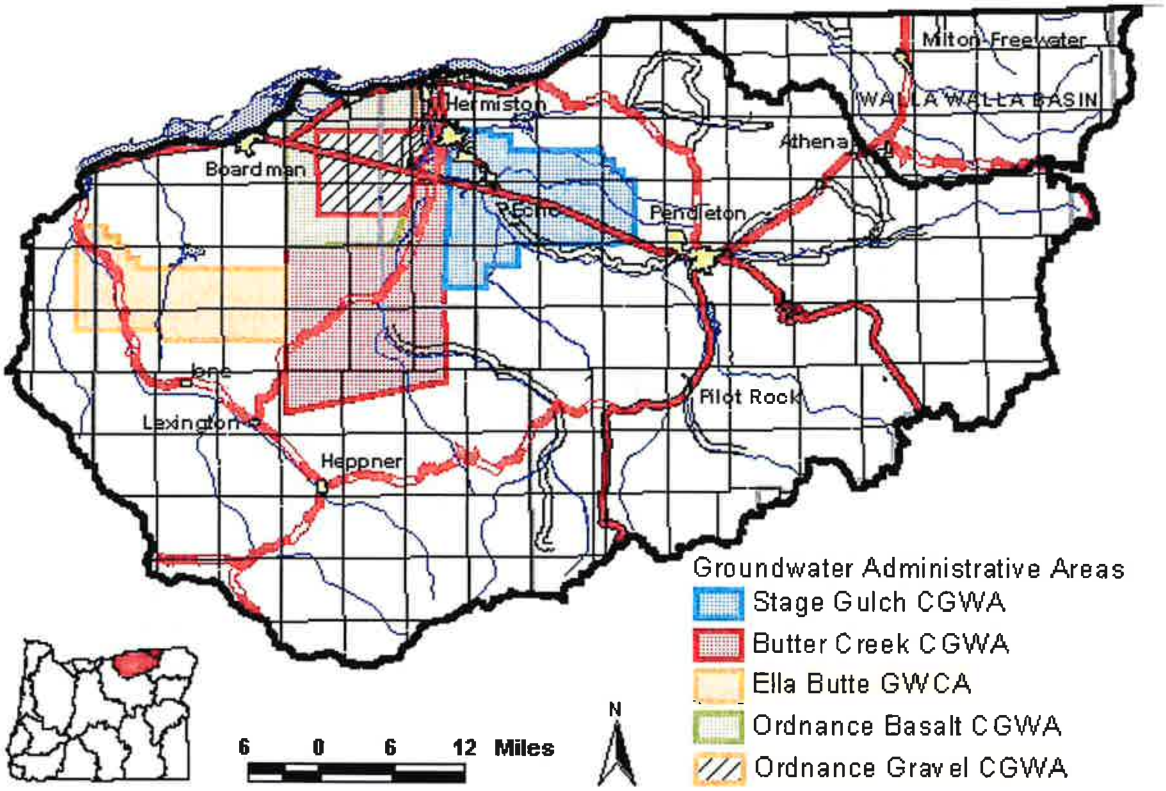

Figure 1 - Umatilla Basin map

In the mid 1970s, the Water Resources Commission began imposing control measures in the basin to correct overdraft and excessive declines. To that end, the Water Resources Commission created the Ordnance, Butter Creek and Stage Gulch Critical Ground Water Areas and restrictively classified ground waters within the basalt in the Ella Butte area *(Figure 1)*. These administrative actions, affecting an area of approximately 800 square miles, severely limit future ground water development and significantly reduce ground water use in much of the area. As a result of these administrative actions, the rate of water level decline has been significantly reduced in much of the controlled area and arrested in some parts. Within these areas, new permits to appropriate ground water are not issued.

Ground water overdraft continues to be a significant issue in the Umatilla Basin. Declines in ground water levels are evident in areas outside of the controlled areas and, to some extent, within the controlled areas. These declines are focused in and around the cities of Boardman, Adams, Athena, and Pendleton. In addition, declines persist within the Ella Butte and Ordnance areas and within parts of the Stage Gulch and Butter Creek Critical areas. This ground water instability is likely to be an indicator of overdraft. A ground water investigation conducted in the early 1980s suggested that ground water throughout the basin was already overdrafted at that time. This would suggest that some of the more recent economic development dependent upon ground water is in jeopardy and that new ground water-dependent economic development is unwise.

In addition to overdraft concerns, interference between ground water users is a significant issue in the Umatilla Basin. Users of the ground water resource are not isolated one from another. As one water user pumps water from the aquifer, water levels decline in response. Those declines cause lower water levels for other ground water appropriators using the same source. This phenomenon is called interference. Interference causes increased pumping lifts and increased costs for other users of the resource. In the more severe cases of interference, some users may not be able to pump enough water to satisfy their water rights.

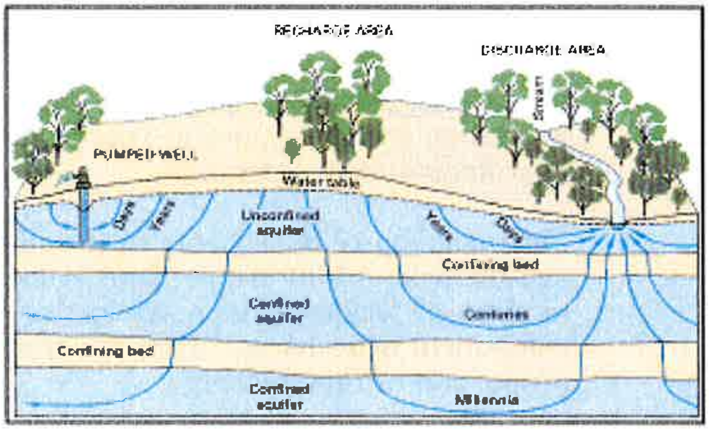

Figure 2 - Ground water flow

Just as ground water users are not isolated from each other, the ground water resource itself is not typically an isolated resource. Most, if not all, ground water in the state receives some amount of recharge annually from rainfall and snowmelt. Ground water then flows through the aquifer system to a discharge area where it leaves the flow system, usually to become surface water, providing base flow to streams long after the snows have melted off the highlands *(Figure 2).* Where surface water is dependent upon ground water discharge, pumping ground water for beneficial uses may reduce discharge to surface water and, therefore, reduce surface water supplies. This may occur to the detriment of surface water rights and other surface water values such as fish and aquatic life habitat, aesthetics, pollution abatement and recreation. Interference with surface water supplies and rights as a result of ground water pumping is a significant issue in the Basin.

GROUND WATER RESPONSE TO DEVELOPMENT

Ground water levels are declining in areas throughout the Umatilla Basin, further highlighting the need for a basin-wide, comprehensive understanding of ground water resources. The following sections present our current knowledge of ground water supplies in areas of the Umatilla Basin. An understanding of ground water occurrence and supply problems within the basin will be improved by a brief introduction to ground water concepts which is provided in Appendix A.

Alluvial Aquifers and Shallow Basalt Aquifers of the Lower Umatilla Basin

A shallow unconfined aquifer occurs in the alluvial sediments of the lower Umatilla Basin. Multiple confined aquifers occur in the underlying basalt flows. The alluvial and shallowest basalt aquifers are the main sources of domestic water for rural residents in the area. The alluvial aquifer is also a major source of municipal water for the cities of Hermiston, Irrigon, and Boardman and an important source of irrigation water in the area between Boardman and Hermiston.

The main source of recharge to the alluvial aquifer comes from leaky canals and ditches. Additional recharge comes from applied irrigation water. In local areas, leakage from reservoirs and streams represents a significant component of recharge. Recharge from precipitation is a relatively small proportion of total recharge.

The principal water-producing zones of the alluvial aquifer in the lower Umatilla Basin occur in deposits of coarse sand and gravel that fill three east- to northeast-trending shallow troughs between Boardman and Cold Springs Reservoir. Well yields in these areas commonly exceed 1000 gallons per minute. However, ground water supplies are limited by the restricted aerial extent of the deposits. In the Ordnance area (discussed later in this report), excessive pumpage from the gravels led to water-level declines that required administrative restrictions on pumping. Water-level declines are unlikely in the gravels in the Boardman area as pumping will be buffered by capture of water from the Columbia River.

Regional flow in the alluvial aquifer is to the northwest with discharge to the Umatilla and Columbia rivers; however, flow directions vary considerably over space and time. The topography of the underlying basalt, seasonal pumping of high-capacity wells, and seasonal recharge from leaky canals are the main factors influencing flow direction. Seasonal reversals of flow are known to occur beneath the southern half of the Umatilla Ordnance Depot and may occur elsewhere.

The Umatilla River is hydraulically connected to the alluvial aquifer between the cities of Echo and Umatilla where the river is in contact with alluvial sediments. At Butter Creek, the river begins to progressively downcut through the aquifer until it reaches basalt bedrock at Three-Mile Dam. These relationships suggest that natural discharge from the aquifer to the river occurs between Butter Creek and Three-Mile Dam. This is consistent with the known occurrence of natural springs in the lower reaches of the river. However, good estimates of the amount of interchange between the river and the aquifer are lacking.

Outside of the Umatilla lowlands, productive deposits of sand and gravel also occur in the narrow floodplains of the mainstem Umatilla River and some of its larger tributaries. These deposits typically occupy river valleys that are incised into the basalt bedrock. Ground water in these sediments is hydraulically connected to the adjacent streams and withdrawing it interferes with streamflow.

Productive water-bearing zones within Columbia River Basalt flows are generally limited to thin zones of broken or fractured rock at the top or base of individual basalt flows. The dense interiors of flows are relatively impermeable and confine ground water to discrete tabular aquifers. However, the geometry of the shallow basalt aquifers in the lower basin indicates that they are hydraulically connected to the alluvial aquifer, the Umatilla River, and the Columbia River where permeable zones in the basalts are exposed beneath the alluvial aquifer and in the beds of the rivers. As with the alluvial aquifer, pumping water out of these shallowest basalts interferes with stream flows.

Ordnance Critical Ground Water Areas

There are two critical ground water areas in the Ordnance area: the Ordnance Gravel Critical Ground Water Area and the Ordnance Basalt Critical Ground Water Area. The Ordnance Basalt Critical Ground Water Area is located west of Hermiston and includes 175 square miles of basalt aquifers near the Umatilla Chemical Depot and Irrigon. It is partially overlapped by the Ordnance Gravel Critical Ground Water Area that includes 82 square miles of alluvial aquifer in the Depot area. The controlling order for both areas was issued in 1976 and prohibits the issuance of new ground water rights. “Exempt uses” are allowed under the order. Exempt uses are smaller uses exempt from the water right permitting requirement and are therefore referred to as “exempt uses.” Exempt uses include single or group domestic use up to 15,000 gallons per day, noncommercial irrigation of up to one-half acre, stock watering, and commercial and industrial use up to 5,000 gallons per day.

The stratigraphy for both areas can be generalized. Alluvial material is present from land surface to an average depth of 50 to 100 feet, attaining a maximum of about 200 feet. These materials vary spatially in thickness and composition but consist of sand, gravel, silt, and clay. These sediments are underlain by lava flows of the Columbia River Basalt Group. These flows are numerous and are not fully penetrated by local wells.

Ordnance Gravel Critical Ground Water Area

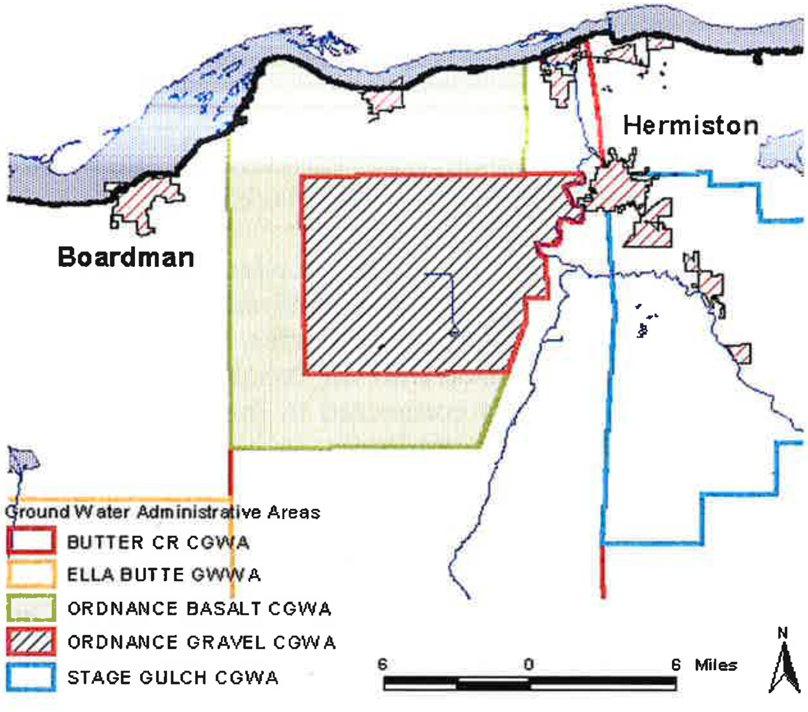

Figure 3 - Ordnance gravel CGWA

The aquifer in the Ordnance Gravel Critical Ground Water Area is unconfined and varies in saturated thickness from 15 to 125 feet. Depths to water are generally less than 100 feet below land surface. Irrigation development began in the 1950's and increased to some 45 wells by the early 1970's *(Figure 3).* These diversions resulted in declines in the ground water resource that threatened the continued use of some well as shown in *Figure 4.*

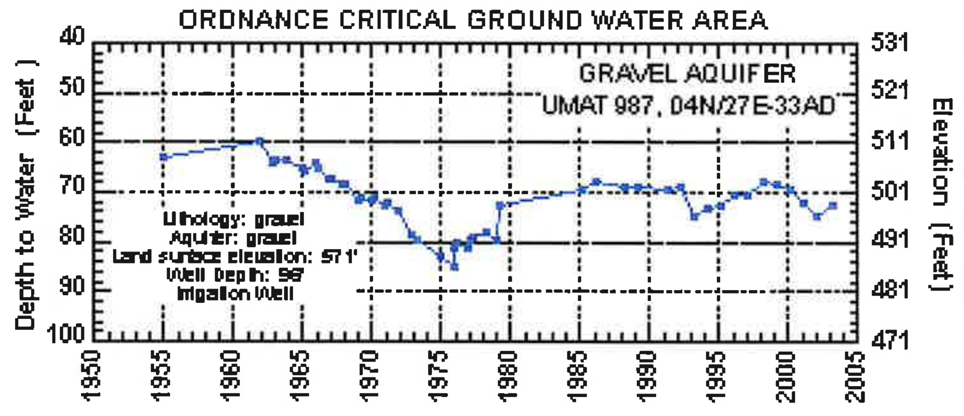

Figure 4 - Ordnance gravel well hydrograph

Although water level declines were only about 20 feet, declines were significant for wells where the aquifer was thin and prompted the administrative action that created the critical area.

The Ordnance Gravel Critical Ground Water Area contains two subareas. During the spring of 1977, several well owners in the Lost Lake/Depot subarea initiated a project to artificially recharge the shallow gravel aquifer south of Ordnance. The project uses an existing canal system, a dedicated leaky recharge canal, and winter/spring water from the Umatilla River diverted near Echo. Water levels in many gravel wells have responded favorably. Historically, recharge has been at a rate of approximately 6000 acre-feet per year. However, access to water for recharge has been reduced in recent years in response to instream needs associated with the Columbia/ Umatilla Exchange Project. Recharge amounts for the last four years have been less than 5000 acre-feet per year. This artificial recharge project is essential to stabilize aquifer levels and supplement irrigation supplies.

Currently, water levels in the critical area are fairly stable. Water use under permit remains high, and there is a slow, steady increase in exempt uses. Water levels in the critical area are better than in the mid-1970s prior to recharge project, but have dropped in recent years (*Figure 4*). More recharge or less water use is needed to correct current water level trends.

Ordnance Basalt Critical Ground Water Area

The administrative order for the Ordnance Basalt Critical Ground Water Area defines two basalt aquifers (*Figure 3).* Aquifers less than 400 feet deep are termed the shallow basalt aquifer and those more than 400 feet deep are the deep basalt aquifer. Local development of these ground water resources began in the 1940s at the Umatilla Army Depot (now, Umatilla Chemical Depot). Ground water development continued and peaked near current levels in the 1960s. Use is now largely for irrigation but also includes municipal use by the City of Irrigon and military purposes at the Depot.

There are several general differences between the shallow and deep basalt aquifers. In the critical area, the depth to water in deep basalt wells is generally about 300 feet while the depth in shallow basalt wells is less than 150 feet below land surface. In addition, the shallow basalt is more readily recharged and is less productive, and has smaller declines. Ground water in the shallow basalt aquifer is, at least in part, unconfined while the deep basalts are confined. The shallow basalt aquifer does not display the uniform water level response that the deep ones do. In these ways, the shallow basalt aquifer acts more like an alluvial resource than the deep basalt and is likely hydraulically connected to the alluvial ground water.

Declines in both the shallow and deep basalt aquifers prompted the administrative action that created the critical area. Pumping by about 13 deep basalt wells resulted in total declines of up to 100 feet *(Figure 5*). A similar number of shallow basalt wells produced smaller declines of 30 feet or less *(Figure 6).*

Available information indicates that the shallow basalt aquifer is stable in the critical area. Water use under existing permits appears far less than when the order was entered. Exempt uses have increased modestly. For these reasons, the outlook for the ground water resource in this aquifer is good.

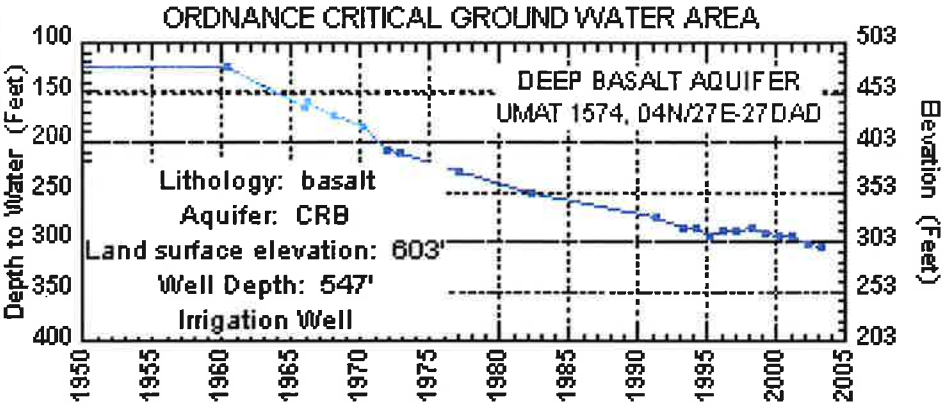

Figure 5 - Deep basalt aquifer hydrograph

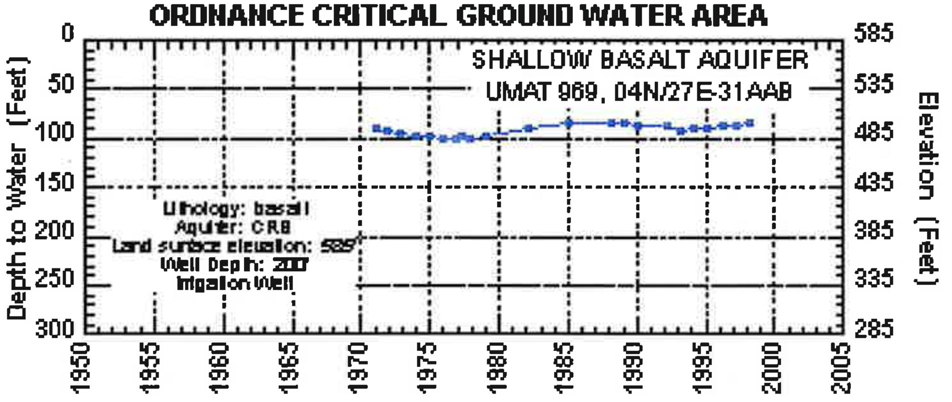

Figure 6 - Shallow basalt aquifer hydrograph

Water levels in the deep basalt aquifer are not currently stable. However, the rate of water level decline is currently less than in recent decades. The water level response is highly uniform among the wells. Water use under existing permits remains high. Given the depth of the aquifer, exempt uses of water are not likely to expand. Declines continue and have resulted in total lowering of water levels up to 180 feet *(Figure 5)*.

West of Ordnance

The 180 square-mile area west of Ordnance is also an area of basalt ground water concerns. The area of concern is bounded by the Columbia River to the north, Willow Creek on the west, the Ella Butte ground water classified area on the south, and the Ordnance basalt critical ground water area on the east *(Figure 1)*.

The basalt aquifers in this area west of Ordnance are several thousand feet thick and are, for the most part, confined. The deepest well in the area is about 1000 feet but most are less than 500 feet. Ground water flow in these aquifers is toward the Columbia River. Recharge is generally very low but the presence of surface water from canal leakage and other artificial sources is locally important to shallow basalt aquifers.

As with all basalt aquifers, there is a vertical stratification that produces aquifers with different water levels (heads) with depth. Deeper wells at low elevation have been capable of strong artesian pressures. Shallower wells have water levels that vary but are usually less than 200 feet below land surface. Basalt hydrology is complex and site-specific conditions can be more variable than this generalization suggests. The distinction between shallow and deep basalt aquifers in the area is difficult to make. As a generalization, the deep basalts are considered to be those below about 400 feet below land surface. Deeper aquifers have been more prone to decline with use. Deeper wells are often capable of yields in excess of 1000 gallons per minute while shallower wells produce less.

Properly constructed wells do not commingle aquifers with different water levels. When wells commingle aquifers, they act to stress the aquifer not only when pumping occurs, but also when the wells are not pumped, which can exacerbate any water level instability in the aquifers. Improper well construction may be an issue in this area.

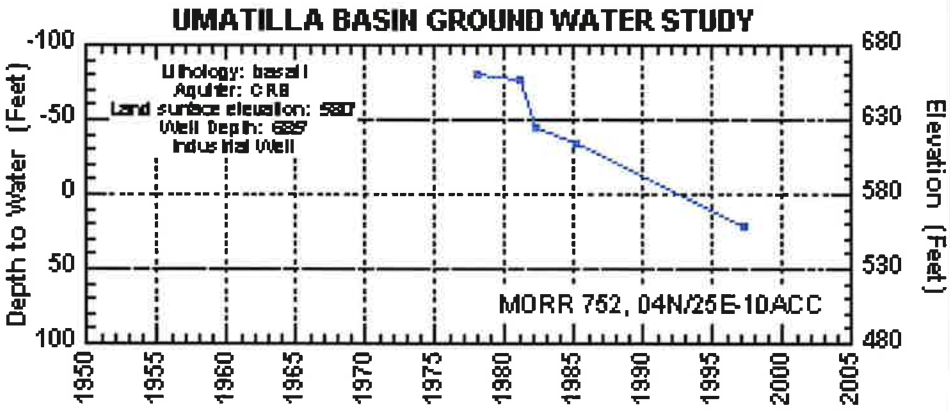

Figure 7 - Port of Morrow hydrograph

Current ground water development is primarily near the City of Boardman in a three-mile strip along the Columbia River. In this area, basalt aquifers provide a water source for municipal, industrial, irrigation, domestic, and other uses. Development of deep basalt aquifers has resulted in water level declines of tens of feet *(Figure 7)* while development of shallow basalt aquifers shows a high level of water level stability. The Port of Morrow is the largest user in this area and developed its permits to use more than 10 cubic feet per second (cfs) in the Port area. The Port has an additional permit to develop more than 8 cfs more from the deep aquifer through two wells near the Boardman Airport.

Ground water development outside of the Boardman area is minimal, although there is some industrial and irrigation uses. Water use permits will allow about 3 cfs of new agricultural use for dairy operations in the center of the area.

Future demand on the basalt aquifer resource is uncertain. Current uses are expected to continue and undeveloped permits will be developed. These will increase the current demand and likely cause additional water level decline. A recent application in the north-central part of the area seeks to divert 35 cfs through nine wells for irrigation. There is speculation that the Boardman Bombing Range is being phased out and that land may go into private control. Such changes could promote additional demand on the basalt ground water resources in the eastern third of the area.

Ella Butte Classified Ground Water Area

Development of the ground water resource of the basalt aquifer in the Ella Butte Classified Ground Water Area began in the late 1960s and 1970s (*Figure 8*). Ground water production supplements limited surface water supplies in Willow Creek. With the development of irrigation from ground water, dry land farmers could greatly increase yields for wheat, peas, barley, and other crops and could produce a crop every year, rather than every other year. Improvements in irrigation methods, such hand lines, wheel lines and center pivots, led to further development of the ground water resource. By the 1990s, signs of ground water level instability had developed in the basalts of the Ella Butte area.

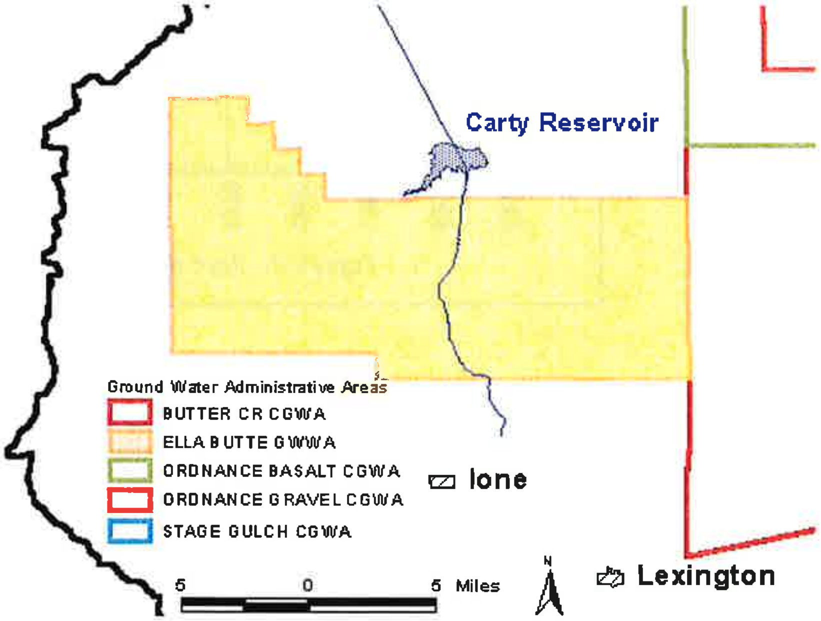

Figure 8 - Ella Butte classified GWA and well locations

Ground water levels in the basalt aquifers were fairly shallow in the Willow Creek valley and are generally deeper to the east. Water levels vary greatly depending on the depth and location of wells. Declines vary from 350 feet in an unused irrigation well located in the eastern portion of

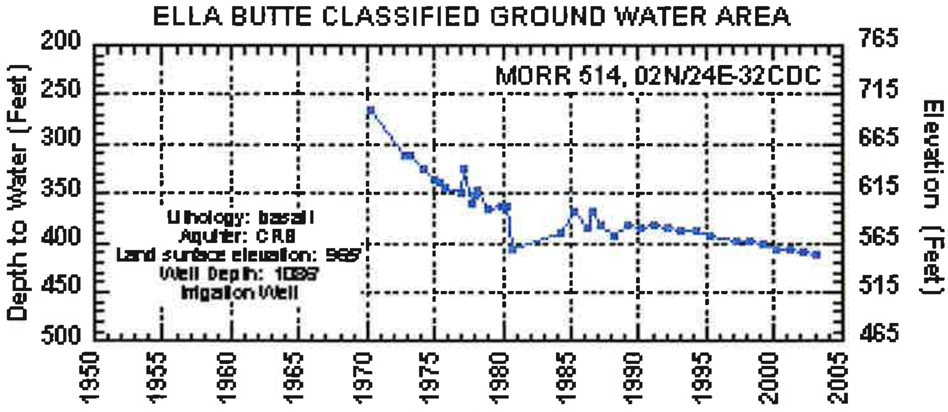

Figure 9- Deep basalt well hydrograph

the area to about 260 feet at a well in Willow Creek valley. Ground water levels in an irrigation well, located in the middle of the area, have declined about 150 feet *(Figure 9).* Three shallow wells used for stock watering or domestic uses have shown 75 to 100 feet of decline *(Figure 10)* since use began about 30 years ago.

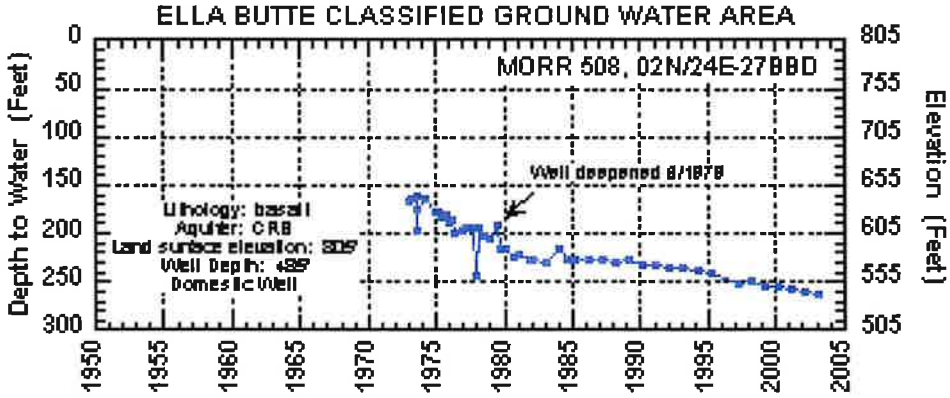

Figure 10 - Shallow basalt well hydrograph

In 1985, the Department initiated critical ground water area proceedings in the Ella Butte area and began the administrative rule process for designating the area in 1987. During the hearing process associated with rule development, testimony from the Ella Butte area indicated that annual pumping from the basalt aquifers was dropping and that a critical area designation was not required. In 1990, the Ella Butte area was classified by administrative rule for exempt uses only. Exempt uses include domestic use, stock-watering, and limited commercial or industrial. The classification prohibits additional large-scale uses such as irrigation or industrial.

Ground water levels are still declining in the Ella Butte Classified Ground Water Area. Recent changes to existing water rights in the Willow Creek area have resulted in 60 feet of decline in the last five years. Ground water

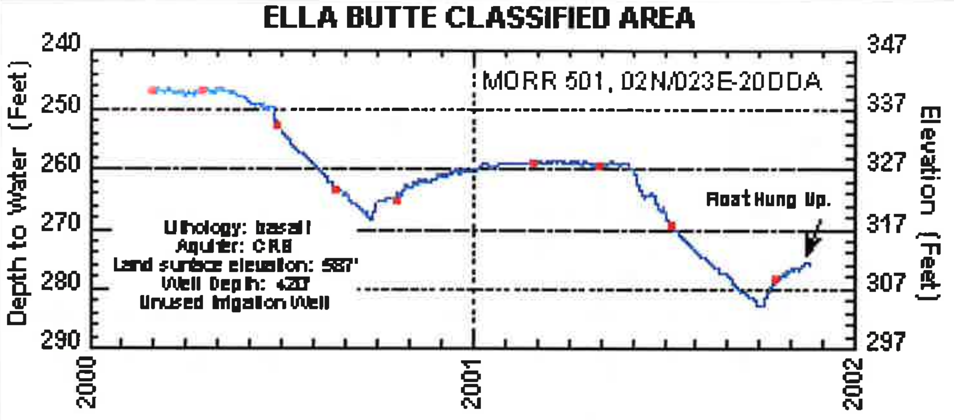

Figure 11 - Deep basalt well short-term hydrograph

levels in the central portion of the area have declined about 15 feet over the same time period. Water levels collected from an unused well in the area indicate that seasonal drawdown in 2000 exceeded the recovery the following winter *(Figure 11).* The slope of the recovery was fairly flat for January through early May when irrigation began. This indicates that the aquifer had recovered as much as possible from the previous year's pumpage. Without reductions in ground water use, water levels will continue to decline.

Butter Creek Critical Ground Water Area

Development of the ground water resource in the Butter Creek Critical Ground Water area began in the 1950's generally as a supplement to limited surface water supplies. Use of ground water from the basalt aquifers increased in the late 1950s and early 1960s as farmers developed ground water as a primary source of water for irrigation *(Figure 12).*

Ground water levels in the basalt aquifer in the early 1960s were fairly shallow. Some wells even flowed at land surface. By the mid-1960s, ground water levels had begun dropping. One well, located in the Echo Junction subarea, declined about 100 feet by the late 1960's *(Figure 13).* By the mid 1970's, the ground water level was approaching 300 feet below land surface. Water level measurements in February 2003 show a total water level decline in the Echo Junction subarea to be in excess of 450 feet.

Ground water levels continue to decline in large portions of the Butter Creek Critical Ground Water Area. The critical area has been divided into "subareas" *(Figure 12).* The Pine City and West subareas still have declines of three to five feet per year *(Figure 14).* Recent, voluntary reductions in pumpage in the West Subarea may have stabilized ground water levels there. However, the reduction in pumpage was by a senior user and is not perma-

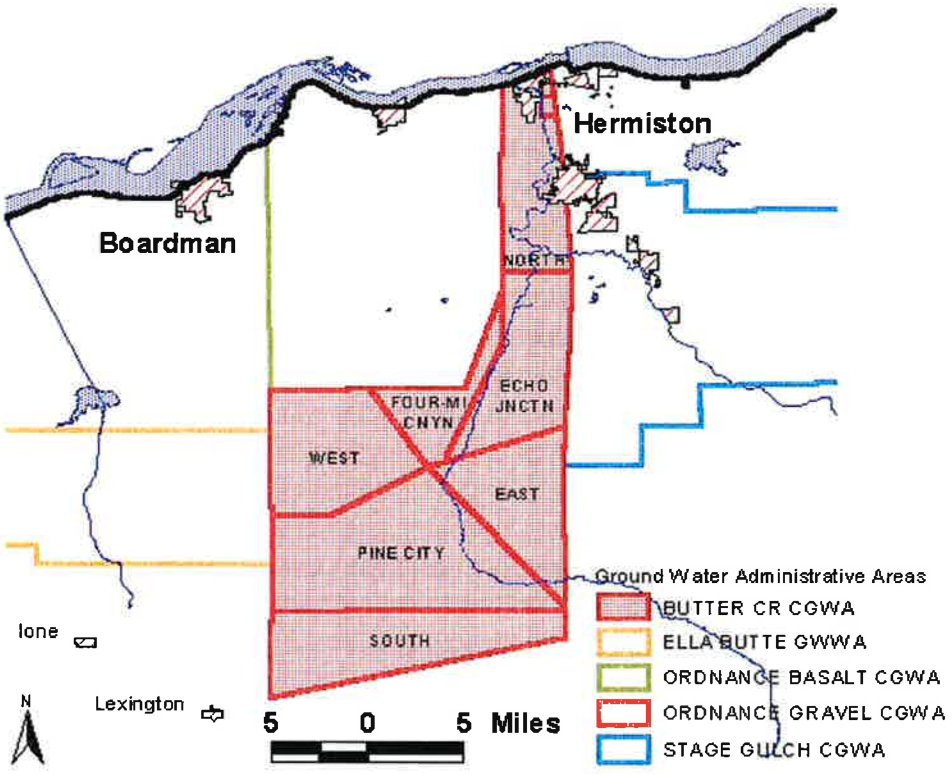

Figure 12 - Butter Creek CWGA

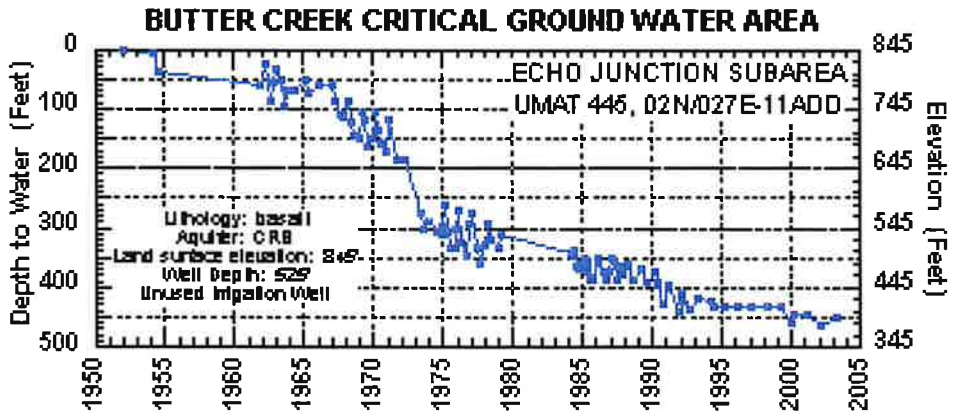

Figure 13 - Echo Junction subarea hydrograph

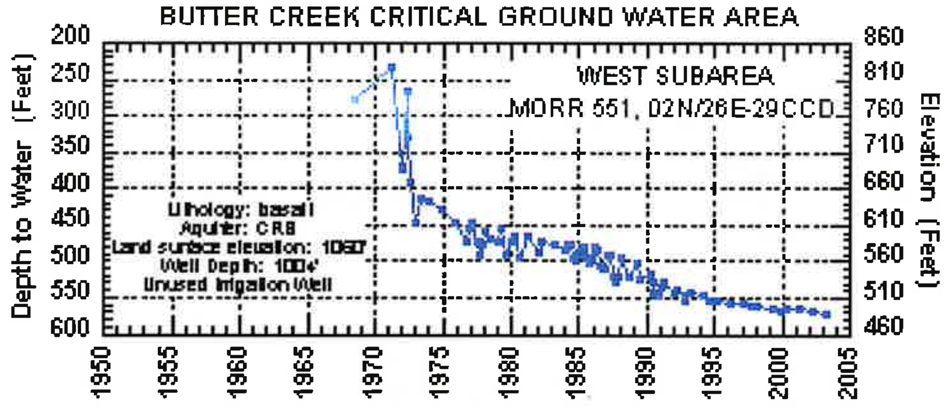

Figure 14 - West subareas hydrograph

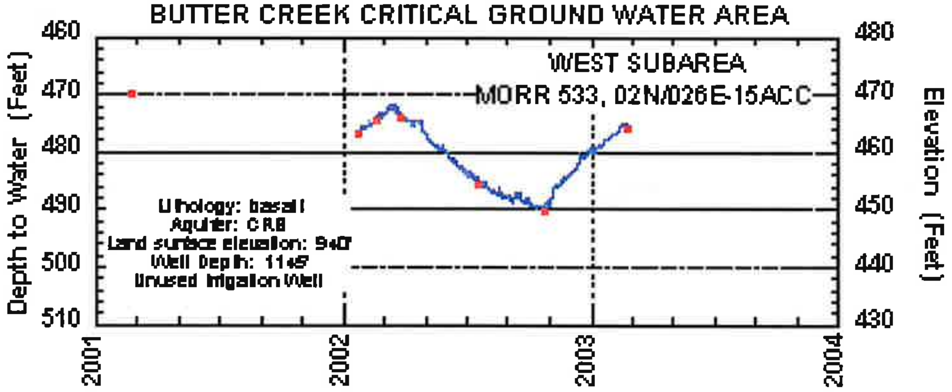

Figure 15 - West subareas hydrograph

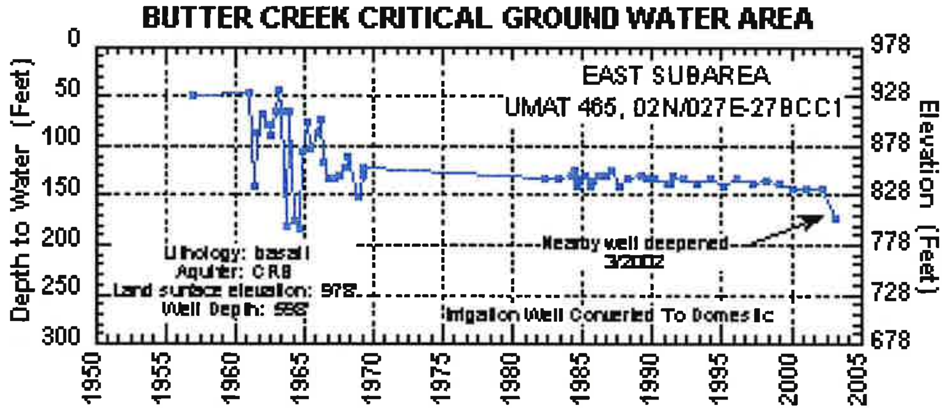

Figure 16 - East subarea hydrograph

nent. A water level recorder was installed on an unused irrigation well in the West Subarea *(Figure 15).* The water level in this area is still rising when pumping begins in the spring, unlike the well in the Ella Butte area. If the wells were not started in the spring, ground water levels would continue to recovery from previous irrigation.

The North Subarea is also showing declines. All permitted uses, except the City of Umatilla, have been regulated off in the area. Water levels in the City of Umatilla's well have declined almost 50 feet. Domestic wells east of Hermiston have declined about 150 feet over the last 45 years. Well construction and additional new uses from domestic wells are also impacting ground water levels in the North Subarea.

In the East Subarea, the ground water level in one well *(Figure 16)* dropped about 30 feet as a result of the deepening of a nearby well. Monitoring of ground water levels will determine if the lowering of the water level will continue or whether it will stabilize at the new level. If declines continue, well reconstruction may be required.

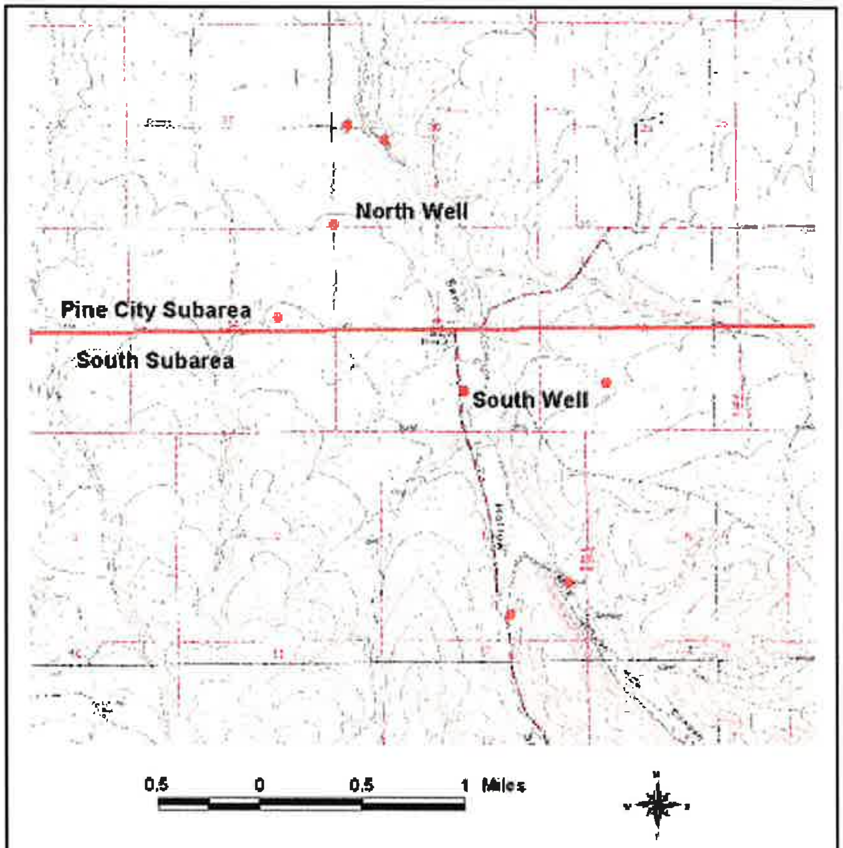

Figure 17 - Well location

Geologic structures such as faults or folds can interrupts ground water flow *(Figure 17).* There is an east-west trending geologic structure that separates the South Subarea from the Pine City Subarea. Ground water level data collected from wells located on either side of the feature show the impact that geologic structures can have. The wells are about one mile apart and have very similar surface elevations. The water level for the southern well has been fairly stable over time compared with the water level for the northern well hydrograph *(Figure 18).* In 1970, the water level in the northern well was about 260 feet below the water level in the southern well. The water level at the northern well is currently over 435 feet lower than at the southern well.

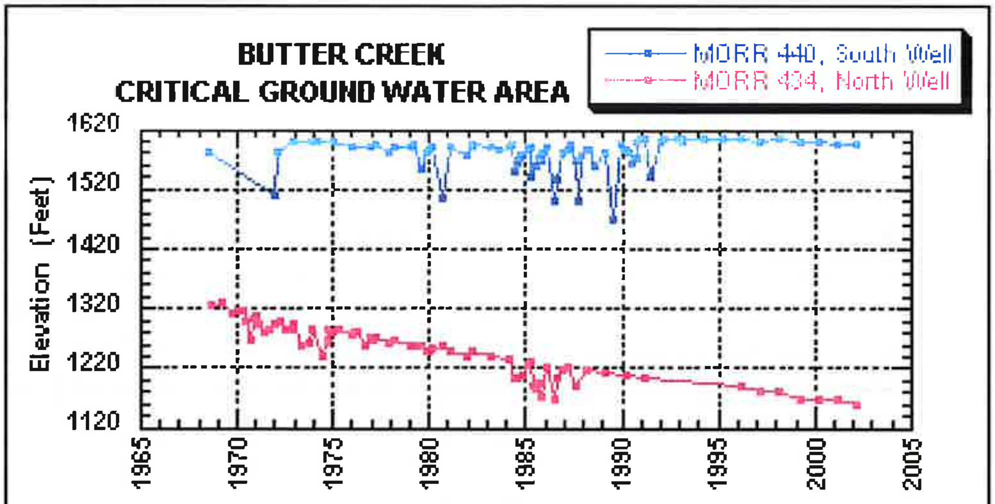

Figure 18 - Basalt wells: opposite sides

Water levels in large portions of the Butter Creek Critical Ground Water Area continue to decline. Without additional pumpage reductions, declines will continue until it is no longer economic to pump water.

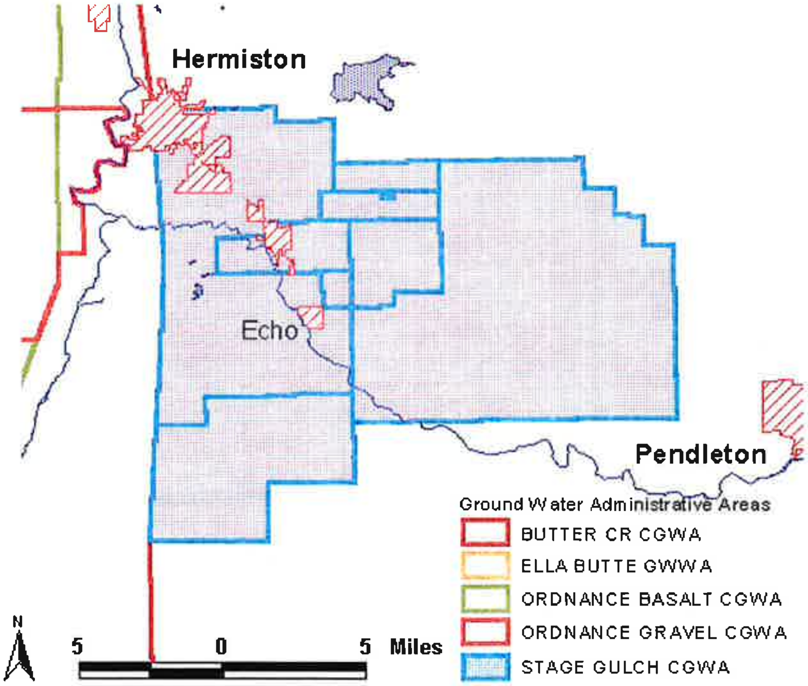

Figure 19 - Stage Gulch CGWA

Stage Gulch Critical Ground Water Area

The Department has been investigating ground water conditions in the Umatilla Basin since the late 1960s. The earliest work was concentrated in the Butter Creek and Ordnance areas, where extensive ground water development, primarily for irrigation, first occurred. As additional development of ground water progressed through the 1970s in areas to the east and west of the Butter Creek and Ordnance areas, the scope of the Department's investigation expanded to include those areas. By the mid 1980s, it was clear that the same problems that had been documented in Butter Creek and Ordnance were occurring in these more recently developed areas.

The Stage Gulch Critical Area to the east of the Butter Creek area *(Figure 1)* was established in 1991 to address three issues developing in the confined basalt aquifers. These issues included excessive ground water level declines, substantial interference between wells, and overdraft of the ground water resource.

The Stage Gulch Critical Ground Water Area includes approximately 183 square miles *(Figure 19).* Over 100 permitted basalt wells are located within the area.

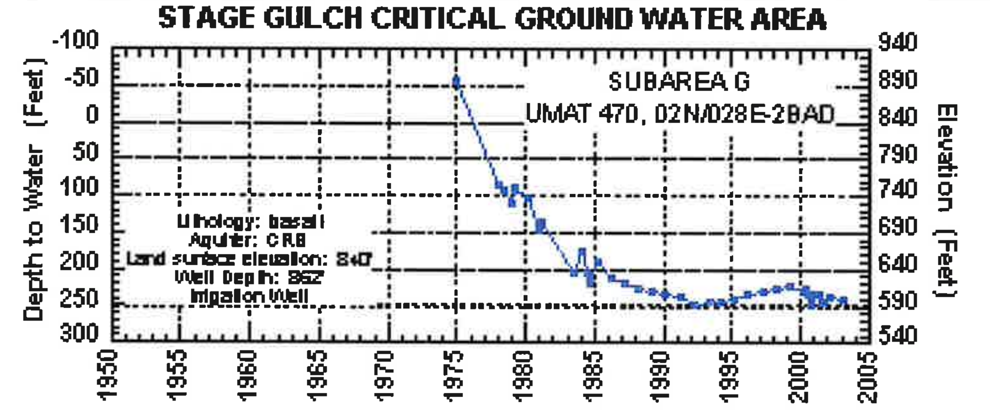

Figure 20 - Basalt well in subarea G

These wells are authorized for primary and supplemental irrigation of over 25,000 acres, municipal use for the cities of Hermiston, Stanfield and Echo and some industrial and manufacturing uses. The critical area is divided into eight subareas, each of which is managed separately.

Since the critical area was established, Department staff have continued to monitor water levels and water use at basalt wells. Several hydrographs illustrate water level trends in these wells. Figure 20 shows the water level data collected at a currently unused irrigation well in subarea G. This well flowed at land surface when first constructed. The water level declined quite rapidly, more than 20 feet per year, during the first decade of water use. The rate of decline decreased to about 8.4 feet per year from 1985 to 1992. Water use in the subarea decreased immediately following the critical area declaration. As a result, the water level rose about 26 feet between 1992 and 1999. Since then, pumpage has increased again, and the water level has declined about 20 feet. Since February 2000, the Department has continuously recorded water levels at this well. The hydrograph in Figure 21 shows the seasonal water level fluctuations, including the response to nearby pumping wells during the irrigation season and the subsequent recovery during the fall and winter months. Other wells in subarea G display water level trends similar to this well.

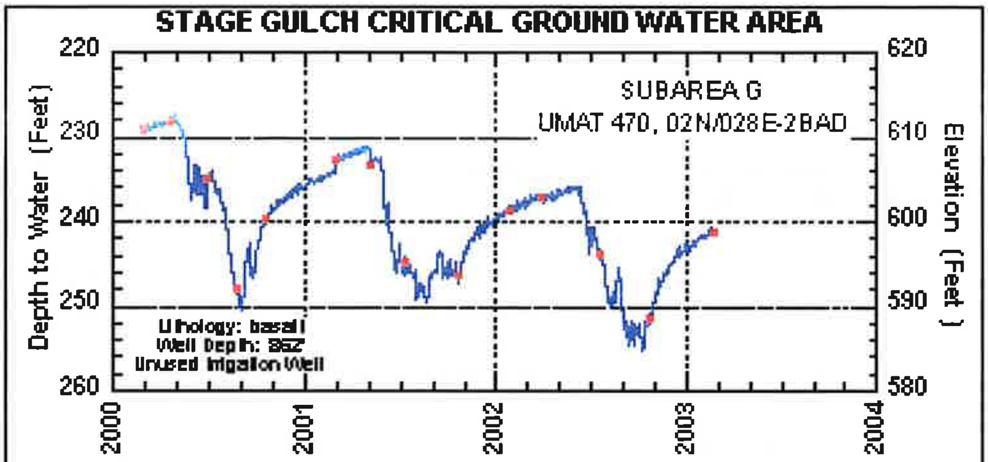

Figure 21 - Short-term hydrograph of basalt well in subarea G

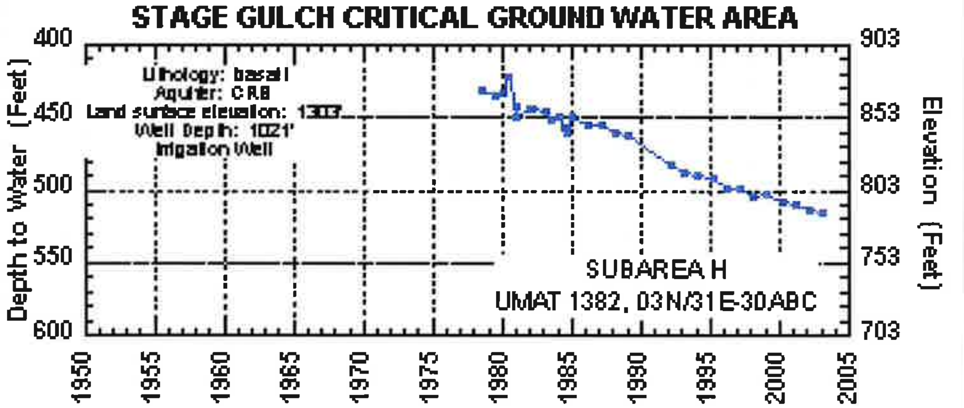

Figure 22 - Basalt well in subarea H

Wells in other subareas exhibit trends generally indicating water levels have not stabilized since the critical area was designated. Water levels continue to decline, but at a lower rate, following establishment of the critical area. Figure 22 is a hydrograph for an irrigation well within subarea H. Water levels at wells in this subarea declined about 2.5 to 4.5 feet per year in recent years. Data from the area generally suggest that, without further reductions in ground water use, water levels will continue to decline until it is no longer an economic source of water.

Pendleton Area

The City of Pendleton currently uses a combination of surface and ground water sources for municipal purposes. The proportion of the city's total water supply that comes from ground water is increasing. Eventually, the City is seeking authorization to develop up to 13 wells tapping the deep confined basalt aquifer.

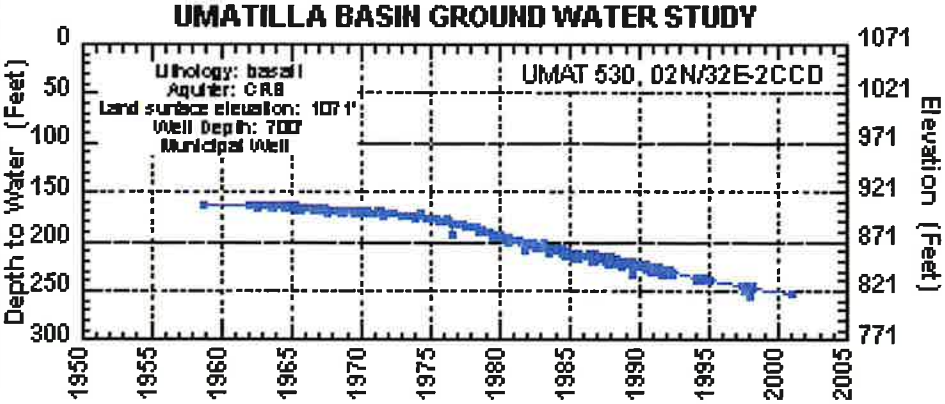

Figure 23 - Basalt well near Pendleton

The City's use from the first well began in 1946. Additional ground water use has grown through the decades as new wells were built. The City now has rights to pump 11.7 million gallons per day and the infrastructure to pump most of that rate. Additional wells are identified on permits but are not yet developed.

The development of deep basalt ground water has resulted in water level declines. The current decline rate is about three feet per year *(Figure 23)* and reflects the highest rate of decline to date. The decline in the City wells is highly uniform. For the most part, municipal pumping is causing the declines. However, other wells in the surrounding area also play a role, but the deep basalt aquifer is not developed by many of the nearby wells.

The City of Pendleton has built a new water treatment plant and plans to implement an aquifer storage and recovery (ASR) project. ASR will consist of injecting and storing a portion of the City's treated water in the deep basalt wells during times when water is available in the winter and spring. During the summer and fall, the stored water will be pumped out of the wells to supplement the surface water supply from the treatment plant to meet higher demands. The City is undertaking a pilot project to better understand the potential for ASR.

The goal of implementing the ASR strategy is to allow the City of Pendleton to continue using ground water while minimizing impacts to the regional ground water supply. By using stored treated water instead of natural ground water, the City expects to reduce the current natural ground water decline. Eventually, it may be possible to halt the decline or begin to see an increase in ground water levels.

Ground Water Conditions in Outlying Areas

Every winter since 1979, generally in late February, Department staff have collected water level data at numerous basalt and alluvial wells in the Umatilla Basin. The number of wells visited has varied over time, but has averaged about 275 in recent years. Most irrigation wells are idle at this time and static water levels are generally at their annual high. All but approximately 45 of the wells measured are in one of the ground water management areas discussed previously in this document.

The wells located outside of the management areas include irrigation, domestic, municipal and unused wells scattered throughout the basin. Concentrations of such wells are in and around the cities northeast of Pendleton, the Pilot Rock area, and a broad area to the southwest which includes Ione, Lexington and Heppner. Some of these wells have long-term records while others have been added in more recent years in response to new permit issuance or concerns by staff or local water users regarding potential well interference or water level declines.

The Department received several complaints from the cities of Adams, Athena and Helix during the late 1980s. In general, the city wells were no longer able to produce the permitted or customary quantities of water, especially in mid to late summer when demand is highest. Upon investigation, the Department determined that the problems likely resulted from multiple causes, including well or pump problems, water level declines and pumping interference from other wells.

There are approximately 40 permitted wells in the vicinity of the cities of Adams, Athena, Weston and Helix, most of which are used for irrigation. Several of these wells pump water in sufficient quantities, and are located close enough to municipal wells, such that measurable pumping interference is likely. The magnitude of the interference was estimated and determined not to be substantial. Therefore, no regulation of nearby junior water users was necessary.

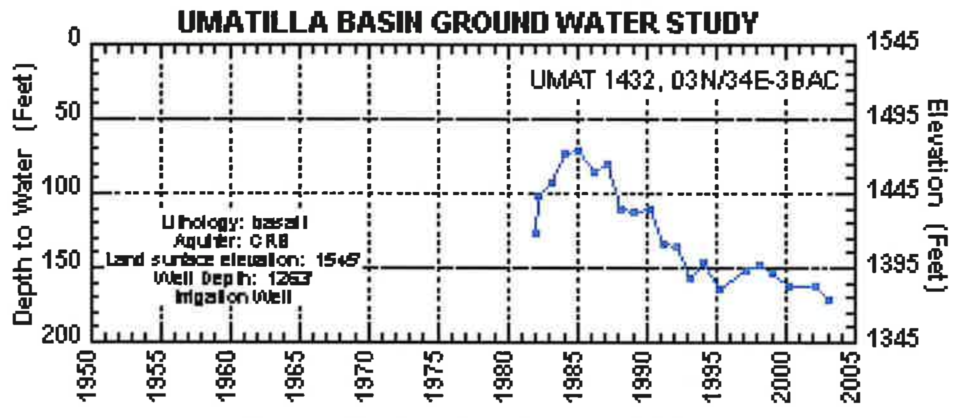

Figure 24 - Basalt well near Adams

The cities of Helix and Adams constructed new basalt wells in 1989. The city of Athena acquired an unused deep well in 1992, converted it to municipal use and obtained a new water use permit which allows additional use. These cities have not reported any significant problems with their wells subsequent to that time. However, water levels continue to decline at

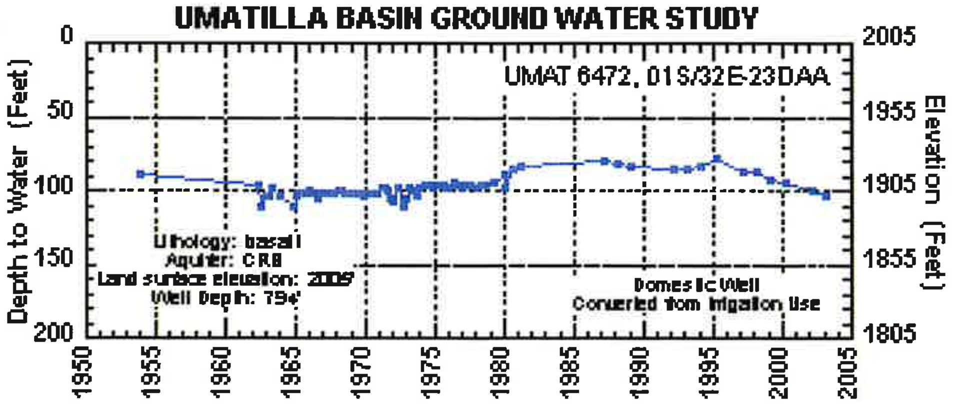

Figure 25 - Basalt well near Pilot Rock

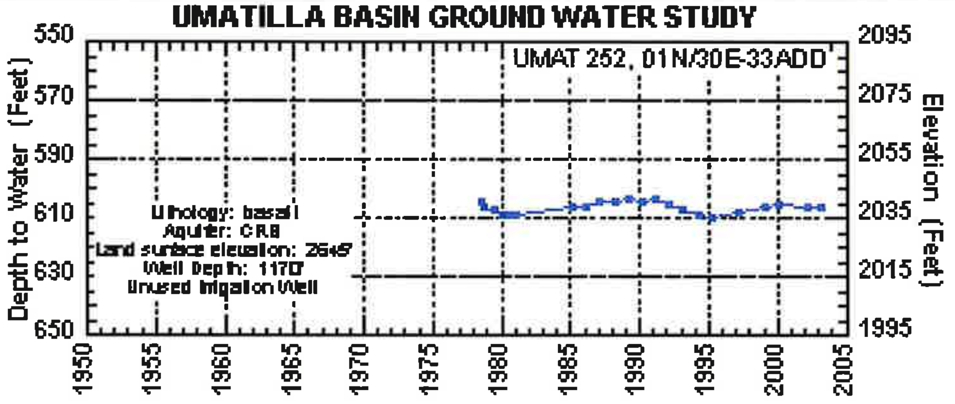

Figure 26 - Basalt well south of Stage Gulch CGWA

many wells in this area. Figure 24 is a hydrograph for an irrigation well near the city of Adams. Winter static water levels at this well have declined about 100 feet since 1985.

In the remainder of the outlying areas of the basin, with the exception of an area from Pilot Rock north to McKay Reservoir, development of the ground water resource is much less concentrated than in the above cited area. The following hydrographs *(Figures 25 and 26)* illustrate water level trends for selected wells in these outlying areas of the Umatilla Basin. In general, water levels in these areas exhibit a range from relatively stable to moderately declining. Water levels in more remote areas are likely responding to long-term climatic trends, while those in other areas may be influenced by both local water use patterns and the climatic trends.

Existing users of basalt wells frequently express concerns regarding potential well interference and ground water availability whenever new uses of ground water are proposed in their area. The Department shares these concerns, given the past and ongoing water level trends in the more heavily developed parts of the basin. Currently, there are pending ground water applications which propose to use significant quantities of water in areas south of the Stage Gulch and Butter Creek critical ground water areas. Water users within the critical areas have protested these applications. Ground water staff are recommending water level measurement and decline conditions to be included in these permits, if issued. Staff currently recommend these or similar conditions for nearly all new permits for basalt wells in the basin. Water level data collected to fulfill such permit requirements will supplement such data collected by Department staff, and may be used in making future management decisions regarding the basalt ground water resource in the Umatilla Basin.

The Next Step

Oregon statutes require the Water Resources Department to manage ground water as a renewable resource. Among other things, the Department is charged with maintaining reasonably stable ground water levels and preventing overdraft, substantial interference between ground water users, and substantial interference with surface water.

Economic activity within the Umatilla Basin is increasing steadily and will require additional supplies. Ground water will continue to be targeted as a source to accomodate this economic growth. Reliance on ground water for those supplies may be unrealistic given today's water management objectives. To be effective, those decisions need to be based on a thorough understanding of the conjoined ground water/surface water system. A comprehensive Basin wide ground water study is being planned to provide the necessary understanding. In its conceptual form, the U.S. Geological Survey would be engaged as a cost share cooperator with the Water Resources Department in conducting the study. The Department is soliciting partners from the Basin to assist in the formulation of a study plan and in the financing the study. Following its completion, those same partners will be called upon to assist in developing a comprehensive ground water management plan for the Basin that makes maximum supplies of water available for economic growth without compromising the statutorily adopted values and goals of sustainable ground water management.

APPENDIX A

Basic Ground Water Concepts

Ground Water Occurrence

Water that fills void spaces in naturally occurring Earth materials is called ground water. Void spaces, or pores, can be present in Earth materials for a variety of reasons, but there are only two or three that are important in the Umatilla Basin.

The first of these is intergranular porosity *(Figure 27).* Water can fill the pore spaces between the silt, sand and gravel particles that make up the alluvial deposits. Alluvial deposits can be made up of as much as 30 or 35% pore space. So alluvium can contain significant quantities of water.

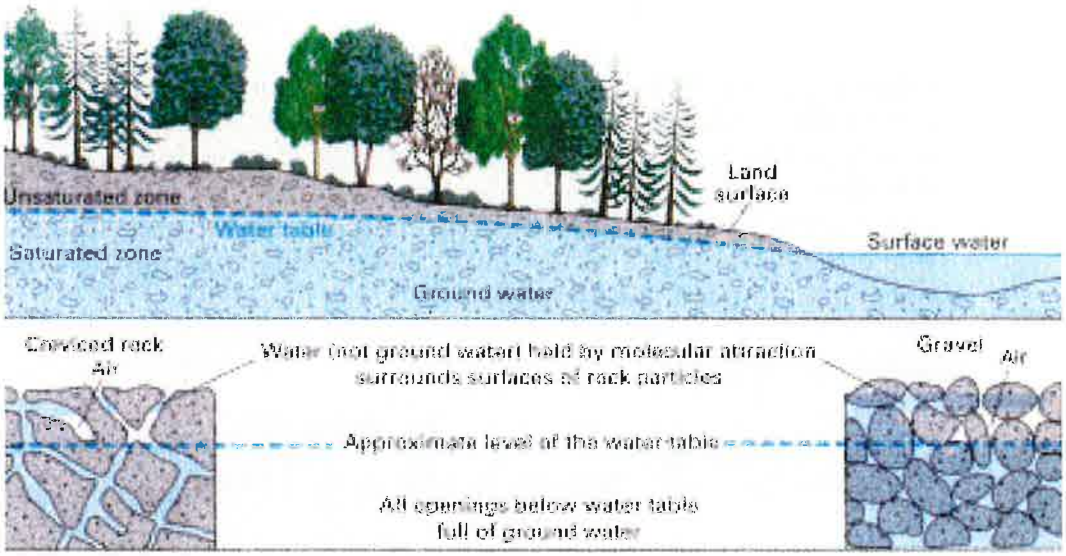

Figure 27 - Intergranular and fracture

The second is fracture porosity. Fractures can be quite open, providing an avenue through which water can readily flow, or be "tight", not allowing water to flow readily. Fractures typically do not make up a large proportion of the rock material and, therefore, do not account for very much storage of water. Also, fractures are usually discontinuous, making them unreliable as sources or conduits of water.

The third is interflow zones *(Figure 28).* The upper surface of each basalt flow is typically weathered, creating some porosity. Often, basalt flow tops were exposed long enough for alluvial or lacustrine deposits or soils to form on them which also contain porosity. Frequently, the bottom of the basalt

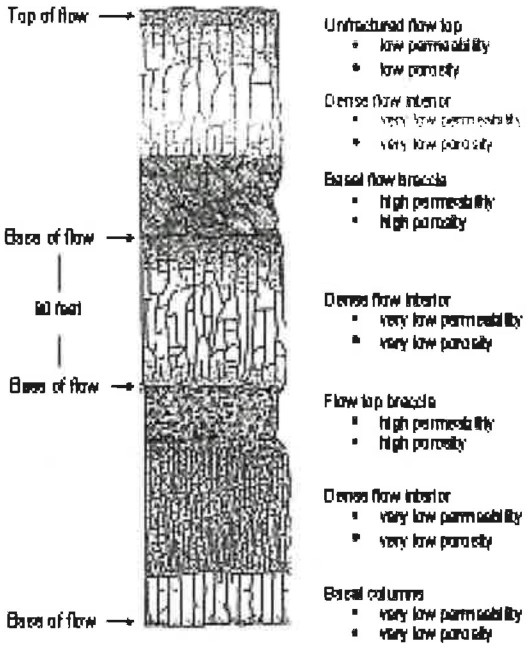

Figure 28

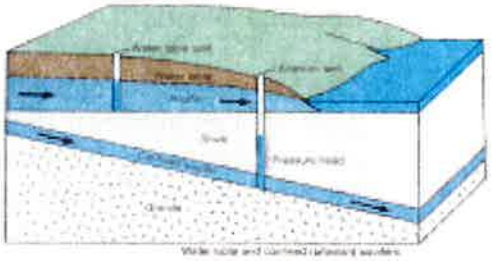

Figure 29 - Aquifer types

flows is quite rubbly leaving relatively large pore spaces in which water can accumulate. These flow tops, overlying soils or sediments, and overlying rubbly flow bottoms comprise what are called interflow zones. These interflow zones can be quite porous and permeable. However, interflow zones make up a relatively small proportion of the total column of basalt. While they store more water that fractures systems, they do not store as much as intergranular porosity.

Aquifer Types

Water can exist underground in either confined aquifers or unconfined aquifers *(Figure 29).* Both are present in the Umatilla Basin.

In unconfined aquifers, the upper surface of the saturated zone is called the water table. The water table may be near land surface or at considerable depth. But the distinguishing characteristic of an unconfined aquifer is that the overlying earth materials are porous and permeable so that atmospheric pressure is readily transmitted through them. The result is that the upper surface of the zone of saturation is at atmospheric pressure. Ground water in the Basin alluvium is unconfined.

This is not the case in a confined aquifer. Earth materials overlying confined aquifers have low porosity and permeability such that there is no efficient connection between the atmosphere and the upper surface of the saturated zone. Because of the confining layer, the pressure at the upper surface of the zone of saturation is greater than atmospheric. In some cases the pressure can be so great that when the confining layer is breached by drilling a well, water is forced all the way to land surface and the well flows. Ground water in the Basin basalts is generally confined.

Ground Water Flow Systems

Recharge

Ground water owes its existence to water present at land surface. That water percolates downward through porous earth materials to saturate void space underground. This process is called recharge *(Figure 30)*. The source of recharge water can be completely natural such as rain fall or snow melt. Water can also percolate through the bed of streams to recharge underlying aquifers.

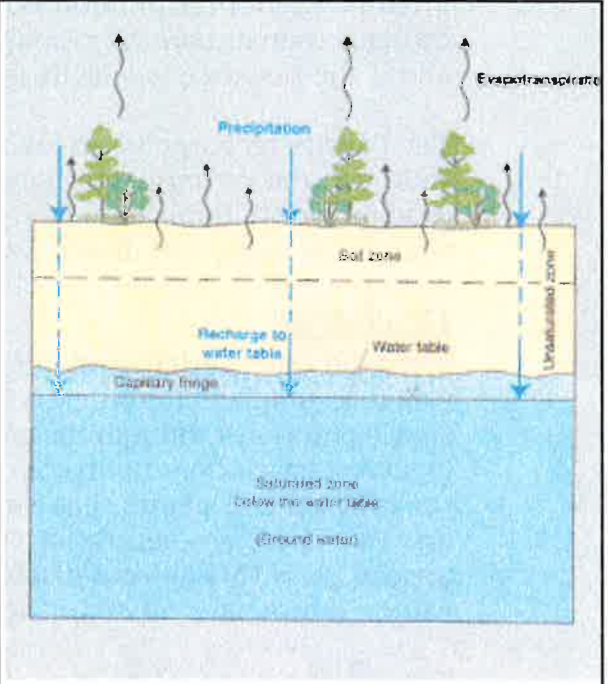

Figure 30 - Recharge and discharge

However, artificial sources of recharge also can be significant. Unlined irrigation canals and unsealed surface water impoundments provide recharge water. In some places, such hydraulic structures are intentionally designed to leak specifically for the purpose of recharging underlying aquifers.

Basin alluvium is readily recharged by water present at land surface in excess of that which is evapotranspired by plants. Some recharge in the alluvium is by way of precipitation, but significant amount also result from canal leakage, irrigation practices and at times from stream leakage.

Basin basalts are not so easily recharged because they are confined aquifers. It is currently thought that most, if not all, recharge to the basalts occurs in the higher elevations of the Basin. There, the edges of the basalt flows are exposed as are the interflow zones. Streams crossing those interflow zones then lose some of their water which percolates down dip to the lowlands where it is tapped by wells drilled through the confining layers. Some additional amount of recharge to the basalts also occurs because of faulty well construction that in some places allows water from shallower aquifers to fall down into the deeper basalts by way of the well bores.

The Umatilla Basin is arid. Down in the lowlands where the unconfined aquifer exists, precipitation is only about 8 to 10 inches annually in Hermiston. Only in the months of November through February does the precipitation exceed potential evapotranspiration around Hermiston. Higher elevations receive more precipitation and there are additional months where precipitation exceeds potential evapotranspiration. It is difficult to maintain the resource if only this natural recharge is available and if the resource is heavily used.

The basalts recharge in an area where precipitation is somewhat greater. However, the recharge mechanism is very inefficient and it takes a long time (probably thousands of years) for the recharged water to flow down to where it is being withdrawn and used.

Discharge

If ground water recharges naturally, it must also discharge. If it did not, water would accumulate until it everywhere reached land surface. Ground water slowly percolates through the aquifers and out into streams, lakes or wetlands. In some cases it does not quite reach land surface, but approaches only into the root zone of plants that then evapotranspire the water as fast as it arrives. These are natural discharge processes that are ongoing largely unseen. It is this natural discharge that maintains stream flow when the winter snows have melted of the mountains.

Ground water can, of course, also be subject to artificial discharge processes. The most common of these is the pumping of water from wells.

In the Umatilla Basin the alluvial aquifer naturally discharges much of its water where the valley is constricted north of Butter Creek *(Figure 31)*. Pumping discharge, of course, occurs in many places.

Natural discharge from the basalts is diffuse and not readily observed. However, by mapping the heads (Figure 32) elevation to which the water

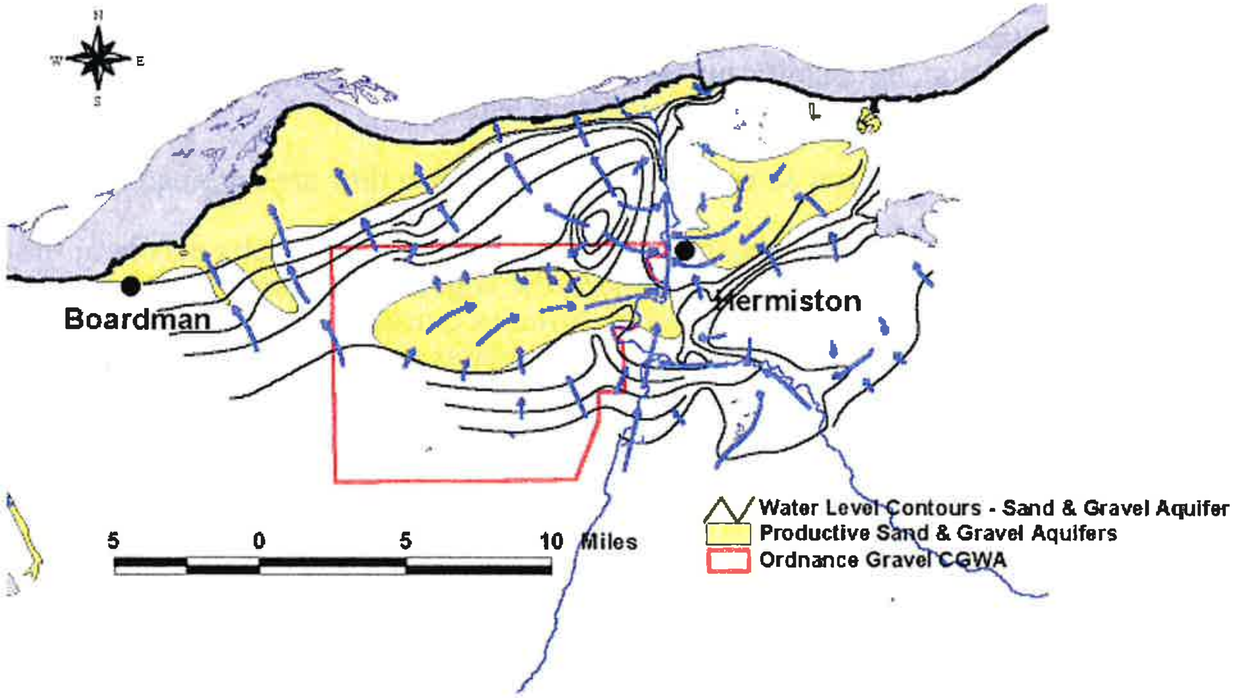

Figure 31 - Alluvial aquifer flow

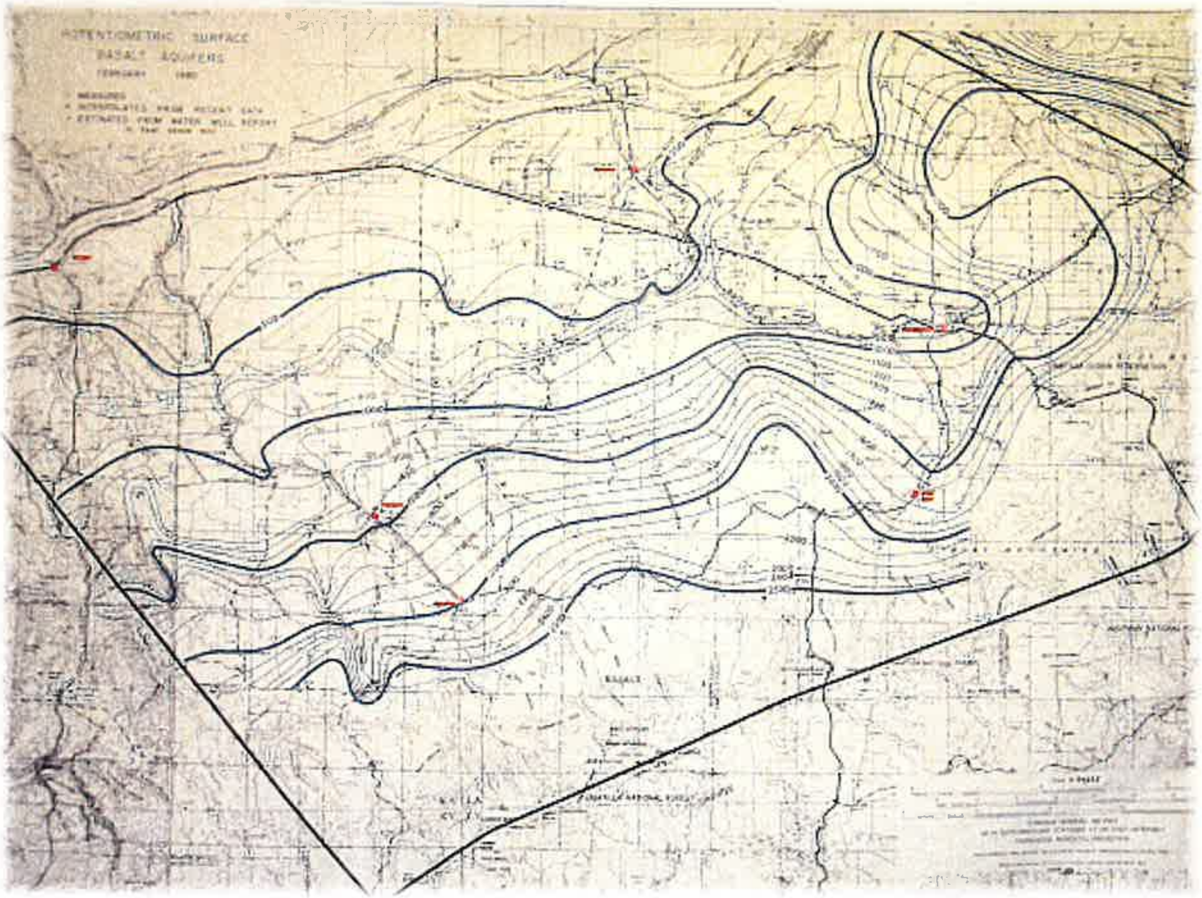

Figure 32 - Basalt aquifer flow

level in this confined aquifer rises when the confining layer is penetrated) in the basalt, it is possible to infer where recharge is occurring. This was done in the early 1980's. Water generally flows perpendicular to the contours indicating discharge to the Umatilla and Columbia Rivers.

Flow

Ground water flow is generally from areas of higher elevation to those of lower elevation. Flow is always down the hydraulic gradient as defined by the three dimensional distribution of heads within the aquifer. However, flow is seldom in a straight line. Water will be diverted by faults and folds and by spatial changes in the hydraulic properties of the aquifers.

APPENDIX B

Geology of the Umatilla Basin

The Umatilla Basin is comprised of two major geologic features - the Deschutes- Umatilla Plateau and the Blue Mountains. The Deschutes-Umatilla Plateau is a broad upland plain formed by flow upon flow of basalt. The flows dip gently northward from the Blue Mountains to the Columbia River. Events that gave rise to these geologic features are described below and a simplified geologic map of the basin is provided as Figure 33 .

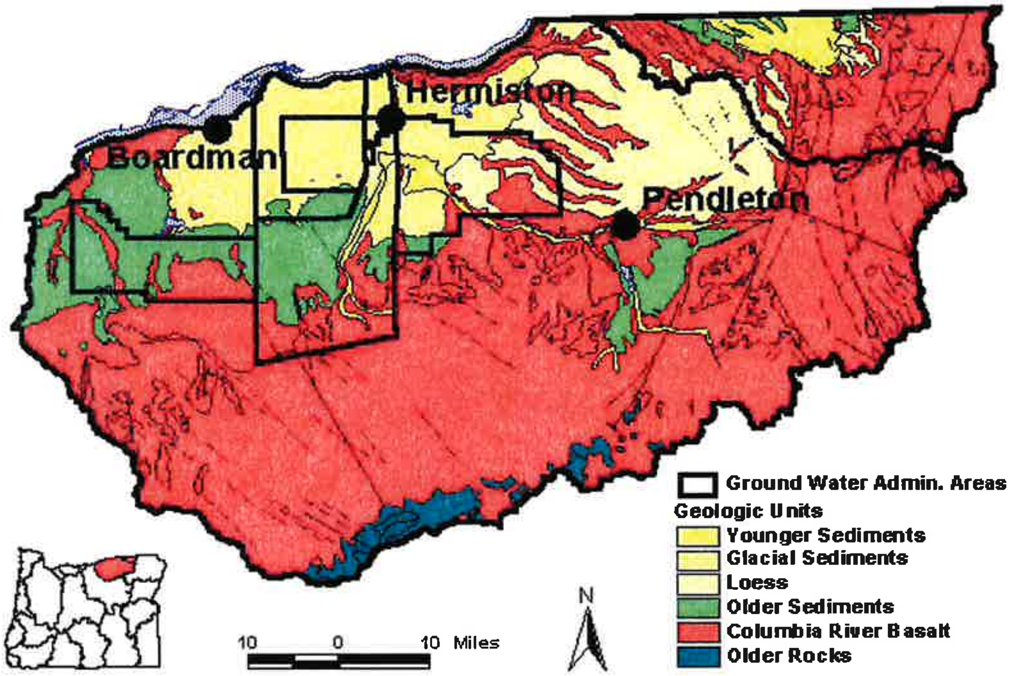

Figure 33 - Simple geology of Umatilla Basin

Beginning about 16 million years ago and continuing over a six million year period, enormous volcanic eruptions poured out basaltic lava flows from fissures in the Earth's crust in eastern Oregon and Washington and in Idaho. These lava flows spread out over vast areas, some flowing as far west as the Pacific Ocean. The rocks formed by these eruptions are collectively referred to as the Columbia River Basalt Group, or less formerly as the Columbia River Basalts.

Over time, scores of eruptions occurred resulting in basalt layers stacked one on top of another. The eruptions occurred sporadically over time but on average 50,000 to 100,000 years elapsed between eruptions. In all, these eruptions built up a sequence of basalt lava flows totaling over 10,000 feet in thickness in some places. These basalt flows form the dominant rock units in the Umatilla Basin.

Coincident with this volcanic activity, regional uplifting formed the Blue Mountains along the south and east borders of the basin. This uplifting folded and faulted the basalts. Large arch-shaped folds (anticlines) form the uplands. Broad U-shaped folds (synclines) form deposition basins between the upland areas.

Throughout much of the Umatilla Basin, the Columbia River Basalt has been overlain by sedimentary deposits. Glacially-derived silts were deposited by wind on top of the basalt-dominated landscape. These wind blown silts have been stripped away in some places and replaced by riverbed and flood deposits, or alluvial deposits. Consisting of sands, gravels, and boulders, these deposits occur in the stream valleys and are extensive in the lower part of the basin.